CODE ONE™

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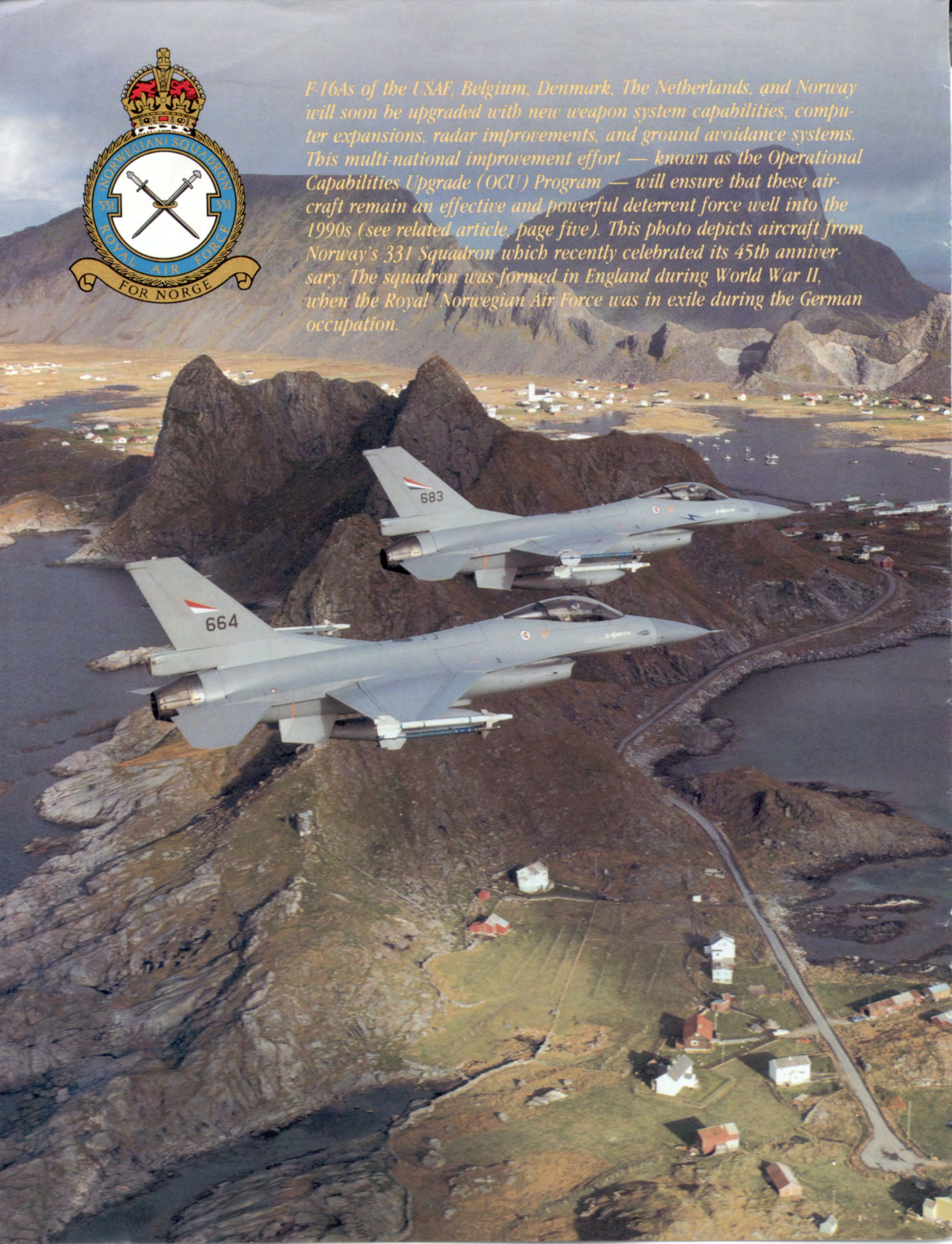
Weekend Warriors

In South Carolina, the 'Total Force' concept is put to the test.



F-16As of the USAF, Belgium, Denmark, The Netherlands, and Norway will soon be upgraded with new weapon system capabilities, computer expansions, radar improvements, and ground avoidance systems. This multi-national improvement effort — known as the Operational Capabilities Upgrade (OCU) Program — will ensure that these aircraft remain an effective and powerful deterrent force well into the 1990s (see related article, page five). This photo depicts aircraft from Norway's 331 Squadron which recently celebrated its 45th anniversary. The squadron was formed in England during World War II, when the Royal Norwegian Air Force was in exile during the German occupation.

GENERAL DYNAMICS
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ABOUT THE COVER

Air Force Reserve and Air National Guard units are proving their value as members of the "total force." Many are now equipped with the best aircraft in the USAF inventory. *Code One* went to South Carolina's McEntire Air National Guard Base to get a feel for how the total force concept is working. The story begins on page two. (General Dynamics photo by Gary Tolbert)

THE swamp foxes

By FRANK C. BADDER
Editor, Code One

Not even in the active Air Force is the Guard thought of anymore as a flying club for semi-retired, part-time fighter jocks. Not after Gunsmoke '85.

In recent years, the USAF's Guard and Reserve forces have been undergoing a transformation. Across the country, these units are being revitalized with better equipment and training as part of a new "total force" concept. Tired old airplanes and outdated maintenance support equipment are finally being put out to pasture, as is the ill-conceived notion that the people who maintained and flew those airplanes were somehow less than top drawer —a misconception that military and congressional experts felt was due solely to substandard equipment and not to any inherent failing on the part of the forces themselves.

In the development stages of the F-16, Pentagon planners recognized an opportunity to provide Guard and Reserve forces with tremendously increased capability at relatively low cost.

And so it was. In increasing numbers, the "weekend warriors" have been getting newer equipment, better training, and (most important of all) a viable role as part of the USAF's total force. In South Carolina, Utah, Arizona, Texas, and Vermont the F-16 Fighting Falcon belongs to the Guard and Reserve. And more will follow as these men and women continue to prove that they *can* attain combat readiness levels on a par with their active-duty counterparts. During Gunsmoke '85, the Air Force Reserve's 419th TFG swept top honors, while the Swamp Foxes of the 169th TFG, McEntire ANG Base, S.C., finished one slot better than their active-duty counterparts from nearby Shaw AFB.

"We have a basic plan," said the 169th's full-time commander, Lt. Col. Joe Khare. "We're going to recruit the best and the brightest off active duty, and if we can win any kind of competition, then by golly we're going to go for it. You know, that's the fighter pilot's tradition. We not only want to compete, we want to win. That's pretty much the philosophy you'll see in the squadron, in talking to most of the guys."

The 169th's DCM, Lt. Col. George Inabinet, described Gunsmoke as "a right unique experience. We had two deployments back to back. We had Norway in September and Gunsmoke in October. I think we ran around 99 percent mission capable rate out at Gunsmoke. We didn't lose a single sortie to an abort. We didn't use a single aircraft spare. We got all the bombs off that we carried to the target, and we fired all the bullets. We had no flaws whatsoever, so we were happy with it."

Inabinet said the 169th's normal MC rate is "around 70 percent. The standard MC rate for the Air Guard or Reserve forces is around 65 percent. We set our goal here to try to maintain 70 percent, and with one shift we think that's right commendable, because when that aircraft comes back in the afternoon broken it's not worked on until the next day. You carry it all night 'out of commission.' The same thing on weekends. If you break one on Friday afternoon it sits broken all weekend. That hurts your MC rate."

"MC rates really bother us," Khare said. "It would be nice if we had an 80 or 90 percent MC rate. But we are constantly and consistently meeting our flying commitment, and our IFE rate is way down. If you put a guy in a piece of equipment that operates the way it's supposed to operate, his training is enhanced. If, on the other hand, he's got to fight that equipment, if he's got emergencies to contend with, if the airplane systems and subsystems don't work quite the way they're supposed to, then he has got to spend his time trying to work around that system and consequently spend less time practicing his art, which is flying a good, full-up jet to its maximum performance capability."


Photo by LTC Don Borowski, National Guard Bureau

169th Maintenance crews provided a 95% MC rate during the unit's deployment to Norway.

"The big proof of the pudding," Inabinet said, "is when you take the aircraft and deploy 'em somewhere and have around-the-clock (maintenance) capability. On those, we've run in the 90s."

Khare credits the F-16.

"It's state-of-the-art. Lots of rivets. Close fasteners. You're not going to see signs of wear in this airplane. Yeah, the airplane can wear out, but it's just too easy not to let it. You take the keel. I've been to the factory and watched the way they make that thing. Machines are doing it and they're all built to specs. Generic. I know when we had the old deuce (F-102) they had a canopy fitted to each airplane. If you lost that canopy you played hell putting another one on it. This thing (the F-16) is so well-built I just don't worry. I don't lose sleep over that. I don't lose sleep over the engines."

So what DOES he lose sleep over?

"I lose sleep over the way we use the airplane - getting the max out of our aircrews. Every time we've tested the airplane, what in fact has happened is the airplane has tested us. We go down there and fly an ORI. We put up a 4.0 sortie rate. What happens? Do the airplanes wear out? No. The airplanes are just really getting into it about day four. They're all up and working good, but the aircrews are running around with their tongues hanging out. We've got an airplane you can do things with. We can use this airplane surgically. The biggest problem we have is making sure the guys are challenged mentally and physically. Are we maximizing our capabilities? That's the type of thing I lose sleep over.

"The other thing I'm kinda worried about is that we need a beyond-visual-range missile on this airplane. AMRAAM is coming, and we can't wait 'till it gets here."

The Swamp Foxes are mud pilots. Air-to-ground stuff, basically. But the bright promise of the F-16 is its multi-mission capability. For the 169th, that means the ability to defend yourself while performing the air-to-ground role.

"The A-7 (the airplane the Swamp Foxes flew before transitioning into the F-16 two years ago) was a very nice, comfortable airplane, but there were areas of the envelope you avoided," Khare said. The thing that jumps immediately to mind is you have no offensive capability, contrary to what the A-7 community thinks at this time. And as far as a close-in fighter, the A-7 is not. When you put g on the A-7, you could feel the kinetic energy build up and you knew there was gonna come a point where you were gonna separate from controlled flight.

"The other thing that used to bother me about it was pointing my nose to the ground. It loved mother earth and it was hard to get it turned around once you got it beyond 20 degrees nose low. I'm talking about scare you to death. In the F-16 you don't worry about its performance element. You just don't have to watch the airplane. The computer and the limiter take care of that. It's got the speed to sprint on the deck, and the capability to pull up and shoot. It'll sprint at such a rate of speed that nobody's going to run you down. The MiG-29 may come from high altitude, but I guarantee, if they meet you head-on on the deck, they've got to turn it around and launch, and they'll run out of gas trying to run you down. With the F-16, you're better to run in, take the threat nose on, pull up, launch one at him, and let *him* figure out what's happening. That, to me, is the big difference in the A-7 and the F-16. You don't have to worry as much about flying. You don't worry about painting yourself into a corner. And you've got a real, no-lie offensive capability."

Khare said one of the hardest things for the 169th's pilots to overcome, when they transitioned to the F-16, was the temptation to forget their air-to-ground mission and "go for it. You know, shoot the other guy down. It's just too good an opportunity. You want to get up there and blow them away. The F-16 is superior in the air-to-air role. We can lock anybody up - anybody that's gonna be a threat - outside their launch parameters. The 16 stopped, once and for all, the old myth that the 104 was the only real fighter that was ever built. There used to be a kind of inner sanctum of people that said the 104 was 'the' airplane. When we got into the A-7, people who flew it said, 'yeah, but it's still not the 104.' This one (the F-16) does it all.

But the colonel admitted that the Fighting Falcon needs a BVR capability in the offensive, air-to-air role.

"We did some composite work with F-15s. You put those two weapon systems together and that's a devastating combination. You've got a great long-range fighter (the F-15) setting up there with the radar coverage, and a great point defender with the F-16 close in. Give us the AMRAAM," Khare predicted, "and we may not be able to sort the fight out as far away, but we'll still have that nose-on capability."

When asked about the Mig-29, touted as the Soviet's equivalent to the F-15, Khare said, "Bring it on." He described it as "a big, draped-wing, bad-looking airplane with twin tails," then added, "and it's got a nice little round canopy they can almost see out the back of, which they need to do because that's where we're going to be. I thought it was really nice that they gave the guy a chance to look, to turn around and see who's shooting at him. Bring 'em on."

Bold words for a Guardsman? Not anymore.

"I've used this analogy before. It runs back to when I was tooling around Southeast Asia in an F-102 (as a Guardsman on temporary duty), watching the war go on. Back then we were kind of the second team. We had our pads on, and we were out there on the bench. We were there if the coach ever really needed us. What's changed now is we're expected to go in for the kickoff and play the entire game. Offense, defense, special teams, whatever it takes. I think we've trained to do that." ■

Lt. Col. George Inabinet . . . USAF's oldest F-16 pilot?

Photo by 1st Lt. Fred Monk, Public Affairs Office, McEntire Air National Guard Base.

New or Old, George flies 'em all

We don't exactly know how to classify this one, but Lt. Col. George Inabinet flies both the oldest and the newest airplane in the Air National Guard inventory. The DCM for the 169th TFG is an F-16 pilot who flies tail number 295. He is also the co-pilot for the unit's C-131, the oldest airplane in the ANG inventory, and *also* a bearer of tail number 295. And if that isn't enough of a coincidence for you, both airplanes were built by General Dynamics.

It is rumored that Col. Inabinet is also the oldest pilot in the Air National Guard - a rumor the 52-year-old veteran vigorously denies.

"But come to think of it," Inabinet said, "I just might be the oldest F-16 pilot."

Anyone care to dispute that?

UNITED STATES

BELGIUM

DENMARK

NETHERLANDS

NORWAY

OCU

Operational Capabilities Upgrade

By T.E. (THOMAS) COLLINS
Director, F-16A/B OCU Program

The F-16's multimission performance capabilities have made it a respected weapons platform in both the air-to-air and air-to-ground role. However, operational use over the last eight years has dictated a requirement to enhance the aircraft's subsystems and capabilities to meet the challenge of the ever-increasing threat. This enhancement is called the Operational Capabilities Upgrade (OCU) Program and, just as its name implies, it's aimed at broadening the F-16's capabilities — specifically the F-16A/B Block 15 aircraft. OCU is a multinational effort by the United States, Belgium, Denmark, The Netherlands, and Norway to assure the operational viability of Block 15 aircraft well into the 1990s.

From extended operational usage — in varying mission roles and in different operating environments — has evolved a set of desired operational upgrades: the long-sought AMRAAM, the Penguin missile, a low-altitude warning system, and enhanced capabilities for the radar, avionics, and computer systems.

Incorporation of these enhancements into current F-16A/B Block 15 aircraft is made possible through Stage I of the Multinational Staged Improvement Program (MSIP), through select subsystem developments of MSIP

Stage II, and through European Participating Air Forces (EPAF) development programs.

The OCU program was authorized by the five air forces on 30 May 1984, and calls for retrofit of all program enhancements to the 637 F-16A/B Block 15 aircraft scheduled for production through November 1987. To accomplish this, the program is structured in three phases:

- **DEVELOPMENT/INTEGRATION** - includes aircraft design, software development and test, system integration, and flight test.
- **SUPPORT DEVELOPMENT/INITIAL KITS** - includes support equipment design, TCTO and TO trial installation and kit proofing, avionic intermediate shop (AIS) development/checkout, 20 initial TO/TCTO kits for aircraft and alternate mission equipment (AME) installation, and installation of 17 AIS shop sets.
- **RETROFIT KIT PRODUCTION** - a multi-year procurement of all kits required to modify the remaining F-16A/B Block 15 aircraft for the five air forces. The first authorization for 196 kits — a one year supply — was made in March 1986.

All retrofit kits will be delivered to the depots of the five participating air forces. The first depot to receive kits will be the Royal Norwegian Air Force AMC at Kjeller, Norway, beginning in mid-1987. Through the end of that year, kits will be sent to the USAF depot at Ogden, Utah, and to the depot facilities of Belgium and The Netherlands. Denmark will begin receiving kits at the Aalborg depot facility in the fall of 1988, under the next kit buy authorization. All modifications are scheduled for completion by the end of 1990.

Specifically, OCU involves the following major upgrades:

- **EXPANDED AVIONIC COMPUTER CAPABILITY** -As increasing mission requirements have exhausted computer memory and throughput reserves, the F-16A/B fire control computer (FCC) and central interface unit (CIU) have become extremely limited in their operational flexibility, The FCC is therefore being modified to expand its memory from a 32,000 word core to a 128,000 random access memory (RAM) with a battery backup. Associated with the memory expansion is a 54 percent increase in throughput, from 250,000 OPS to 385,000 OPS. Current OCU program requirements utilize only 40 percent of this modified capacity, leaving 60 percent for future enhancements. The modified unit is now referred to as the expanded fire control computer (XFCC).

The CIU is being modified to expand its memory capacity from 40,000 UV PROM to 64,000 EEPROM with an attendant RAM increase from 4000 to 8000. Current OCU program requirements utilize only about 60 percent of the modified computer capacity, leaving some 40 percent for future growth. And additional growth capacity is available through a plug-in board that will increase the 64,000 EEPROM to 128,000 EEPROM. The modified CIU is now referred to as the XCIU.

- **ADVANCED WEAPONS** - The OCU F-16 will be "wired" to accept the USAF AIM-120 AMRAAM (advanced medium range air-to-air missile), the Royal Norwegian Air Force MARK III (Penguin) anti-shipping missile, and the European-developed ASRAAM (advanced short range air-to-air missile). Compatibility is being assured by incorporating MIL-STD-1760 wiring provisions in the aircraft wing. AMRAAM data link provisions are being implemented in the software of the APG-66 radar set. The associated radar set hardware changes will be implemented at such time that AMRAAM is committed to operational F-16A/B aircraft. Following that commitment, the hardware changes will be accomplished as a field-level retrofit.

F-16 pilots have long awaited a "beyond visual range" (BVR) missile capability, and AMRAAM development efforts have therefore been closely monitored. Less is known, however, about the Penguin - a missile that is at least as impor-

OCU modifications will be made at depot facilities of the five participating nations, with kits supplied by General Dynamics Fort Worth Division.

The Penguin missile, being tested at Edwards AFB.

tant to many air forces as the AMRAAM. The Penguin is a medium-range, anti-ship missile designed for over-water or over-land launch, and for operation in a fjord-clutter background. Developed in Norway by Kongsberg, the Penguin being evaluated for the F-16 by the Royal Norwegian Air Force is an adaptation of the operational ship-launched version currently installed on the frigates and fast-attack aircraft of four navies. The missile is a "fire and forget" weapon that uses inertial navigation for the flight to the target and relies on passive infra-red homing for the final attack. Before launch the seeker may be programmed to overfly a given number of targets or to avoid distractions such as fires on damaged ships and IR decoys. The missile system software has been integrated with OCU-related aircraft avionics, using the XFCC and XCIU for control and operation. Targets may be acquired through the aircraft's radar, or in a completely passive mode via the head-up display. The missile is drop-launched from the aircraft and will skim the water's surface, or climb for terrain clearance when launched over land. With a range in excess of 40 kilometers, the Penguin provides a stand-off capability against sea-borne targets. Beginning in 1987 the USAF, in agreement with the Royal Norwegian Air Force, will conduct a weapon evaluation program utilizing the Penguin.

• **MISSION DATA LOAD CAPABILITY** - The data transfer unit (DTU) developed under the MSIP Stage II program will be incorporated into the OCU. The DTU is comprised of a data transfer receptacle (installed in the aft right-hand cockpit console) and the data transfer cartridge, with which the pilot can load such information as steerpoints, targets, weapons inventory, weapon delivery profiles, and bingo fuel. The cartridge greatly reduces aircraft setup time, and can record fault maintenance data, thereby facilitating aircraft maintenance actions. The data transfer system is fully compatible with the Royal Netherlands Air Force's Mission Planning System (CAMPAL) - the first fully integrated mission planning system in the F-16 program. It is now in use in The Netherlands.

• **INTEGRATED LOW-ALTITUDE WARNING SYSTEM (LAWS)** - This system is comprised of three elements (a barometrically based altitude penetration warning, a radar altimeter, and a modification of the existing "ground clobber" subsystem) integrated into a total system for enhanced situational awareness.

Operation of the first element, sometimes referred to as "line in the sky" (see *Code One*, Vol. 1, #2), depends on a pilot-entered mean sea level (MSL) altitude in the FCC. If the aircraft descends through the preset MSL altitude, "line in the sky" gives the pilot three visual warnings and (in the event that the pilot's attention is directed outside the cockpit) an aural warning.

The second element, a combined altitude radar altimeter (CARA), provides above-ground-level (AGL) warnings to the pilot. This element operates during all mission phases, regardless of whether the pilot is engaging in air-to-air, air-to-ground, or simply navigating from point A to B. The CARA constantly measures AGL altitude and compares this value to the one preset by the pilot. Again, when the aircraft descends through the preset altitude, the system triggers visual warnings; but instead of a simple, aural tone, the CARA has a voice that says "warning, warning."

The third element involves a modified "ground clobber" system. The previously assumed one second pilot delay has been removed and the vertical velocity trigger has been changed from a descent rate of 3000 feet per minute or greater to any descent rate. The system operated according to certain priorities: CARA altitude, radar ranging height above target, and system altitude height above the selected steerpoint. This system is predictive in nature, and its calculations include data on aircraft angle-of-attack, airspeed, gross weight, dive angle, temperature, normal accelerations, and bank angle. The warnings are activated when the FCC receives a negative CARA altitude rate and it predicts that the pilot must pull four g's within two seconds to avoid the ground (by ten percent of the altitude lost during the pull-up, plus 50 feet). Warnings are given earlier if aircraft bank angle is greater than 45 degrees or if airspeed is insufficient for the aircraft to pull four g. This system also includes visual warnings and voice messages.

When a Voice Message Unit is installed by retrofit in 1987, the line-in-the-sky's tone will become the voice message "altitude, altitude," the CARA's message will change from "warning, warning" to "altitude, altitude," and the ground clobber system will tell the pilot to "pull up, pull up."

• **AIRCRAFT/RADAR SOFTWARE UPDATES** - Modifications will include a major software update to the APG-66 radar, XCIU, and XFCC. This software will contain Block 15S capabilities as the baseline and will incorporate changes required to support OCU systems (AMRAAM, ASRAAM, Penguin, mission data load with DTU, and LAWS). Also included will be modifications to interface with the new computer hardware, and a rewrite of the XCIU operational flight program that will improve efficiency and reduce total memory requirements.

The XFCC and XCIU software will also incorporate data to enhance the operational capability of existing weapons. These changes include (1) an improved algorithm for weapon separation effects; (2) updated separation-effects data for CBU-58, MK-82 Snakeye, MK-20, BL-755, and MK-82; and (3) delta bomb range corrections. Weapon-carriage flexibility will be improved through the expansion of air combat maneuvering instrumentation capability to all six missile stations and the LAU-3 rocket launcher capability to four air-to-ground store stations.

The OCU program is progressing on schedule. The development program has met all major milestones, as has the flight test program being conducted by the Combined Test Force at Edwards AFB, Calif. A major program milestone was achieved in early August when the modification of two F-16A/B aircraft was completed. These aircraft will be tested in an operational environment at Nellis AFB, Nev.

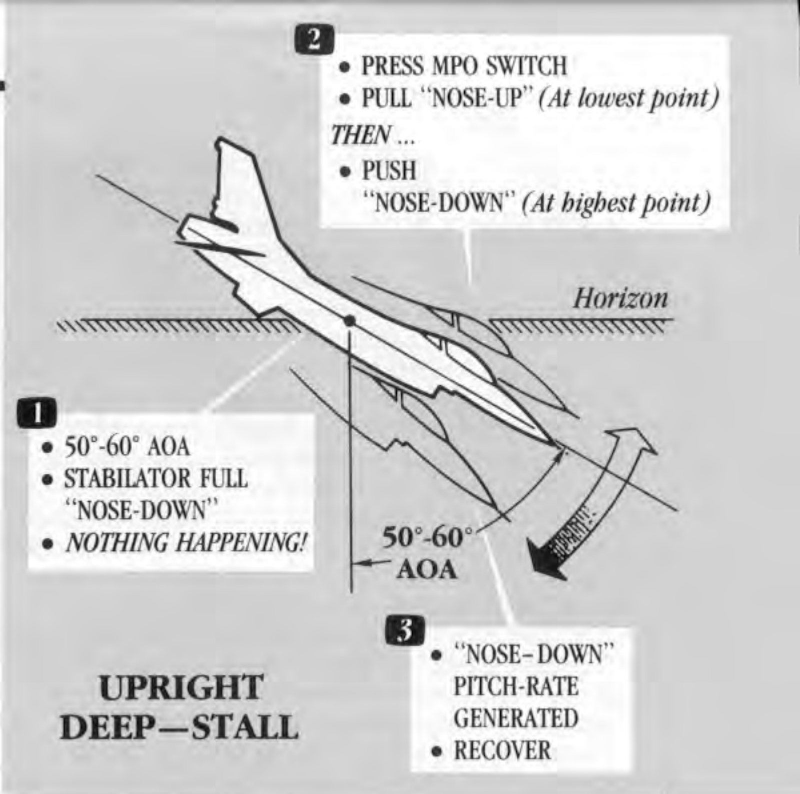
The program's scope continues to increase. The EPAF have incorporated OCU enhancements into their production follow-on buy aircraft beginning in October 1987 and continuing into 1991. Additionally, USAF and EPAF planning calls for OCU retrofit of their F-16A/B Block 10 aircraft. And baseline capabilities, to the extent allowed by USG security regulations, are now part of the common FMS F-16A/B configuration. ■

SEMPER VIPER!

by JOE BILL DRYDEN
Experimental Test Pilot

In the last issue of **Code One**, I left you hanging (pardon the pun) just as we were getting into a "deep stall." You will recall that to that point I had discussed with you just what the flight control system is doing; how you can use different aerodynamics as a result of using this different approach to flight control systems; how your cues in the cockpit are different when you are flying the F-16; and how you can force the F-16 into a departure if you ignore these slightly different cues. I left you with a description of what a departure is and how it is really no big deal. What might happen next is a "deep stall." And a deep stall just might be a "big deal" if you are not able to recognize one and know how to correct your screw-up! What has happened is that there are certain angles of attack (in the 50- to 60-degree range) where the F-16 is essentially neutral in so far as pitching moment is concerned (think of moment as a force). If you can somehow arrive in this 50-60 degree AOA range at zero pitch rate, the F-16 is quite content just to sit there forever. The pitching moment chart printed with this article depicts the contribution of all the forces acting on the F-16 to pitch it nose-down or nose-up. Although the computer is actually moving the surface before you engage the MPO, you can think of the three lines showing what forces would result if you were holding the stick full back, full forward, or not holding the stick at all.

The magnitude of the numbers on the left side is unimportant for the purposes of our discussion. Just follow the two lines that show the sum of the pitch forces acting on the F-16 with the stabilator full nose-up or full nose-down. You can see that in the 50-60 degree AOA area, even though the stabilator is already commanding full nose-down, the pitching moment available to decrease the AOA is essentially zero! Remember that I told you that the "black box" has already taken you out of the loop as soon as it saw an AOA greater than 25 degrees. But you, in all your cleverness, did something to the airplane to end up in the 50-60 degree range with little or no pitch rate. The flight control system is doing its best in commanding full nose-down. It just happens to be in the area where it is unable to do what it would like. It is now up to us to rectify our mistake and do our part to recover the airplane.

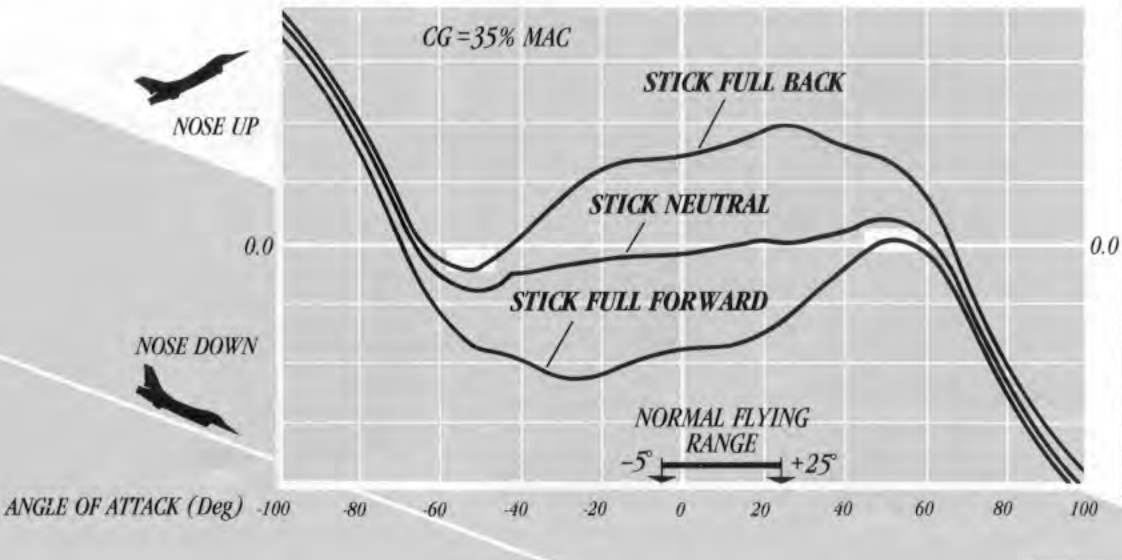


UPRIGHT DEEP—STALL

Look at our pitching moment curve again and notice in the 50-60 degree area that although we cannot command any nose-down moment, we can still command nose-up. How is that going to do us any good when we want to go nose-down? Pay close attention and I'll show you some "black magic" to get around the "black box."

Soooo, everything is trying to go nose-down but nothing is happening; we are going to be very clever and engage the Manual Pitch Override (MPO) and pull nose-up. From the pitching moment curve you can see that in the 50-60 degree range we have the ability to do just that. But why do we want to increase the AOA when everything is screaming to reduce it? If you pay strict attention to the curve you see that we have the ability to increase the AOA above the 50-60 degree range where we were stuck. Notice also that once we get to still higher AOA we have some ability to move the airplane nose-down - if we now command the tail full nose-down. So, if we do push from here, we can generate a nose-

Pitching Moment



down pitching rate. As we approach the 50-60 degree area again the moment will once more go to zero, but the difference now is that we have a pitch rate established that will carry us right through the "deep stall" point and recover the airplane. Whew! Just when you thought all was lost. If you'd been paying attention, you would not have gotten there in the first place. But once you did, you can see that recovery is possible from a less than optimum position.

How do we recognize a deep stall? First of all, we should know where the F-16 is susceptible to a deep stall. But in order to deep stall we must first depart. In order to depart, we must be *slow* (slower than the recommended minimum airspeed maneuvering limits in the dash one). Once we are slow, we must do something foolish - like abruptly pull back stick, or roll rapidly while "snatching" a lot of back stick, or try to "help" the roll rate with a lot of rudder. (The black box will try to fade the amount of rudder we can get under these conditions but we can sometimes fool it here as well.) If you're paying a lot of attention, you'll see a fairly obvious increase in the pitch attitude as the F-16 departs (in other words, the nose goes "up" . . . regardless of the attitude of the airplane at the time). Depending on aircraft configuration, you may then see the nose slice left or right.

Centerline stores make this worse. Centerline stores also tend to make the deep stall more oscillatory in pitch. The F-16 is also not too happy with asymmetry. Something like an ALQ-131 pod at #3 or 7 can make the airplane a potential handfull at the higher angles of attack. There is then a brief period of calm because you've dissipated what airspeed you had going in. From there the F-16 will self-recover or go into a deep stall. If it is going to deep stall, there is a slight but nevertheless characteristic "shudder" as the airplane parks itself in this 50-60 degree AOA region. This shudder is good information, because the F-16 will seldom self-recover after giving you this cue.

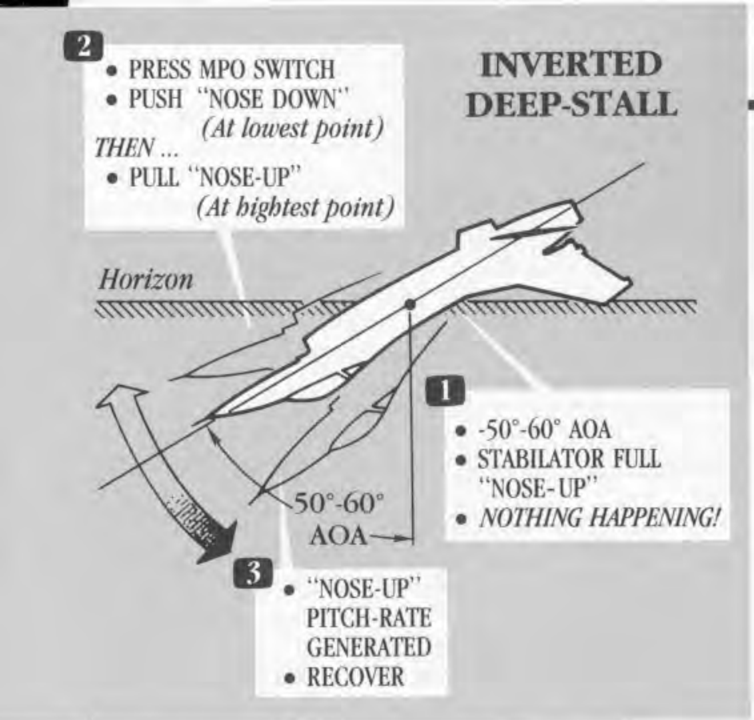
Once you're sure the aircraft is in a deep stall (but don't be too quick, because it will usually self-recover) then it's time to get serious about recovering. The deep stall can be extremely smooth or very oscillatory in nature (in pitch and/or roll). The recovery technique is the same in either case. First, find the MPO switch. (A little practice beforehand when things are more calm would be an excellent idea.) Hold the switch in the override position and pull back on the stick. If you can determine where the nose is, the best time to pull is at the lowest point in the oscillation. If the deep stall is extremely stable (and they sometimes are) then just hold the switch and pull. What you're looking for is an increase in the pitch attitude. You're also getting an increase in the AOA, but since the gauge is pegged you'll be unable to see it on the instruments. Depending on the configuration, you may or may not see an obvious increase in pitch attitude. The AOA is increasing, however, while you're holding back pressure - which is what we're really after. If you can detect an increase in pitch attitude, then push when the nose is at its highest point. If, for whatever reason, you're not sure if you can see any increase in pitch attitude, then you can almost do the recovery by the numbers (but the idea is *not* to be Joe Cool by reaching over, engaging the MPO switch, and then trying to make the stabilator actuator white hot by wildly pumping the stick).

The time required for the aircraft to go through one cycle (nose up to nose down) is very close to three seconds. Now I know it's difficult to establish just how long three seconds is while your body clock is running ten times normal rate, but try real hard. So if all else fails, then (1) find the MPO switch, (2) hold it in the override position (i.e., outboard, left, and/or port), (3) pull back on the stick, (4) count three potatoes, (5) push forward on the stick, and (6) you should be flying again. But you're still at low airspeeds, so all the no-nos that I've already pointed out about snatching on the controls still apply. Be *s-m-o-o-o-o-t-h*.

If you look at the pitch moment chart again you can see both sides are nearly a mirror image of each other. In other words, the aircraft can do the same thing inverted as it can upright (from an aerodynamic standpoint, not a flight control standpoint). So it is also possible to get the F-16 in an inverted deep stall. If, during your upright deep stall recovery, you continue to hold forward pressure as the nose starts down, it is possible to pitch right over on your back and end up in an inverted deep stall. So, as the nose definitely pitches down, and the AOA is off the peg, quit pushing on the stick. If you're really smooth you can even help your condition by adding a *small* amount of back pressure to keep the pitch attitude to a manageable level (something like 60 or 70 degrees nose low instead of nearly vertical, or worse).

I told you that you could pitch over on your back if you go too far with an upright recovery. It is also possible to end up in an inverted deep stall from the original departure (depending on what you were doing just before you departed). How do you tell the difference? Easy. If you can see the ground through the *top* of the canopy, you're inverted. If the cockpit floor is hiding the ground, you're upright. If the AOA gage is pegged at the big number end, you're upright. If it's pegged at the little number end, you're inverted. If you have some small amount of positive g on the airplane, you're upright. If you have some small amount of negative g, you're inverted.

The only difference is this: Remember I told you if you managed to get the F-16 above 29 degrees AOA the black box took you out of the loop, tried to reduce the AOA below 25 degrees, and countered any yaw rate? Well, if you're inverted it does *not* try to counter the yaw rate. It is possible to develop a yaw rate (read "spin") while you're inverted. It's not difficult to stop, however. Look at the ground near the horizon, or look at the turn needle to determine the direction of rotation. Then step on the opposite rudder to stop the rotation. It's important to do this first, because you can't use the MPO effectively until you've stopped the rotation. Usually, the F-16 will self-recover as the rotation stops. If it doesn't, you'll have to pitch-rock the aircraft in a manner similar to what I told you before. From the pitching moment chart you can see nearly an identical point on the inverted side of the chart. If you get to a negative 50-60 degree AOA the same thing happens. The F-16 will stay



there all day. The recovery is nearly the same, except in the other direction. Find the MPO switch, hold it in the override position, push full *forward* on the stick, look for the nose to go down (in this case, towards the sky), or wait your three potatoes, then pull on the stick. The nose should pitch toward the ground, the AOA gauge will come off the negative peg, and you're flying. Remember – be smooth. Help the airplane. Don't keep pulling and pitch it through to an upright deep stall.

I have implied that the airplane will always recover in one cycle. This is very nearly always the case, but there are exceptions. If the deep stall is very oscillatory and you pull out of phase (i.e., the first pull starts as the nose is just starting down instead of being at its lowest point) or you do not hold the stick long enough in either direction, it IS possible that it won't recover the first time. Don't panic. Even if you were out of phase the first time, you most likely have established your own phasing and the next cycle will recover the airplane. Just don't rush the second cycle and it should be a good one (remember the three potatoes). In some configurations with the small tail (or extreme aft CGs with the big tail) we have seen even three or more cycles required - so don't give up too soon. But in just about every case, a single, properly executed pitch cycle will recover from a deep stall. With a nominal 2.5 to 3 g available at 200 KCAS, the F-16 can pull out with some amazingly small altitude losses. *but don't press!* If altitude becomes critical, admit your mistake and *eject.*

I have taken about a million words to tell you how to recover from a situation you should have never gotten into in the first place, so pay close attention to what I told you in the first parts of this series. Learn to detect the subtle cues that the F-16 is putting out. Improve your SA to know when you are slow. Smoothly (this does not necessarily mean slowly) approach the limiters when you're at low airspeed and there is never any reason to depart or deep stall. **PERIOD!** Not even if you find yourself well below the dash one minimum maneuver airspeed limits.

One final, very important fact that is being overlooked. The guys in the F-16 Test Force at Edwards AFB, with the help of the TAC fighter pilots stationed there, have designed an excellent training program to show you first hand what I've been telling you here. All it involves is about three hours of briefing and one sortie to show you what you need to know to sort out this "different" airplane when you want to start maneuvering close to (or even beyond) the limits.

• • • • •

NEXT: The F-16's cockpit. Is it just another place for fighter pilots to sit? Or is it also "different" from other fighter aircraft? Joe Bill Dryden will answer these questions in the next issue.

FURTHERMORE

By P.F. (PHIL) OESTRICHER
Director, Flight Test

Joe Bill's comments reminded me of my first F-16A deep stall. It was extremely stable and entered via a rudder roll (not likely now, due to the "rudder fader" feature). After wandering around for a turn or so in a very slow, upright spin (also unlikely now), the airplane stabilized in a wings-level, fuselage-level, constant heading, MIL power descent - with no buffet, vibration, or noise. It looked just like a cross-country cruise, except for an indicated airspeed just under 100 knots and an altimeter trying to destroy itself at three seconds per thousand feet. I didn't use the MPO as we hadn't invented it yet, but got the desired results from the flight test spin-recovery chute.

On two occasions I've had such an active deep stall in an F-16B that the dutch roll coupled into a pitching motion and the jet self-recovered . . . after 30 seconds and 10,000 feet! Bottom line? Joe Bill is "right on" when he says deep stalls can either be extremely smooth or very oscillatory.

One last thought on deep stall recovery: the recovery really ought to be over the first time the nose points near straight down. When it does, **get off the MPO switch** and do the instinctive thing. Hold the nose there for a few seconds (with whatever pitch command is appropriate) and then start a smooth recovery. Staying on the MPO switch after it's no longer needed generally gets you into the other deep stall.

By STEVE BARTER
Senior Experimental Test Pilot

My experience with MPO cycles in deep stalls has been somewhat different, due to the **unusual** nature of the testing we were doing. This unusual nature consisted of both symmetrical and asymmetrical AMRAAM/AIM-9 loadings combined with aft cg's - and allowing the deep stalls to develop for up to 15 seconds before MPO engagement.

In many cases, of course, we were looking for departures and deep stalls to investigate their characteristics. Specific test maneuvers were accomplished to cause departures including "rating through the limiter." Joe Bill said that we must do something "foolish" to depart. Well, my foolishness was that it was my job to fly these configurations!

Two specific test loadings come to mind for multiple MPO cycles. The first had AMRAAMs at stations 1, 2, 8, and 9 with a fuel tank on the centerline. The second had AMRAAMs at the same stations with two 370s and a centerline ECM pod. Both had the center of gravity controlled to the most aft limit. The first configuration took three properly executed MPO cycles to recover from an upright stall, and the second one took four cycles. The problem was that these deep stalls were very oscillatory about all three axes, which caused the yaw rate limiter to work hard to prevent a spin. A part of the yaw rate limiter includes using the horizontal tails for roll, which reduces their authority in pitch. Therefore, it takes more cycles to generate the proper pitch rate or to "catch it" when the yaw rate is low and cause the recovery. All of this is aggravated by centerline stores - especially the 300-gallon tank.

During some of the F-16 departure/deep-stall testing we decided to wait a while instead of immediately beginning pitch rocking with the MPO when definitely in a deep stall. This was to see if the deep stalls became oscillatory. If so, would they self-recover? And if not, were they more difficult for the pilot to rock out of? The answers were yes, no, and definitely yes, respectively. I flew a configuration with a centerline ALQ-119 pod. About 15 seconds after the departure and eight seconds into the upright deep stall, I began pitch rocking. I would describe the deep stall as moderately oscillatory about all axes. This one took five cycles to recover.

Don't jump to the conclusion that this is a C-model problem. It isn't. It's a function of allowing the motions to develop for a **long** time before using the MPO. The eight seconds was a very long time for me, and none of you should ever wait that long before using the MPO **in a deep stall.** But... **make sure you are really in a deep stall** before using the MPO! If you've confirmed a deep stall (check all your cues) that won't self recover, then use the MPO.

I'll repeat that these were **very unusual** cases/configurations at **grossly aft cg's,** and we intentionally let some deep stalls go well beyond the normal recovery initiation point. Learn from this, observe your cues, and if definitely stuck in a deep stall, use the MPO properly and you will recover.

There's one other thing you probably ought to be made aware of. Since late 1981 there has been a high-AOA training program at the F-16 Combined Test Force at Edwards AFB. Because several of this magazine's articles have been about high AOA topics, I thought you might like to hear what this program is about.

The purpose is to provide continuous and on-going advanced maneuvering training to F-16 CTF pilots. Even though the F-16's high-AOA regime can be described in words, it can't really be mastered without some "hands-on" experience. This program gives that hands-on training and, we feel, makes pilots more effective and generally safer. It strives to make them familiar with maneuvers that can be accomplished (1) without departure, (2) with departure and deep stall characteristics, and (3) with recovery techniques. Specific objectives are:

1. To familiarize F-16 pilots with F-16 flight qualities during high-AOA maneuvering - to include normal maneuvering, self-recovering departures (AOA excursions), and deep stalls.
2. To demonstrate and perform maneuvers that can and cannot result in a deep stall.
3. To demonstrate and practice the proper use of Manual Pitch Override.

The actual training has a ground phase and, of course, a flying phase. The trainee pilot flies in the front cockpit with an experienced high-AOA IP in the rear. The ground phase takes about three hours and includes:

1. A basic discussion of the F-16 flight control system emphasizing the high-AOA features (AOA limiting, yaw rate limiting, rudder fadeout, etc.).
2. F-16 departure characteristics.
3. A study of prior flight test departures.
4. A discussion of departure reasons (cg, pilot technique, aerodynamics, etc.).
5. A discussion of recovery techniques for upright and inverted deep stalls.
6. A review of several "flight characteristics" video tapes.

The flying phase consists of one flight in **any** F-16B (small or big tail) or F-16D, loaded with AIM-9s on stations 1 and 9. Fuel is controlled to arrive at the proper cg for the maneuvers. Initially, various manuevers are flown which will not result in an AOA excursion (above 29 degrees AOA) or a deep stall. These generally include:

1. A one-g deceleration to max AOA.
2. While at max AOA, a one-g max-command, 360-degree roll.
3. From about 250 KCAS while at max g, a max-command, 360-degree roll.

Next, maneuvers are flown which result in AOA excursions above 29 degrees, but the F-16 self-recovers. These are:

1. From a high pitch attitude and slightly below 200 KCAS, roll 180 degrees and **abruptly** pull aft and hold.
2. From the same high attitude and well below 200 KCAS, roll 180 degrees and **gently** apply full aft stick.

Finally, upright and inverted deep stalls are demonstrated with MPO recoveries using the following:

1. From a very high pitch attitude and a very low airspeed, roll 180 degrees and **abruptly** pull full aft.
2. From a high pitch attitude and a very low airspeed **abruptly** roll 360 degrees with **full** flaperon **and** rudder.
3. From a high pitch attitude, hold wings level to **zero** airspeed.
4. From a high pitch attitude hold wings level **inverted** to **zero** airspeed.

As you probably know, many of these maneuvers are not within normal flight manual limits, so don't go experimenting. Even those maneuvers intended to produce deep stalls usually don't - they just self-recover. They are presented here in a general form to give you an idea of the **extremes** we go to for this specific training.

As a high-AOA IP, I have observed highly experienced F-16 pilots who became confused or used incorrect procedures during this training sortie. It happens. Even after a thorough briefing, knowledge of the flight manual, and intentionally departing the airplane. But after observing it first hand and actually having to use the MPO several times in a controlled situation, they were able to "rock out" perfectly. Every pilot I've ever flown with on this sortie has said that this training is invaluable. ■

In a hostile environment, aircraft survivability may well depend on the electronic warfare systems that the aircraft carries - systems designed to confuse or deceive the enemy and his weaponry.

Because enemy weapons and guidance systems are constantly changing, it is necessary to keep pace by making corresponding changes in our EW systems. AFEWES plays a key role in protecting our nation's aircraft by providing data to play this "electronic chess game."

AFEWS

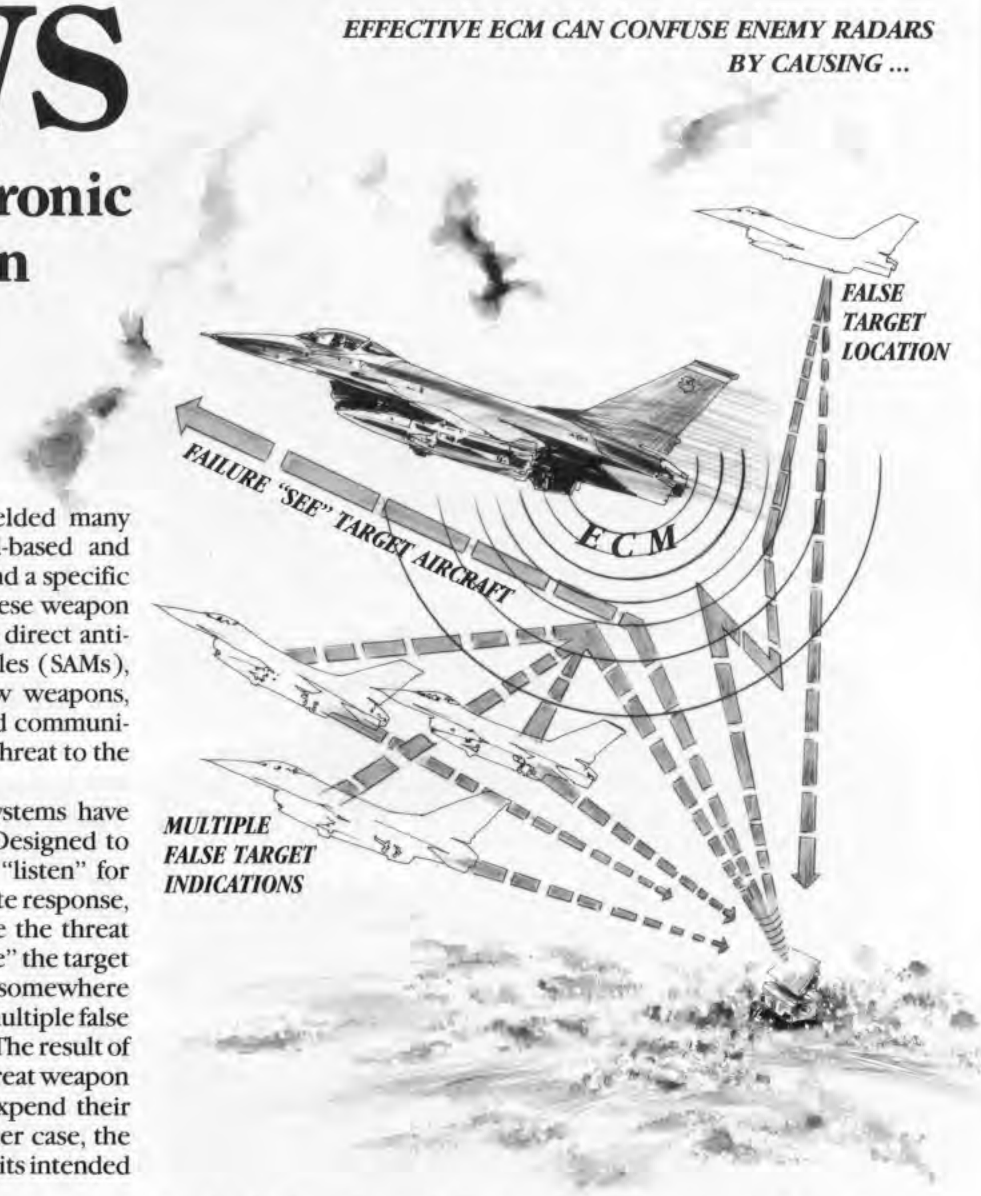
the Air Force Electronic Warfare Evaluation Simulator

by D.R. (DEWEY) TIPTON
AFEWES Project Manager

In recent years, the Soviets have fielded many mobile weapon systems, some land-based and some airborne, each designed to defend a specific portion of the air combat theatre. These weapon systems use radar to acquire targets and to direct anti-aircraft artillery (AAA), surface-to-air missiles (SAMs), and air-to-air missiles (AAMs). These new weapons, linked with modern command, control, and communication (C3) systems, present a formidable threat to the survivability of any penetrating air force.

Electronic countermeasure (ECM) systems have been developed to overcome this threat. Designed to confuse enemy radar, these ECM systems "listen" for threat radar signals, determine an appropriate response, and then transmit counter signals to cause the threat radar to do one of the following: (1) not "see" the target aircraft at all, (2) report the aircraft to be somewhere other than where it really is, or (3) record multiple false targets in addition to the real target aircraft. The result of this "electronic warfare" (EW) is that the threat weapon systems either do not fire at all or they expend their munitions on empty patches of sky. In either case, the ECM-protected aircraft survives to carry out its intended mission.

The importance of quality EW equipment is now universally accepted. Large investments have been made in EW system developments in the past, and even larger investments are planned for the future. But because of the time and expense required to develop EW systems, great care must be taken so that correct technical decisions are made during the design and development phases, and the resulting systems are thoroughly checked out in realistic situations to assure complete and correct operation. For these reasons, the USAF has developed a variety of EW test and evaluation capabilities.



The Air Force Electronic Warfare Evaluation Simulator (AFEWES) is a major USAF test facility operated and maintained by General Dynamics/Fort Worth Division to test and evaluate the effectiveness of proposed EW systems. ECM equipment on all major USAF aircraft typically passes through AFEWES several times (at different development stages) prior to operational deployment. AFEWES is managed by the Aeronautical Systems Division's Electronic Warfare System Program Office (ASD/RWW) through an operating location at Fort Worth, and is also used by the U.S. Army, U.S. Navy, and friendly foreign governments.

AFEWES is a secure laboratory where EW hardware is evaluated in a realistic (but simulated) threat system environment. AFEWES threat simulators are specially designed hardware receivers with simulated antenna patterns and target aircraft. For security purposes, radio frequency (RF) propagation between transmitter and receiver is contained within waveguides and coaxial cables in the laboratory. Signal levels are continually adjusted to simulate the effects of range, aircraft movement, antenna scanning, and other factors appearing in a real-world environment. The threat system operators (General Dynamics employees) work with functionally correct displays and controls, providing real-time responses to the items under test. AFEWES can also simulate ECM systems so that techniques and concepts can be evaluated before new hardware is fabricated.

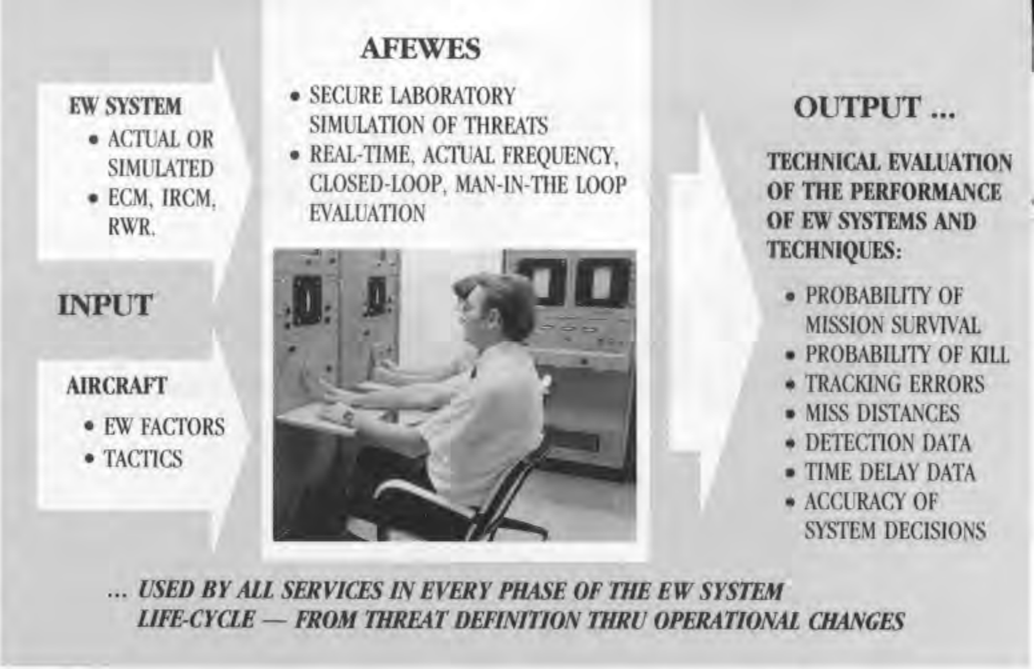

AFEWS SECURE LAB — High quality EW evaluation at a reasonable cost

AFEWES began in 1958 as an outgrowth of the Fort Worth Division's B-58 program. The supersonic Hustler was the first aircraft designed with an internal ECM system. But, because of problems encountered while attempting to flight test this equipment, a radar simulator was conceived. The value of this simulator was quickly recognized within USAF test circles, and contractual arrangements were made to test ECM systems planned for other aircraft.

Since then, numerous AFEWES upgrades (to reflect new technology, incorporate new threat information, and expand into new EW areas) have resulted in an unsurpassed simulation capability. Today, AFEWES has a large array of AAA, SAM, AAM, and C3 threat system simulations against which proposed ECM systems can be evaluated. As a result, most major ECM programs include AFEWES testing as a critical development milestone.

EW testing is also conducted at flight test ranges, such as the one at Eglin AFB, Florida. But while flight testing provides a complete operational environment, AFEWES testing is less expensive and offers many other attributes that make it desirable for evaluating ECM effectiveness:

- **Security** - Since AFEWES emissions are contained within a secured and controlled environment, the customer and the intelligence community do not have to fear compromise of their data. This allows AFEWES to operate simulations in more detail than would be permissible for an outdoor facility, and to test the most sensitive ECM techniques.
- **Repeatability** - The ability to repeat tests under precisely controlled conditions is also a major attribute. In AFEWES, EW encounters can be repeated numerous times under a given set of test conditions, then run again under altered conditions so that alternatives can then be compared and the best equipment settings or techniques selected.
- **Scoring** - At AFEWES, effectiveness is "scored" in terms of tracking error, miss distance, probability of kill, and probability of survival. Tracking error is displayed in real time on strip-chart recordings, and is recorded on magnetic tape for post-test analysis. At the end of each test run, miss-distance data are typed out for all missiles (or projectiles) fired during that run. Kill/survival probability data are calculated post-test using end-game data (the relative position of the missile/projectile as it approaches and passes the target) recorded on magnetic tape.
- **Pre-Fabrication Testing** - The ability to test simulated techniques prior to manufacturing flightworthy hardware means that test items can be evaluated and refined before final design decisions are made . . . and before large sums are spent for fabrication.
- **Instrumentation** - Another AFEWES attribute is the ease of instrumenting test items. AFEWES simulations permit real-time measurements - at any point in the



AFEWES

- SECURE LABORATORY SIMULATION OF THREATS
- REAL-TIME, ACTUAL FREQUENCY, CLOSED-LOOP, MAN-IN-THE LOOP EVALUATION

EW SYSTEM

- ACTUAL OR SIMULATED
- ECM, IRCM, RWR.

INPUT

AIRCRAFT

- EW FACTORS
- TACTICS

OUTPUT ...

TECHNICAL EVALUATION OF THE PERFORMANCE OF EW SYSTEMS AND TECHNIQUES:

- PROBABILITY OF MISSION SURVIVAL
- PROBABILITY OF KILL
- TRACKING ERRORS
- MISS DISTANCES
- DETECTION DATA
- TIME DELAY DATA
- ACCURACY OF SYSTEM DECISIONS

... USED BY ALL SERVICES IN EVERY PHASE OF THE EW SYSTEM LIFE-CYCLE — FROM THREAT DEFINITION THRU OPERATIONAL CHANGES

signal path - to determine the cause of unexpected test results. The effects of induced system degradations can also be readily measured and evaluated.

• **Signal Density** - Lastly, AFEWES can simulate a dense signal environment (over 200 threat signals) either as background for primary threats or as primary signals to test signal processing equipment. The cost and security concerns in building and maintaining this many emitters at a flight test range makes this type of testing impractical for outdoor facilities.

AFEWES' facility resources are continually being expanded and improved to meet the specific test objectives of new technologies and a constantly changing threat environment.

AFEWES hardware resources include:

• **Individual Radar and Threat System Simulators** - Hardware systems, complete with operator consoles and RF receivers, designed to simulate the actual electronic circuitry of specific threat weapon systems so that ECM equipment and techniques can be tested against them. Aircraft interceptor (AI) simulations include a cockpit simulator with a radar display, flight instruments, and a simulated flight control system.

• **The Multiple Emitter Generator (MEG)** - Simultaneously simulates multiple, dynamic radar signals at numerous locations to test EW receiver and signal processors.

• **Communications/Data Link (Comm/DL) Simulator** - Determines RF jamming effects on voice and data link communications.

• **Command, Control, Communication (C3) Elements** - Simulates brigade, battalion, and regimental headquarters' control over AFEWES SAM battery simulations.

• **JammEr Techniques Simulator (JETS)** - Simulates actual or conceptual ECM techniques at RF. JETS is used against AFEWES)simulated radars to evaluate technique effectiveness against specific threats.

• **Infrared (IR) Simulator** - Provides the necessary elements and environment to evaluate IR missile-seeking heads and IR countermeasures (IRCM).

In addition to hardware resources, support is available to plan tests, to process and analyze data, and to use AFEWES-collected and other data in mission models to predict mission success under various alternatives.

The individual radar and threat system simulators are the key elements of the total AFEWES capability. Most of these systems are designed to simulate specific threat systems, using intelligence data input packages (IDIP) supplied by the USAF's Foreign Technology Division (FTD). Simulated radar characteristics are identical to FTD estimates of real-world threat radars in several ways (RF, pulse width, pulse repetition frequency, antenna pattern, bandwidth, minimum discernible signal, and tracking response characteristics). Controls and displays, normally available to the radar operator, are also included to provide one of AFEWES' major advantages - allowing experienced radar operators to interact with a scenario in real time.

Throughout each simulated encounter, the RF signals are scaled in amplitude so that correct RF levels are maintained by the radar receivers and by the ECM equipment being tested. A master computer continuously calculates RF signal amplitudes to account for changes in range, penetrator radar cross-section, scintillation, ECM antenna patterns, threat radar antenna patterns, etc. Radar and ECM antenna pattern data are stored in support computers and recalled as needed for each calculation.

The simulated echo from a penetrating aircraft is combined at the RF level with any ECM signal present, and both signals are applied to the radar mixer. After mixing and amplification, the target's correct jammer-to-signal (J/S) ratio is present in the output of the radar intermediate frequency amplifier.

In addition to generating target aircraft signatures, computers are used to calculate and record data for analysis of ECM effectiveness; e.g., penetrator position, weapon trajectory, theoretical J/S ratios, miss distances, etc. The data can be analyzed as is, or integrated into mission models to evaluate total mission effectiveness.

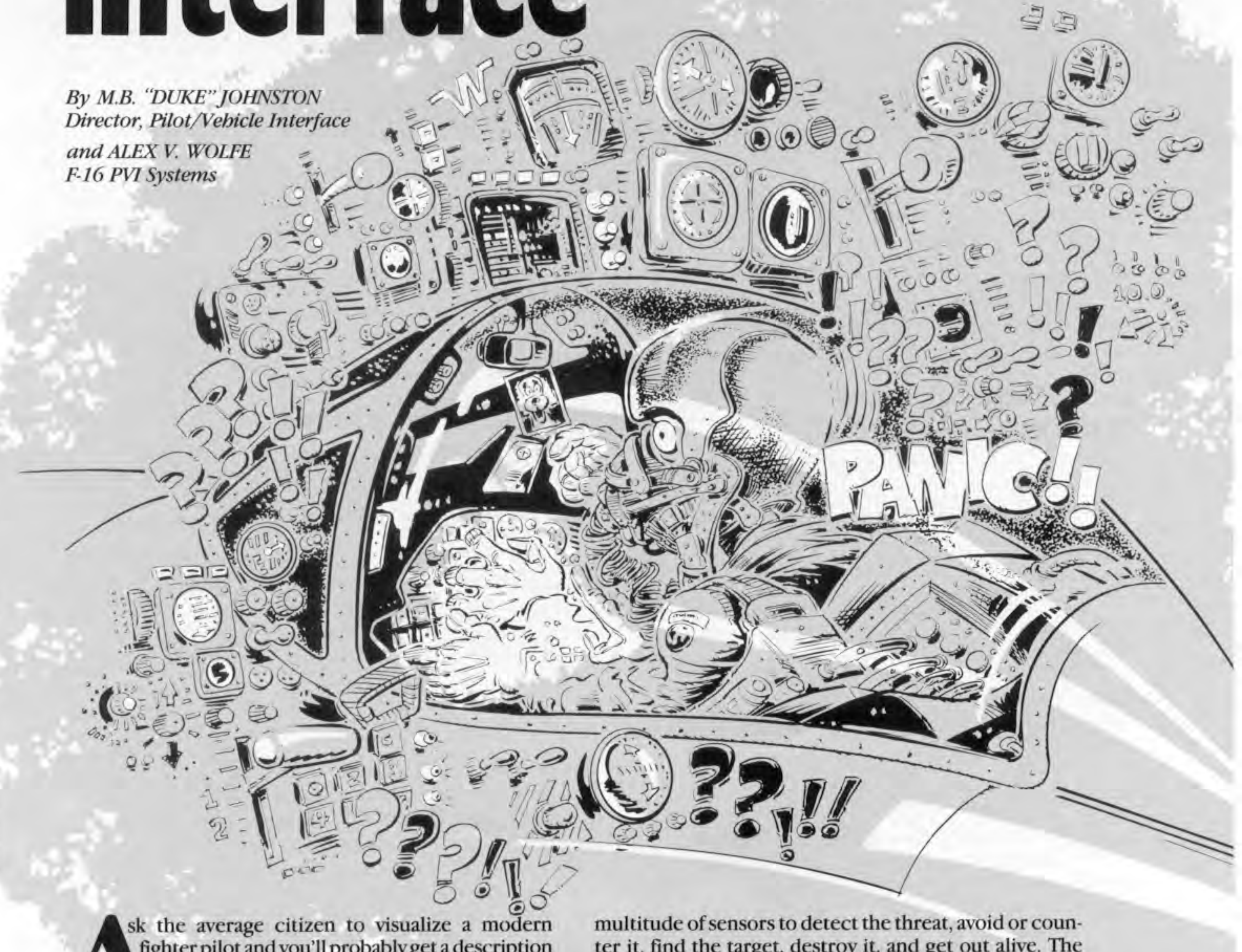
The various threat simulators are available for stand-alone use, or they can be "netted" with other AFEWES simulations; and ECM equipment can also be supplied by JETS or by customer-furnished equipment.

In addition to normal acceptance tests, AFEWES simulators undergo simulator validation (SIMVAL) and correlation testing to assure configuration realism. SIMVAL testing compares AFEWES simulator parameters with IDIP values and is accomplished by the USAF's Foreign Technology Division. Correlation involves the comparison of test results when identical tests are conducted by AFEWES and other test facilities.

Since its beginning in 1958, AFEWES has become the largest, most complete facility of its kind in the free world, providing high-quality EW evaluations at a reasonable cost. General Dynamics is committed to maintaining this system in the future, providing free-world air forces with the ability to fight and survive in the modern, high-threat battlefield environment. ■

Pilot/Vehicle Interface

By M.B. "DUKE" JOHNSTON
Director, Pilot/Vehicle Interface
and ALEX V. WOLFE
F-16 PVI Systems



Ask the average citizen to visualize a modern fighter pilot and you'll probably get a description of Clint Eastwood in a g suit. Over the years, Hollywood has created an image of fighter pilots as devil-may-care risk takers whose only **real** concern is to align the sights and squeeze the trigger. A dangerous and therefore glamorous profession, but hardly the image of a man with an excessive workload. Right?

Wrong! Maybe that image was true at some point in the past, but scratch today's fighter pilot and he'll probably bleed technical data. The complexity of tactical fighter operations must keep pace with the increasing sophistication of threat systems. In an offensive role, today's fighter pilot must penetrate an efficiently integrated air defense system. And he must do so in daylight or darkness and in all types of weather, aided by a multitude of sensors to detect the threat, avoid or counter it, find the target, destroy it, and get out alive. The modern pilot is more than just a flyer - he has become a manager of multiple, complex systems.

Task saturation has become a major concern. To help solve this problem, a new organization called Pilot-Vehicle Interface (PVI) has been established at General Dynamics Fort Worth Division. PVI's primary role is to provide a focal point for developing the best possible cockpit design - a design that accommodates new systems, incorporates new technologies . . . yet one that doesn't overload the pilot in the process. The job is difficult at best and cuts across the entire engineering community.

Cockpit design is not an exact science, but involves numerous pilot-oriented disciplines; e.g., human factors engineering, system design, crew station design, opera-

tional analysis, and hardware/software design. Multidisciplined design teams are exploring evolutionary technologies as cockpit operational concepts grow from paper studies to mockups to design simulations - and ultimately to actual flight tests. And PVI is now an integral part of today's cockpit design process.

Things were not so complicated 70 years ago. At the beginning of World War I, aircraft were used primarily as scout or reconnaissance platforms. Many of these aircraft carried a two-man crew (a pilot to fly the aircraft and an observer to perform reconnaissance duties). The cockpit was very basic - a few instruments (compass, engine tachometer, clock, airspeed indicator, oil pressure gauge, water temp gauge) and a place to sit. With the advent of the forward-firing machine gun, however, aircraft became vulnerable to attack from their six o'clock position. To counter this threat, two-seat aircraft were equipped with a swivel- or ring-mounted machine gun for the rear-seat observer. This countermeasure was effective against airborne threats, but the increased weight and drag lowered the aircraft's speed, climb rate, and maneuverability. Single-seat aircraft enjoyed a consideral advantage in dogfights, and their less-complicated design therefore predominated at the close of World War I.

Prior to and during World War II, the single-seat configuration remained the dominant design for fighter aircraft. Workloads could easily be handled by one pilot, speeds were relatively slow, and flight duration was short. Air-to-surface missions were limited to day, under-the-weather conditions. Defenses were unsophisticated, and airborne radar did not yet exist. Major cockpit functions involved basic flight instruments, a simple weapon system, communication, and engine monitoring. Pilots navigated mentally using time, heading, airspeed, and a map.

Following World War II, however, technology began to change all this. Two major innovations were airborne radar and jet propulsion. Radar would eventually provide all-weather interception of enemy aircraft, all-weather navigation, and blind weapon delivery. The impact of jet power was more immediate. It significantly increased speed and range . . . but compressed reaction time, thereby increasing pilot workload. One solution was to add a second seat. A number of the early jet interceptors had two-seat configurations, but in the early days of jet propulsion, the single-seat configuration still predominated, now in the form of day/night visual weapon systems. Technology for all-weather operations was still limited. The Navy A-6 and Air Force F-111 aircraft were the first systems capable of accurate, safe, all-weather bombing missions, but workload requirements dictated the addition of a second seat.

In the most recent designs, our fighter and ground attack aircraft (F-15, F-16, F-18) have returned to the single-seat concept, mostly owing to advances in computer technology. Avionic systems automation has greatly reduced task saturation in navigation, radar interception, target acquisition, and weapon delivery. But task saturation is still a problem, and a prime PVI consideration is to efficiently integrate new systems into the cockpit design.

An abbreviated look at the evolution of some specific cockpits will show how cockpit philosophy changed as missions became more complex.

The S.E.-5 cockpit is representative of World War I fighter cockpits. The pilot had few if any systems, and the primary instrument was a compass. The air superiority mission was simple - roam the skies, find the enemy, maneuver to a position of advantage, and shoot him down. Ground-to-air threats were of little consequence, and the airplanes did not fly in bad weather.

Of course, the World War II P-51 had far superior performance and firepower, and its air superiority mission was being coupled with an emerging air-to-ground role. The operating envelope was expanded—as was the cockpit design, which now had to handle new system requirements. Oxygen systems, bombing systems, increased emphasis on flight instruments (for weather and night flying) and the demands of higher speed significantly increased pilot workload. Integrating these systems, however, was still the responsibility of the human brain.

The F-86D — a single seat, all-weather interceptor — is representative of Korean War-vintage aircraft. Radar capability was incorporated, but pilots still had to mentally compute intercept geometry. Faster speeds and higher g's increased workload. The cockpit design was oriented around the radar scope, and system integration continued to rely on individual pilot intelligence.

In the F-111, speed, flight duration, mission requirements, and threat detection and avoidance systems all combined to increase workload beyond single-pilot capability. Computer and sensor technology significantly increased mission capability, but system complexity demanded two people in the cockpit. The F-111's mission is to perform night, all-weather bombing. Its terrain-following radar (TFR) allows high-speed flight at very low altitudes to avoid or counter threats while locating and destroying the target.

Cockpit design is complicated by a TFR autopilot, a ground-map radar navigation system to locate the target, and a computer-aided weapon release system. The number of instruments and controls to operate ancillary systems would be staggering for a single pilot.

But newer technologies are simplifying the "advances" brought about by older technologies. The single-seat F-16 is incorporating technologically advanced systems without swamping the pilot who has to operate those systems. A specific design goal of the F-16C was to achieve more capability while controlling pilot workload. Consider the following:

- The radar has eight air-to-air modes and eight air-to-ground modes. And an infrared sensor is capable of displaying visual scenes at night. Enemy threats are detected and defeated with an on-board threat warning

Cockpit photos of the S.E.-5, P-51, and F-86 were provided by the U.S. Air Force Museum, Wright-Patterson Air Force Base, Ohio.

SE-5

P-51

system and hands-on electronic countermeasures. Routine flying chores (instrument flying, comm, nav, IFF, etc.) are all displayed and controlled head up.

- The up-front controls (UFCs) consist of an integrated control panel and a data entry display. This "up-front" arrangement allows quick and easy access - by either hand and without head movement - to communication, navigation, identification, and flight management functions. Priority access to frequently needed controls, plus "smart" features, provide easier, faster operation than the knobs and switches in earlier-generation fighters.
- The head-up display (HUD) provides all essential flight information and weapon aiming cues, so the pilot can keep his head "up" (out of the cockpit). The HUD can also accommodate forward looking infrared (FLIR) imagery for night operations. The FLIR video enables the pilot to navigate and attack targets with visual references at night just as he does in daytime.
- The two multifunction displays (MFDs), located on either side of the up-front panel, provide increased display and bring a large number of system controls within easy reach. With two MFDs and the HUD, a pilot can display three sensors simultaneously and still have two more display formats accessible with a hands-on, single-switch operation. The pilot can program the displays to suit himself.
- The data transfer unit (DTU) allows complete mission data (stores, navigation coordinates, radio frequencies, etc.) to be programmed on a solid-state memory cartridge before flight, then quickly inserted by the pilot during preflight. The cartridge eliminates most of the tedious and time-consuming cockpit data entry, thus reducing the chance of error.

Because of all these new technologies, the single-pilot concept has had a resurgence within the USAF. Despite the complexities of the modern battlefield, the F-16 pilot can fight with a reasonable expectation of accomplishing his mission and surviving in the process. Threat detection and avoidance is a primary cockpit design consideration. Expected threats include (1) radar- and optically-directed AAA, (2) radar, optical, and infrared surface-to-air missiles (SAMs) and (3) look-down/shoot-down airborne interceptors. These threat systems have very low altitude coverage capability and are mobile, thus making mission planning a difficult task. And threat density in future conflicts will probably be the highest ever faced by any attack fighter in the history of air warfare.

Operational contingencies may necessitate mission changes such as routing, target, time-on-target, and fuel usage while airborne. The pilot must be alert for decoys, false radar targets, camouflage, radar and radio jamming, etc. Frequent IFF mode and code changes are required so that friendly forces can be monitored. Airborne communication authentication must be accomplished to verify all instructions as legitimate.

Clint Eastwood in a g suit? Not hardly. To survive this demanding scenario, the man/aircraft must be able to fly and operate at very low altitudes and high speeds, precisely navigate to and from the target, detect and avoid or counter threats, and accurately deliver the specified weapons on time and on target. It's an understatement to say this workload asks a lot from both man and machine. The pilot is truly task saturated!

Practically every system on an airplane culminates in the cockpit. Almost every maintenance action involving a major system - such as flight controls, propulsion, or avionics - ends with a cockpit check-out. Specialists in areas such as cockpit installation, propulsion, flight controls, escape systems, avionic systems, human factors, safety, displays, and other subsystems all have an influence. The traditional approach to cockpit design had each discipline provide its controls and displays independently. This worked successfully until pilot task saturation became overwhelming and cockpits could no longer satisfy growing mission requirements.

Today's cockpit integrator must solve this problem of pilot task saturation, and a PVI organization is one way to accomplish that. Basically, it is an interfacing or integrating organization responsible for tying pilot and machine together. But that's really a simplified way to describe a revolutionary discipline within the Fort Worth Division's engineering community - a discipline that results in a tangible product . . . the total cockpit. PVI coordinates and integrates the various disciplines to produce the desired result - a cockpit environment that is "pilot friendly" even in the most complex mission scenario.

As past issues of *Code One* have shown, simulation is a primary tool in this design effort. Part-task simulations eventually lead to full-mission simulations in a high-fidelity flight simulator. Designs are evaluated, modified, and then reevaluated, etc. until an acceptable configuration emerges.

F-86

F-111

F-16C

Once the engineer's design work is completed, full-mission simulation can be conducted (using operational pilots) to evaluate and refine the cockpit/ mechanization.

The scenarios and pilot tasks are as realistic as possible within the limitations of a simulator. Pilots are required to wear gloves, helmet, oxygen mask, g-suit, flight suit, survival vest, and any other equipment that might be used in flight. A visual scene, such as East Germany, is used. Performance and handling qualities represent the airplane configuration. System performmance and operation are as realistic as possible (e.g., false alarms on the radar, drift in the INS, etc.). To collect data for analysis, the pilot "flies" several tightly structured sorties.

Finally, the pilot flies a simulated combat mission. This mission is structured to force the pilot into a high-workload situation using the system being evaluated. It is basically left up to the individual pilot as to how he accomplishes the mission - how he sets up the cockpit, employs tactics, etc. The routes, time-on-target, weapon loads, etc. are specified in an Air Tasking Order. As the pilot flies the mission, threats are encountered, changes to the plan are transmitted, airplane problems arise, etc. All these situations must be handled without assistance from the test conductor. The primary objective of this combat simulation is to identify design deficiencies and document potential improvements.

Once the deficiencies and suggested improvements are identified, fine tuning can be initiated. The design is now in the final stages. A cockpit review team, co-chaired by General Dynamics and the USAF's System Program Office, is composed of experienced F-16 pilots tasked to review the final design and make recommendations. This team also uses the above-mentioned simulation tools in its evaluation, and team members often participate as evaluation pilots.

Cockpit design has come a long way since the first fighter roamed the skies. With the technology of the 60s, we had reached the point where innovations, for want of an integration scheme, were imposing too much workload for single-pilot operation. The solution has been PVI - to direct the design of workable systems that integrate new technologies and thus reduce pilot workload. Simulation is the major tool to accomplish this task, and the need to communicate operator desires is a dominant consideration. As always, changes and improvements to the process will reform the discipline. But it's safe to say that cockpit design integration - PVI - is here to stay. ■

Age Shall Not Wither,

NOTE: This is the second installment in a series of interviews with some of the greatest fighter pilots of all time.

This interview, conducted in London on May 1982 by Code One's *art director, Bob Cunningham, is with Sir Douglas Bader, Royal Air Force (Retired). After losing both legs in a crash of his fighter aircraft in 1931, Sir Douglas acquired artificial legs, learned to fly with them, and was later credited with 22.5 victories during aerial combat in World War II. In combat over France on August 1, 1941, he had a mid-air collision and was captured. In later years, he was knighted for his work in helping the handicapped.*

Nor The Years Condemn...

the Interview...

CUNNINGHAM: Sir Douglas, how did the aerial warfare of World War II differ from that of the First World War?

BADER: In my day - and in World War I days - you had to do the navigation yourself. You had to see the enemy, you had to get behind him, and then you had to shoot him down. But in World War I, a dogfight was with airplanes flying in small circles at 90 to 100 miles per hour. When World War II started, they said, "No, you'll never do deflection shots at 200 or 300 miles per hour," like the Hurricane and Spitfire did. The fact was, World War II was just like World War I - except that the circles were bigger, that's all. I read every book by McCudden and all these fellows, and I reckoned these chaps knew because they did it. All my fighting and everybody else's subsequently was based on World War I, where the chap who got the surprise and the height had control of the battle, and the bloke who shot best shot them down. And of course the awful thing (I must say this because it always makes me laugh)... In the far-off happy days of World War I, when they staggered off in these aircraft with open cockpits and no guns, they'd have a pop at each other with pistols. And they wouldn't hit each other. And they'd say "Cheers," and go back off to their bases. Then, of course, some shit invented a machine gun that fired forwards, and we started killing each other. There's the trouble. You didn't recognize the bloke, but you saw him. And of course, now . . . now you're being shot by people you never see - by missiles -and it's become too impersonal. But, I mean, everything I did in World War II in the way of being a fighter - attacking another fighter - was based entirely on World War I. Entirely on the McCuddens, the Richthoffens.

CUNNINGHAM: Sir Douglas, which was the better fighter? The Spitfire or the Me109?

BADER: It's a very interesting thing. Naturally, the Spitfire was better. The Spitfire was a stronger airplane than the 109. It would take more g and it wouldn't . . . I mean, it would come flying back. Some of them almost had their fins shot off - or, you know, ammunition boxes knocked clean off, with a hole you could put a body through - and it would still come back. But the 109 was a jolly good airplane. It was smaller, it was initially quicker on the dive, and we were quite sure it wouldn't take the g's the Spitfire would.

CUNNINGHAM: Did you ever do any air-to-ground work?

Wing Commander DOUGLAS BADER - 22.5 Victories

BADER: Oh yes. But the only air-to-ground I ever did was beating up E-boats in the Channel. There was a lull after 1940 - after the Battle of Britain finished - and, we used to go off two at a time. They used to call it peasant shooting, some of the blokes, because the French were on the other side. But we used to go over and look for things, you know. You see, an E-boat was great fun because they used to come through the Channel, escorting or something, and we used to go and give them a squirt and shoot them up, and then they'd go away. It was great fun. But that was the only air-to-ground I've done.

CUNNINGHAM: Does any one combat stand out in your memory over all the others?

BADER: Uh, yes, I suppose it does, really. Now I think probably my first Battle of Britain contact was in August 1940, when I had just 12 airplanes. My squadron. I was leading, and we got the absolute classic one. All the World War I methods were right in my mind. A large formation of German airplanes was coming. We were warned. We had taken off and we were vectored down south. They were coming in from the south and slightly west of south. The sun was over toward the west and, what happened in those days, the chaps in control would vector you . . . in other words, direct you . . . so that you did a straight cut-in like that - mind the angle - which was quite wrong, because you can get all sorts of wrong conditions. And when I heard they were coming and they gave me a vector of 135 degrees, I thought, "Right." And I turned southwest, went up into the sun, and then I saw them. They were coming in from there, and I got up into the sun and they never saw us at all. And we got 'em. Dived straight into them and broke the formation up. It was the absolute classic. I mean, Richthoffen, uh, what's his name, Rickenbacker, Bill McCudden - they would have all approved of that one. And that is one I remember very well, because we got no coaching at all. We knocked down twelve of them, and we didn't get a bullet in any of us. It's always the early one that one thinks of. Really, it was the absolute classic one - classic World War I. All the things had been met: the sun, the height.

CUNNINGHAM: What, in your opinion, was the best of the German fighters?

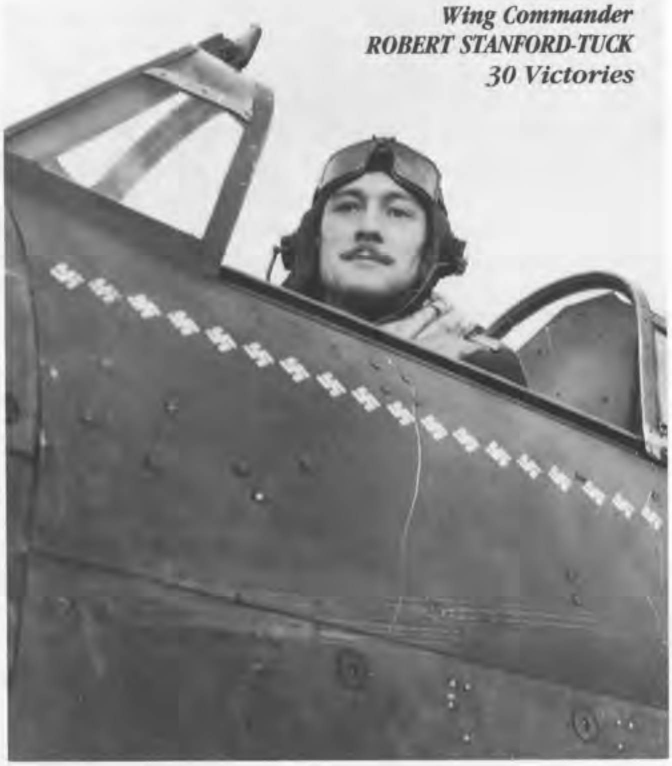
BADER: Well, you see, I have no experience, because I missed the 190. I was shot down in August, '41, and the last I had was their 109Fs with the Spitfire V, and they were just about marginal together, you know. There wasn't much advantage, except we could turn.

CUNNINGHAM: Did you ever engage your friend, Adolf Galland?

BADER: Adolf Galland? He was probably THE great German fighter pilot - and a great leader. He was a great chap. A nice chap, too. And he was a good shot, and everything else. But you see, we knew each other's name on the other side of the Channel, and, uh, it happened that his wing was based in Visont, behind the line on the French coast. We always came in from Tangmere on a course of about 100, 110 degrees - straight over his territory, so his chaps were always up. This happened two or three times a day - I mean everyday for a long while in 1941. We didn't recognize his markings, but we knew it was his lot. We used to exchange bullets every day from May 1941. But, he came to be a friend of mine, Adolf Galland, and we still have arguments about the old days. He comes and stays with me, you know, and he's, uh, he's a very . . . he's acquired a tremendous sense of humor. He's a very dear chap. I'm very fond of him.

Generalleutnant ADOLF ("Dolfo") GALLAND
104 Victories

Wing Commander
ROBERT STANFORD-TUCK
30 Victories



CUNNINGHAM: Did you ever engage anyone in a single combat that you thought might defeat you?

BADER: No.

CUNNINGHAM: How many sorties did you fly a day?

BADER: Oh God, we used to do three or four a day. The Spitfire could take an awfully lot of punishment. I mean, extraordinary. But I think, generally, if you think of some of the bombers that got back, what they'd take if you didn't hit a vital spot. The German Ju.88 took a hell of a lot of punishment, too. I tell you, it was their best airplane. A very strong airplane. You could really fill it with the stuff.

CUNNINGHAM: You were a very good shot yourself, weren't you?

BADER: I don't say I was as good a shot as Bob Tuck *[RAF ace Robert Stanford-Tuck],* but then I was a better pilot. I wish he could hear that. I have told him several times, actually. Sorry he's not here to hear that. The thing was . . . when he was in training he was almost failed, and his instructor at the school said, "For Christ's sake, let's have another go-round and we'll see what we can do." And he managed to pass. But, he was a very good shot. You see, there were those fighter pilots who were bad pilots and good shots, and fighter pilots who were bad shots and good pilots, and a rare combination of good pilots and good shots. My final score was 22-and-a-half, because myself and a friend of mine blew one airplane to pieces, so we had one-half each. That's how that works out.

CUNNINGHAM: In your last combat, where you had your collision - would you give a brief description of that combat?

BADER: Gee, it was my fault really, like all these things. When I lost my legs it was my fault. The thing was, when I turned across, a 109 was on my right. I didn't think he was near enough or would do anything stupid, and my impression was that I hit him. Or he hit me, with his propeller, and took the whole back end of my airplane off, cause when I turned around . . . the airplane went down like that into, uh . . . it just sort of fell down. There was nothing on the stick at all. And when I looked around as far as I could see, there was nothing behind the cockpit. In other words, you would turn and see the fin normally, and I thought, *"The thing's gone!"* Dolpho said I was shot down, but the German Historical Branch . . . nobody can tell me. I then accused Johnny Johnson *[Johnson, who was in Bader's squadron at the time, became the RAF's leading ace of WWII]*. I said, "Well, you probably shot me down. You wanted a promotion, you know." I never to this day . . . you know, a fellow could easily have shot me down, and at very close range with cannons, you know, knocked my back end off. But there it is. The fact was, it doesn't matter how it happened - there it was. I came down in a pretty steep dive, slightly turning to the right, and I pulled the hood off and got out. And having got out I wasn't free. *I was stuck on the outside of the fuselage.* My foot was evidently caught. My right foot had caught in some part of the cockpit. And there I was - hanging along the fuselage outside the airplane, and I couldn't get any further. Because of the buffeting I was really nailed against the airplane. A lot of noise of course. My helmet had come off and so on, and after what seemed like a very long time - it was probably only two seconds - I suddenly broke away from the airplane and pulled the parachute. I had a leather belt which holds this leg on around my waist. There's a bit of spring steel in the first bit, and what had happened, the belt had broken and luckily the leg went off through my trousers. And so I arrived with only one leg. But I arrived.

CUNNINGHAM: Later it was arranged for a spare pair of legs . . .

BADER: Yes. I'll tell you, the exact truth is the Germans came to see me and the fighter pilots, and I said to one who spoke English, "I've lost my right leg. Will you telephone England and have them send me my spare." I have a spare. I have four legs, actually. Two I wear and two spares, you see. And so he said, "Oh yes, we'll do that." And he came back - I think the next morning - and said they'd gotten a message on the International Wave Band asking to send me a leg out and they hadn't heard anything from them (the British). Well, it transpired (I heard this after the war) that they had offered a free flight to land at St. Omer airfield - while I was in the hospital at St. Omer -with my legs and they wouldn't shoot it down. And, uh, our blokes said, "Nonsense. We'll drop it, but not a free ride and all the propaganda they'd get out of that, you know." So they came over in an ordinary bombing raid and one fellow detached himself and dropped the leg at the St. Omer airfield. There's a picture in the book, *Reach for the Sky*. You see the airplane and a box coming down with flak bursting around it, like a land mine, and luckily they didn't hit it. That's how it happened. In the meantime, the Germans *[Adolf Galland's people]* had found this other leg and this fellow brought it in. It was a bit buckled around the foot and so on, and he brought it in and I said, "Look. This is how it works." And he took it back and they repaired it, and they brought it back to me. It made a hell of a noise. But, I mean, I could put it on and walk. And so then I walked out of the hospital and tried to escape, with not a good result. I nearly did. If I had managed to be out for another hour, I think I could have made it.

CUNNINGHAM: What was your favorite method of attack?

BADER: Well, there's only one favorite method with fighter pilots - whether it's a bomber or whatever - and that's to come up from underneath. You've got to get behind for obvious reasons, so he can't see you, and you've got to be slightly underneath because then you have the plan of the airplane, not firing at just a silhouette. And it was the same with anything, whether it was a bomber or you were firing at engines or whatever you were doing. The vulnerability was underneath. Of course the 109 was not particularly difficult to shoot down, depending on how you maneuvered and so on. The pilot was sitting on an L-shaped tank. The petrol tank was the same shape as the seat. Oh, they had armor plating and so on, you know, but I would still keep my cheeks pretty tight if I was sitting on a petrol tank.

CUNNINGHAM: Do you have any advice for a designer of a modern fighter?

BADER: Yes. Build it strong so it won't break. That's all I want the modern fighter to be. That's what they used to say in the war. And give us some maneuverability. That's what you want, really.

CUNNINGHAM: Who, among the other aces, do you have a great deal of respect for?

BADER: Oh, there were some wonderful blokes around. Sailor Malan. He died at an early age after the war from Parkinson's disease. A personal friend of mine. A lovely chap. And Bob Stanford-Tuck. He is still alive I'm glad to say. And there were many of them. Stan Turner was a Canadian. He was with me for a long time. Johnny Johnson. These people, all from the war, have gone on and are doing pretty well, you know. They were all ten years younger than me, and they're all now at the tops of their professions doing jolly well. Oh, the names that one can think of without particularly remembering. Frank Carey is another one. He worked with Rolls-Royce after the war. He was a great pilot. Peter Townsend is in France. Another splendid chap. But, I say, there were so many of them. Many are still alive, and many more dead, which is a sad thing. The wonderful thing about the youngsters who died in World War II that one knew . . . it's not the fact they are dead, but that they went out on the crest when they were 22 years old, 23 years old, or younger, some of them. But they didn't know anything but flying and fighting, which they loved. And what I think, you see, what we say in the ceremony of the service to them, "They shall not grow old as we grow old. Age shall not wither nor the years condemn." One always remembers them as they were. You don't suddenly find some dreary old bum, like myself, who's 72 years old with bags under his eyes and creases all over. That's what we finish up with. But it's such fun to remember them only when they were on the crest. It's a tremendous satisfaction - a feeling actually - that it's all right. That's what I feel about it.

[EDITOR's NOTE: Sir Douglas Bader - Cavalier of the British Empire, Distinguished Service Order, Distinguished Flying Cross - died September 5, 1982.]

When Enough Is Too Much

By D.G. (DONALD) GWYNNE, JR. Aerospace Safety

The F-16 is a great single-engine fighter, and it's not too bad as a glider, when necessary.

The flameout pattern works fine with no thrust. It also works when normal idle thrust is present, so long as about 20 degrees of speed brakes are used. That's how SFOs are flown. But if the thrust levels are significantly higher - due to closed nozzle (EEC off operation), BUC IDLE, stuck throttle, or whatever - then attempting to fly an SFO pattern often gets the pilot into trouble.

The problem and the solution have been recognized for some time. The March 1985 issue of AFISC's *Flying Safety* magazine specifically addressed "returning to land with an engine operating successfully in BUC and then flying an overhead SFO pattern. This has resulted in long, hot landings which have the potential for running off the runway."

If the pilot still elects to attempt an SFO with more than idle thrust levels, the flight manual suggests "controlling descent rate and airspeed with the speed brakes." But if thrust is excessively high or if landing on a runway where stopping distance may be critical, the procedures for "thrust too high for landing" should be considered.

In other words, shut down the engine and make like a glider.

"WHAT!?," he exclaimed, "Shut down the engine before I've gotten onto terra firma?"

Well, consider the pros and cons of intentional shutdown when landing is assured:

PRO
- *Lower landing speed*
- *Shorter rollout distance*
- *Reduced chance of brake fire*
- *Avoids high-speed, departure-end arrestment.*

CON
- *No go-around option*
- *EPU will require servicing.*

Some abnormal high-thrust problems can be cured simply by shutting the EEC off. Don't forget, however, that this still leaves you with an idle thrust level that is higher than normal, closed-loop operations. This is because "EEC off" results in the nozzle remaining closed when the landing gear is lowered, since the idle area reset function resides within the EEC.

If the throttle linkage is jammed or disconnected, the pilot could select BUC. BUC thrust levels for a given throttle position are considerably lower than UFC levels. But if thrust remains too high for a normal landing, the option of shutting the engine down (with the FUEL MASTER switch) when landing is assured should be seriously considered. Remember, with the EPU operating, the HUD flight path marker is still available as a landing aid.

Compare these two mishaps and their outcomes:

1. After his engine did not respond to a throttle reduction, the pilot turned the EEC off, which cleared up the problem. The pilot set up an SFO approach, apparently fearful that the engine might decide to quit, although it seemed to be working fine with the EEC off. With 75 percent RPM set, and with the nozzle closed (EEC OFF), the thrust available was considerably in excess of what he had practiced in previous SFO patterns, even with full speedbrake deflection. The aircraft crossed the fence at more than 220 KIAS, floated halfway down the 8,000-foot runway, then was spiked on at more than 200 knots. A tire blew, the aircraft skidded off the side of the runway, and the pilot decided it was time to leave. The ejection was successful, but the aircraft went through a ditch, turned upside down, and burned. It is likely that simply retarding the throttle below 75 percent would have prevented this mishap. So might have a straight-in approach. But if the throttle had really been stuck, an inflight shutdown to an SFO pattern would probably have saved this aircraft.

2. On four-mile final, pilot retarded the throttle, but the aircraft did not slow down below 200 knots. During the go-around, with the throttle positioned near midrange, the engine went to MIL thrust and would not respond to the throttle. At first, the pilot tried speedbrakes, landing gear, turns, etc. to control speed on final, but this resulted in another go-around. Overhead the field, the pilot turned on the JFS, turned on the EPU, closed the speedbrakes . . . and shut the engine down using the FUEL MASTER switch. A safe landing from an SFO pattern followed.

Every time I hear of someone landing long and fast out of an SFO with excess thrust, it seems they arrive at the departure end at 70 to 100 knots, or more. You say shutting the engine down before touchdown sounds too risky? Have you ever considered the consequences of landing long and fast, then missing the departure end cable for some reason? It won't be fun. ■

GLC, AUTOPILOT, and AIRFRAME OVER-G

By L.F. (LARRY) SMITH
Aerospace Safety

GLC (g-induced loss of consciousness - also known as GLOC) has become a familiar F-16 acronym over the past several years. Many agencies are striving for new ways to either prevent GLC episodes or prevent a "rock kill" if the pilot takes an unscheduled nap.

To prevent the latter, some pilots are resorting to their autopilot ALT HOLD and HDG SEL submodes . . . but there are pitfalls in this.

It's true that these submodes will function at any aircraft attitude and that, with enough altitude and thrust available, they will eventually return the aircraft to a reference altitude and heading. Let's look at a high-g turn and see how the autopilot might function in this manner. Assume that the pilot selects ALT HOLD and HDG SEL while straight and level and depresses the paddle switch. He then rolls into approximately 90 degrees of left bank and achieves 9 g. Shortly thereafter, GLC occurs and, hopefully, the pilot releases the paddle switch. (The altitude at which the paddle switch was released is the reference altitude; the heading under the "captain's bars" is the reference heading.) Since the aircraft was in 90 degrees of left bank when the paddle switch was released, the HDG SEL submode commands a 20 degrees/second roll until 30 degrees of bank is achieved; 30 degrees of bank is maintained until the aircraft heading nears that under the "captain's bars." When GLC occurred and the aft stick input was removed, the nose very likely began to fall. As altitude decreases, ALT HOLD tries to correct. When the altitude error reaches 300 feet low, ALT HOLD commands an incremental one g to return to the reference altitude. Eventually, the aircraft is straight and level. Sounds great, doesn't it?

Well, maybe not. There are a number of significant disadvantages to this use of the autopilot. First, the autopilot has low authority (-.5 to +1 g incremental in pitch; 20 degrees/second in roll). Secondly, at large bank angles (greater than 150 degrees), HDG SEL may command a roll in the longer direction, through inverted to upright, to achieve a 30-degree banked turn towards the "captain's bars." Thirdly, remember that ALT HOLD doesn't care if you're upright or inverted; if you're below the reference altitude, a positive-g command will occur . . . and if the bank angle is greater than 90 degrees, that extra g will be bringing the rocks closer. All three of these characteristics combine such that a significant amount of altitude may be required to recover from even a shallow dive angle. Fourthly, the paddle switch must be continually depressed to avoid undesired autopilot inputs while maneuvering. Finally, if the pilot elects to maneuver with the submodes engaged (paddle switch not depressed) the potential for over-g exists.

So now you're probably asking how a "low authority" autopilot can cause an over-g. It's really very simple; the autopilot commands are put into the system downstream of the limiter. Thus, you can be on the limiter at 9.3 g (yes, you're really flying a 9.3-g machine!), and the ALT HOLD submode can add up to an additional one g if you descend below the reference altitude - and any way you want to slice it, 9.3 + 1 = too much g! Conversely, if you climb above the reference altitude, ALT HOLD will decrease your g command by up to .5 g. This mechanization is why FCF pilots flying 9-g checks with ALT HOLD engaged may get more or less than the g they're looking for.

All of this is not very encouraging, but then, the autopilot wasn't designed to prevent GLC-related mishaps. Flight evaluations at Edwards AFB have substantiated that the autopilot is not particularly suited to this role. As a result of these evaluations, and concern about the potential for over g, a recommendation to use the autopilot as a GLC auto-recovery system has not been endorsed. Work is still progressing on a suitable mechanization for preventing "rock kills" after a GLC. But until such a mechanization is found, concentrating on GLC preventive measures will yield the best results. ■

the fight against LEAKS

By T.E. (TOM) FARRELL
Logistics Engineer

Like any other high-performance military aircraft, the F-16 fights a continual battle against fuel leaks. Over a million flight hours have been logged on the aircraft, providing ample opportunity to establish fuel leak trends, identify major trouble areas, and establish short- and long-term solutions. However, this is the type of problem that cannot be permanently defeated. Fuel leaks will occur throughout the service life of any aircraft. On the plus side, ongoing research and testing efforts should reduce the number of fuel leaks to an absolute minimum.

A number of design techniques are used to reduce fuel leaks in the F-16: (1) the arrangement of tanks for accessibility during manufacture and repair, (2) the use of machined, integrally-stiffened tank boundary members to keep leak points to a minimum, (3) the use of double-row fastener patterns to assure good joint clamping, and (4) the use of tight-fitting fasteners - wherever possible - to reduce fastener leaks.

The primary method used to prevent fuel leaks, however, is the multiple barrier sealing system. In F-16 fuel tank design, multiple fuel barriers are provided at all faying surfaces of the boundary structure which lead to the fuel tank exterior. (A "faying surface" is any area where adjacent structures join or overlap.) The multiple fuel barriers consist of sealed faying surfaces, a sealant groove in the faying surfaces, sealed structural voids, fasteners installed with sealing compound, and fillets of sealing compound over fastener heads and along edges of faying surfaces (on the fuel side) at all accessible tank boundaries. Injection holes are located along the sealing grooves to facilitate the repair of fuel leaks which occur. A fuel leak has to cross a number of barriers to reach the outside world.

Despite the techniques described above, quite a number of fuel leaks do occur and must be classified to determine corrective action. When a fuel leak is discovered, its growth during a six-minute interval is measured. The size of the leak determines its classification: Class A (slow seep), Class B (seep), Class C (heavy seep), or Class D (running leak). Depending on the leak location, each classification has a corresponding repair action which ranges from periodic inspection to grounding the aircraft. Most repairs entail either fastener replacement, fastener retorque, faying surface reseal, or sealant injection.

General Dynamics has had a leak reporting system in place since 1977, through which the field sites provide inputs on leakage. The majority of leaks are reported on a General Dynamics leak report form, prepared by Air Force fuel shop personnel and forwarded by General Dynamics field representatives. The balance are reported on Field Service Reports and Logistics Department Activity Reports. This information is entered in a computer and is used to identify problem areas and fuel leak trends.

Four areas on the F-16 have been identified as the source of most fuel leak problems: the lower surface of the wing, the wing attach fittings, the fuselage upper skin flush screws, and the fuselage blind fasteners in the engine compartment. Each area presents a different problem with a different solution.

LOWER WING SURFACES — The early model F-16s (Blocks 1 and 5) had blind fasteners installed in the lower surface of the wings. After these aircraft had accumulated a number of flight hours, it was discovered that these fasteners were the cause of an inordinate number of fuel leaks. An engineering change, introduced into production on Block 10 and all subsequent aircraft, replaced the blind fasteners with interference-fit Hi-Lok fasteners (C9570). This has effectively eliminated the leak problem for these aircraft. However, earlier aircraft (those manufactured with blind fasteners) are a different story. A retrofit is not possible because the interference-fit Hi-Lok fasteners are of a smaller diameter and have a smaller head size than the blind fasteners. Also, many locations lack sufficient understructure flange-width to accommodate the oversized Hi-Loks. And even if an acceptable replacement fastener were designated, it is doubtful that a retrofit action would be economically feasible because of the size of the task. Each wing would have to be removed, the upper skin removed, all fuel equipment removed, all the lower surface blind fasteners drilled out, all the lower surface holes resized, and the wing reassembled. To further complicate matters, the lower-surface skin is a fracture-critical part and is sure to take some "dings" during this procedure. The entire job is estimated to take approximately 40 working days per aircraft, and might cost more than new wings. In addition, the repaired wings -because of previously accrued flight hours - would have a much shorter life-span than new wings. Presently, the only viable fix is to replace the offending blind fasteners with others of their kind. Needless to say, this remains an area of high concern.

WING ATTACH FITTINGS — This fuel leak problem area has been eliminated for aircraft on the assembly line, and a solution to correct the problem in previously fielded airplanes is in work. The leak problem is created by improper grip length on the wing attach fitting bolts. A bolt grip-length gauge has been developed to insure that bolts of proper grip length are installed in the wing attach fittings. This gauge has been used - with excellent results - in production of all aircraft delivered after November 1983. For field use, the gauge is designated Support Equipment Requirements Data (SERD) 11726. It will be a local fabrication tool, but presently does not have a contract; therefore, the SERD is on hold. Contract negotiations are being conducted at the present time (May 1986) and it is believed the bolt grip-length gauges will see field delivery beginning in late 1988. Following delivery of these gauges, major fuel leak problems in the wing attach fittings should be a thing of the past.

FUSELAGE UPPER SKIN FLUSH SCREWS — The fuselage upper skin flush screws have been a major contributor to fuel leak problems. Eighteen months of testing have revealed that screw loosening/leaking is caused by the production use of nuts with an excessively high locking torque. The specification requires an 18 inch-pound locking torque to prevent the nut from backing off. However, a survey found that some nuts required a locking torque as high as 35 inch-pounds before the self-locking feature would engage. Action has been taken to locate and eliminate the discrepant nuts in production. The applicable technical orders have been updated with procedures to insure that the proper locking torque is applied, and it has been recommended to the field to discard the old screw and nut and install new ones when repairing a leak. These changes have effectively corrected the fuel leak problem in this area.

FUSELAGE BLIND FASTENERS — The final major problem area is leaks at fuselage blind fasteners. Blind fasteners were used on fuselage fuel tanks on Blocks 1 and 5. Block 10 and all subsequent aircraft have crimp pins and nuts. The crimp pins and nuts have not demonstrated a leak tendency and appear to have solved this problem for aircraft equipped with them. For earlier aircraft, the field has been advised to replace the blind fasteners, on a one-for-one basis, with crimp pins and nuts - provided proper clearance for the nut is available on the internal structure. A large number have been modified by depot, but structural difficulties prevent this action on some early aircraft. In general, however, the problem in this area has been solved.

FUTURE FUEL LEAK SOLUTION: ADHESIVE SEALING — Future F-16s are expected to have far fewer fuel leaks as a result of a new method of fuel tank sealing. Adhesive sealing for F-16 fuel tanks has been authorized for the center and aft fuselage fuel tanks on Block 30 aircraft. A significant improvement in fuel tank sealing and significant improvements in aircraft maintenance through the reduction or elimination of fuel leaks should result. This method has been previously used with outstanding success on the F-102, F-106, CV-880, and CV-990 aircraft programs. An F-16 test aircraft - equipped with adhesively sealed fuselage fuel tanks - has flown over 1100 hours with only four slight "stain" leaks at flush screws. These results, along with the success of the previous programs, promise a considerable reduction in fuel leaks for Block 30 aircraft. This method may also be extended to the wings in the near future. An F-16 test aircraft, fitted with an adhesively sealed left wing, has flown over 150 hours without a fuel leak. Wing adhesive sealing may be incorporated into production.

The F-16 fuel leak problem areas which have been identified have either been solved or are in the process of being solved. The key to prompt action is the recognition of a problem's existence. The only way that can happen is by diligent reporting of all fuel leaks so that trends and tendencies can be pinpointed. When new problems arise, new solutions will be found. Fuel leaks aren't going to be eliminated, but the future definitely looks good. ■

COLD PROOF TEST

By C.S. (CHARLES) BOGLE
F-111 Program Manager

To verify the structural integrity of critical components, F-111s are chilled to minus 40 degrees while the wings are subjected to a simulated 7.33 g.

A General Dynamics Fort Worth Division team recently completed a major refurbishment of the F-111 Cold Proof Test Station at McClellan AFB, California. This modernized facility will be used by the U.S. Air Force's Sacramento Air Logistics Center (SMALC) to perform structural testing on the USAF fleet of F-111 aircraft.

This fleet-wide, non-destructive test program will be the third conducted since F-111s were first delivered to the USAF in the 1960s. The test will reconfirm the structural integrity of the F-111 as it continues a USAF service life that is predicted to extend beyond the year 2010. This unique procedure makes the F-111 one of the most thoroughly tested aircraft in the world.

These cold-proof structural tests have been conducted to date on all F-111 aircraft at 1,000 to 2,500 flight-hour intervals. This third series of tests will be conducted at intervals of from 3,000 to 5,000 flight hours, depending on the particular model of F-111 aircraft. It takes several years to cycle the entire fleet through the tests, since this test is conducted as a part of the planned depot-level maintenance.

To simulate critical positive- and negative-load maneuvers on the F-111's repositionable wings, four test conditions are imposed at two different angles of wing sweep. The maximum positive load condition of 7.33 g (7.33 times the force of gravity) results in the wings being deflected over six feet at the tips.

The structural loading tests, conducted at minus 40 degrees Fahrenheit, verify the integrity of the high-strength D6AC steel alloy used in the wing carry-through box, wing pivot fittings, and certain fuselage bulkheads. Fatigue cracks of a detectable length are identified by non-destructive test (NDT) techniques prior to the load tests. The critical crack length is significantly smaller for the steel alloy at the sub-freezing temperatures imposed during test loading. If the cracks are too small to be identified by NDT and are of a critical length, they are detected by failure of the part under test load. This is a potentially lifesaving measure, because any part that fails during the test might eventually have failed in flight.

The McClellan test facility was originally constructed by General Dynamics in 1970, along with other facilities at Fort Worth and Waco, Texas. (The Fort Worth and Waco facilities were deactivated in the early 1970s.) The California facility was modified by General Dynamics in 1973 to add expanded test conditions prior to the second fleet-wide test program. Over the life of the facility much of its original equipment has become obsolete.

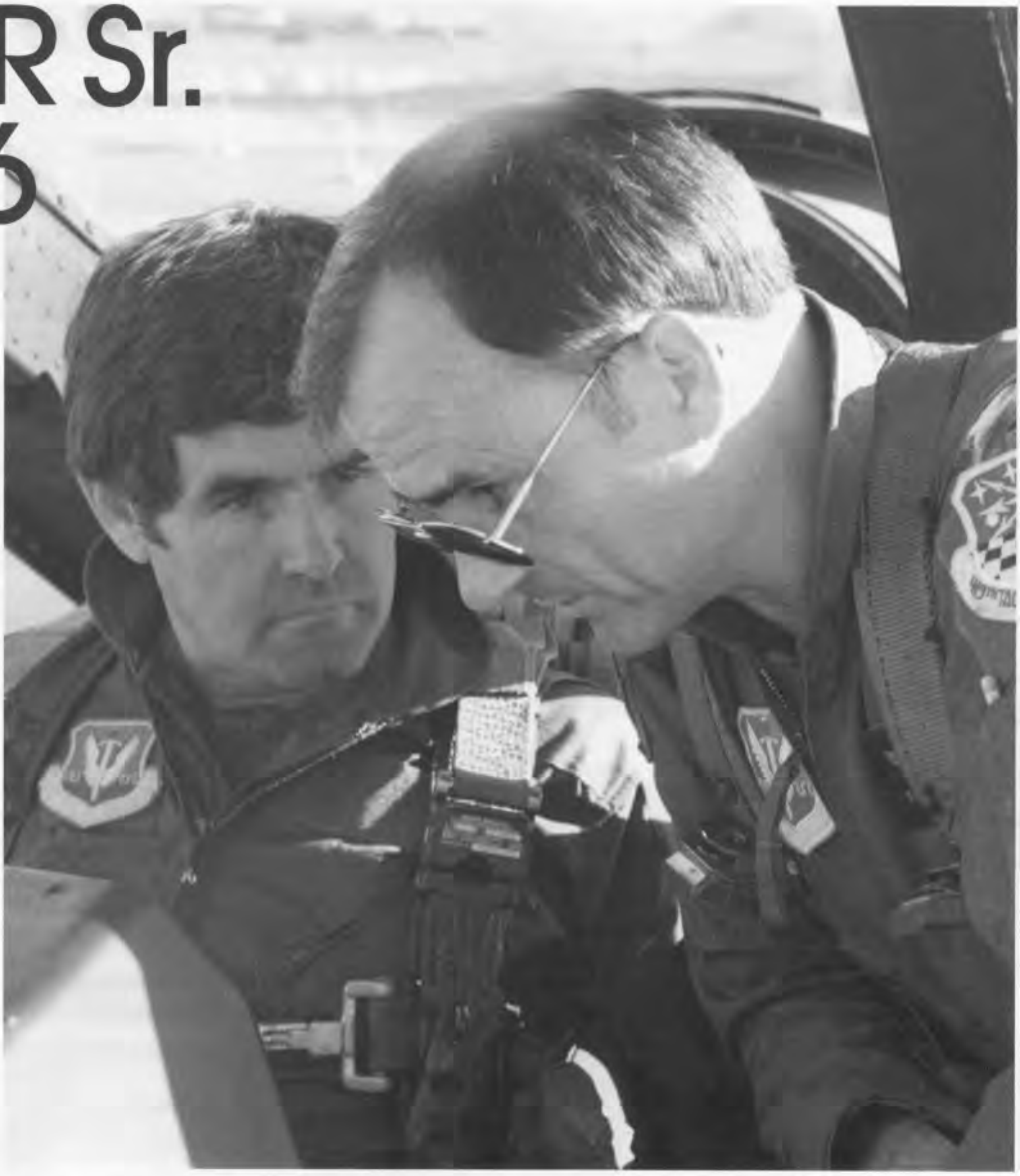
The test portion of the modernized facility consists of an environmental test chamber, a control room, and associated systems (hydraulic, pneumatic, load control and data, safety, and environmental). A computer is used to control the test loading conditions and gather data. Structural loads are applied to the aircraft wings with hydraulic actuators or rams. The low temperatures are produced with a liquid nitrogen air chilling system.

The Fort Worth Division's refurbishment contract, awarded in June 1985 by SMALC, covers all design, construction, equipping, integration, and demonstration of the testing portion of the facility. In addition, the Fort Worth Division will continue to support the program with training, maintenance, and technical publications support through mid-1987. The Sacramento Air Logistics Center was responsible for renovation of the building that contains the Cold Proof Test Systems.

A similar cold proof facility, to test USAFE F-111 aircraft assigned to support NATO, is being built at Filton, England, by British Aerospace Company. This testing in England is a part of the F-111 depot-level maintenance contracted by the U.S. government. By accomplishing these maintenance tasks in England, considerable expense is avoided that would otherwise be associated with the return of the aircraft to McClellan AFB, California. General Dynamics, British Aerospace, and Sacramento ALC have been working closely together to insure equivalent testing at both facilities. ■

AL UNSER Sr. Gets F-16 Ride

— official USAF News Release



Three-time Indianapolis 500 champion Al Unser Sr., left, listens intently to the safety instructions of Colonel Bane Lyle before Unser's orientation flight in an F-16B Fighting Falcon at Hill Air Force Base, Utah. Col. Lyle, 419th Tactical Fighter Wing Director of Operations, flew Unser in the fighter as part of a series of public service announcements Unser filmed for the Air Force Reserve at Hill. (USAF Photo by Capt. Tony Epifano)

Al Unser Sr. was grinning from ear to ear as he walked into the room.

"That was really neat," he said. The three-time winner of the Indianapolis 500 stood there looking at the helmet he was holding and chuckling contentedly. He had just finished the ride of his life. An auto racer's dream. High speed and unsurpassed maneuverability combined in one machine.

But **this** machine was no earthbound racer. It was a General Dynamics F-16 Fighting Falcon belonging to the Air Force Reserve's 419th Tactical Fighter Wing at Hill Air Force Base, Utah. The 419th had recently won "Gunsmoke," the USAF's worldwide air-to-ground gunnery competition.

Unser had just returned from a stirring, 45-minute orientation flight as part of a series of public service announcements the famous auto racer was doing for the Air Force Reserve.

"I've always wanted to do this (fly in a high-performance fighter)," the senior Unser said. "Very few people get to attempt this. I wanted to do it."

Unser said he has driven some racers at speeds up to 250 mph. During his F-16 ride he topped Mach 1 (over 700 mph). Besides the uncommon speed, Unser felt the tug of powerful gravitational forces as the aircraft was put through its paces.

"I've pulled g's before," he said, "but nothing that great. Not that strength. G-loads you can feel are really an experience. I couldn't even hold my head up."

Col. Bane Lyle, the 419th's Deputy Commander for Operations and one of the best fighter pilots in the Air Force (he finished second in competition for Top Gun honors at Gunsmoke '85) flew the mission. After takeoff, Col. Lyle put the F-16 through a six-g vertical climb to 16,000 feet, then made a Mach 1.2 run at 300 feet over Hill's gunnery range, skipped over some hills, and flew over the Bonneville Salt Flats. After executing a nine-g turn, Col. Lyle let Unser get the feel of the aircraft.

"When I first started flying it I was a little nervous," Unser admitted. "I grabbed the handle like I would kill it!"

At the flight's termination, Col. Lyle demonstrated a simulated flameout landing, but by that point nothing could faze Unser, who said the flight had ended much too quickly. "I would have liked to have stayed up there. I really enjoyed it. It was neat."

As he said in his commercial for the Air Force Reserve, "If I had this engine in my car, Al Jr. (Unser's son -also a champion racer) would never beat me to the checkered flag." ■

Kelley AFB Gets F-16

The Texas Air National Guard's 149th's Tactical Fighter Group officially accepted its first F-16 in a recent ceremony at Kelly AFB in San Antonio. The unit is the first to fly the Fighting Falcon in the state where it is manufactured.

The initial aircraft was taxied to the ceremony area by Col. Clifton Clark, Commander of the 50th Tactical Fighter Wing at Hahn Air Base, West Germany. The F-16s assigned to the Texas ANG were based at Hahn before the 50th TFW began its conversion to F-16C/Ds.

In accordance with tradition, Col. Gary R. Walston, Commander of the 149th TFG, accepted the aircraft's transfer papers from Col. Clark.

"The receipt of this high-technology, high-performance, front-line fighter is a clear demonstration of the broad support we receive from the Air Force and the heavy reliance our country places on the Air National Guard," Col. Walston said. "The acceptance of the Fighting Falcon marks a most significant event in the 149th's 40-year history."

Maj. Gen. Robert W. McDonald, Commander of the Texas Air National Guard, and Maj. Gen. Oly Logan, the USAF Tactical Air Command's Air National Guard advisor, participated in the ceremony.

An F-16 air show, flown by Maj. Ron Oholendt of the 311th Tactical Fighter Training Squadron at Luke AFB, Ariz., was one of the highlights of the event. An F-4 flyby was also performed, commemorating the 149th TFG's previous aircraft. ■

USAF Receives F-16 No. 1000

The U.S. Air Force recently took delivery of its 1,000th F-16 multimission fighter. The milestone aircraft marks the 1,572nd Fighting Falcon delivered to 10 air forces worldwide since the first F-16 rolled off the line in August 1978.

Of the worldwide production total, 1,178 have been delivered from Fort Worth, 216 from the Fokker plant in The Netherlands, and 178 from SABCA near Brussels, Belgium.

The USAF's 1,000th Fighting Falcon, a single-seat F-16C, is a truly multinational product. Among its major components are a forward fuselage section built in Fort Worth, a center fuselage section built by Fokker, and an aft fuselage section built by SONACA in Belgium. The aircraft's left wing was produced by SABCA, and the right wing by Israel Aircraft Industries.

The aircraft has been assigned to the USAF's 86th Tactical Fighter Wing at Ramstein Air Base, West Germany.

The USAF currently has 1,859 F-16s on order and is planning to procure a total of 3,047 of the maneuverable, single-engine fighters through the mid-1990s to modernize its active forces, the Air Force Reserve, and the Air National Guard.

Ten air forces are currently flying the Fighting Falcon, and orders have additionally been placed by the U.S. Navy and four foreign nations. ■

First F-16 Block 30 Is Delivered

General Dynamics Fort Worth Division recently marked a new milestone in the F-16 Multinational Staged Improvement Program with delivery of the first production Block 30 F-16C to the U.S. Air Force.

Block 30 is the latest F-16 configuration. Incorporated changes include an engine bay designed to accommodate either of the alternate F-16 engines, adhesively sealed center and aft fuselage fuel tanks, and avionics hardware and software enhancements.

F-16C No. 178, assigned to the USAF's 86th Tactical Fighter Wing at Ramstein Air Base, West Germany, is also the first production Fighting Falcon equipped with a General Electric F110 engine. The F110, an augmented turbofan in the 27,000-pound thrust class, is an alternate F-16 power plant to the Pratt & Whitney F100.

With minor adjustments, the new engine bay will accommodate either engine. Some F-16s are now being delivered in an upgraded, higher-thrust version of the F100, designated the F100-PW-220. The original F100 engine is in the 25,000-pound thrust class.

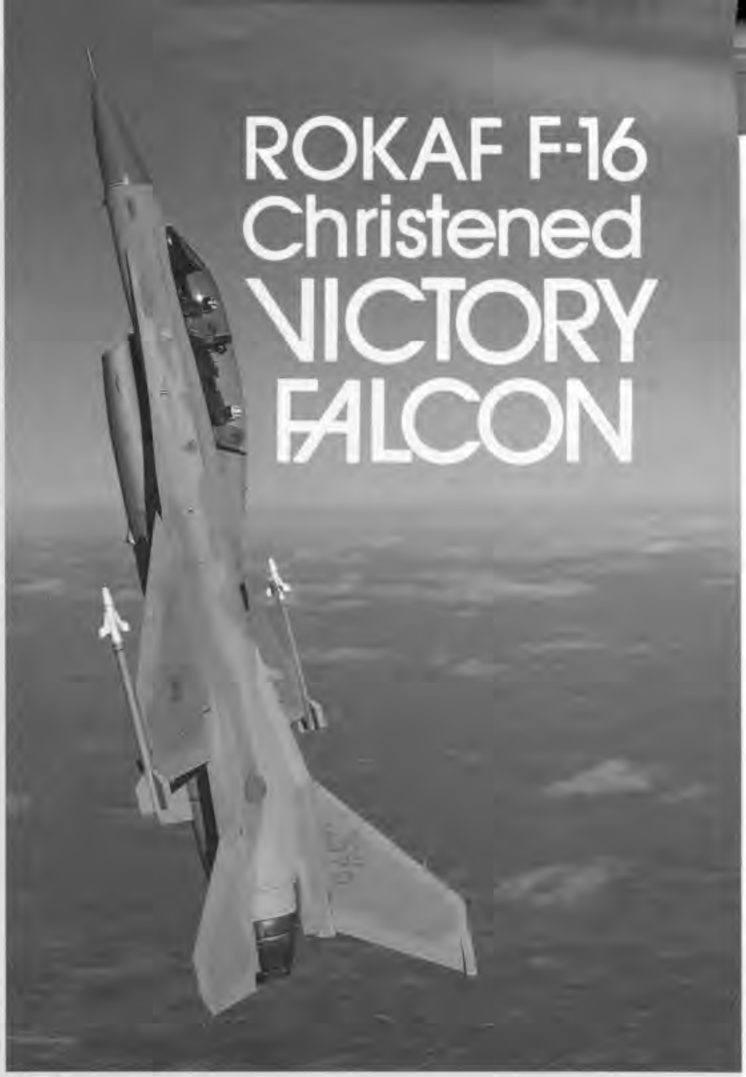
The introduction of adhesively sealed fuel tanks is a major change, and is expected to substantially reduce F-16 life-cycle costs through lower tank maintenance. Adhesively sealed tanks also provide a significant weight savings and are expected to lower production costs, since adhesive sealant is less labor-intensive to apply than conventional polysulfide sealant.

All F-16C/Ds - from Block 30 on - will be delivered with adhesively sealed center and aft tanks. Additionally, the USAF is evaluating a proposal to seal F-16 lower wing skins with adhesive film and is considering a requirement for adhesive tank sealing in future aircraft production.

The avionics hardware changes introduced with Block 30 include expanded-memory for the Programmable Display Generator and the Data Entry Electronics Unit. This expanded memory will provide growth capabilities in later aircraft block versions. Other hardware changes involve wiring provisions for future systems, such as the Airborne Self-Protection Jammer.

Several incremental changes in the basic Block 30 configuration will be introduced with aircraft delivered over the next three years. Block 30B will include new equipment associated with the Advanced Medium Range Air to Air Missile (AMRAAM), and Block 30C will mark the first USAF aircraft delivered with the upgraded F100 engine. Block 30D, late in 1987, will be the first aircraft delivered with a modular common inlet duct (a larger inlet designed to complement both new engines).

Block 40 - the next major production configuration change - will occur in 1988 and will incorporate low-altitude and targeting infrared for night (LANTIRN), the global positioning system (GPS), and other advanced capabilities. ■



ROKAF F-16 Christened VICTORY FALCON

By D.W. (Don) Jones
Korean F-16 Program Manager

The President of the Republic of Korea formally christened the ROKAF F-16 as the "Victory Falcon" during ceremonies in Korea on Friday, 27 June. In his address, President Chun Doo Hwan called the F-16 "the favorite of modern science and technology," and said the modern fighter "enjoys foremost performance and fire power."

Following flight demonstrations by ROKAF and USAF F-16s, the President walked to one of the two ROKAF F-16s on static display, removed a white nylon cover from the forward fuselage, and formally christened it the "Pilsung Poramae" (Victory Falcon). ROKAF Chief of Staff General Kim, In Ki then escorted the President on an inspection tour which included a cockpit briefing by the 161st TFS Commander.

The ceremony was attended by several high-ranking Korean government and military officials, including the Defense Minister and the Chairman of the National Defense Committee. U.S. attendees at the event included the U.S. Ambassador to the Republic of Korea, the Commander of the 314th Air Division, and the Chief of JUSMAG.

The ceremony was covered by both Korean television networks and was a front page story in all the major Korean newspapers. Korean television supplemented their coverage with F-16 file footage.

President Chun was reportedly pleased with the event and expressed pride in having the F-16 in Korea. ■

Photo by SSgt. Dave Noland, Det. 3, 1367th AVS.

Accepting the trophy for USAFE's Loadeo '86 are (l-r) Col. Clifton Clark, Commander, 50th TFW; DCM Col. R.E. Pasieczny; and CMSgt Richard A. Thomas.

F-16 Unit wins Loadeo Competition

Top honors at the 1986 USAFE Munitions competition were shared by the 50th Tactical Fighter Wing and the 52nd Tactical Fighter Wing.

"Loadeo" - the integrated combat turnaround (ICT) portion of the competition - was won by the 50th TFW, an F-16 unit from Hahn Air Base, West Germany. But the 50th narrowly missed a dual victory in the two-sided competition when they were upset in the combat ammunition production (CAP) event by the 52nd TFW, an F-4 unit from Spangdahlem AB, West Germany.

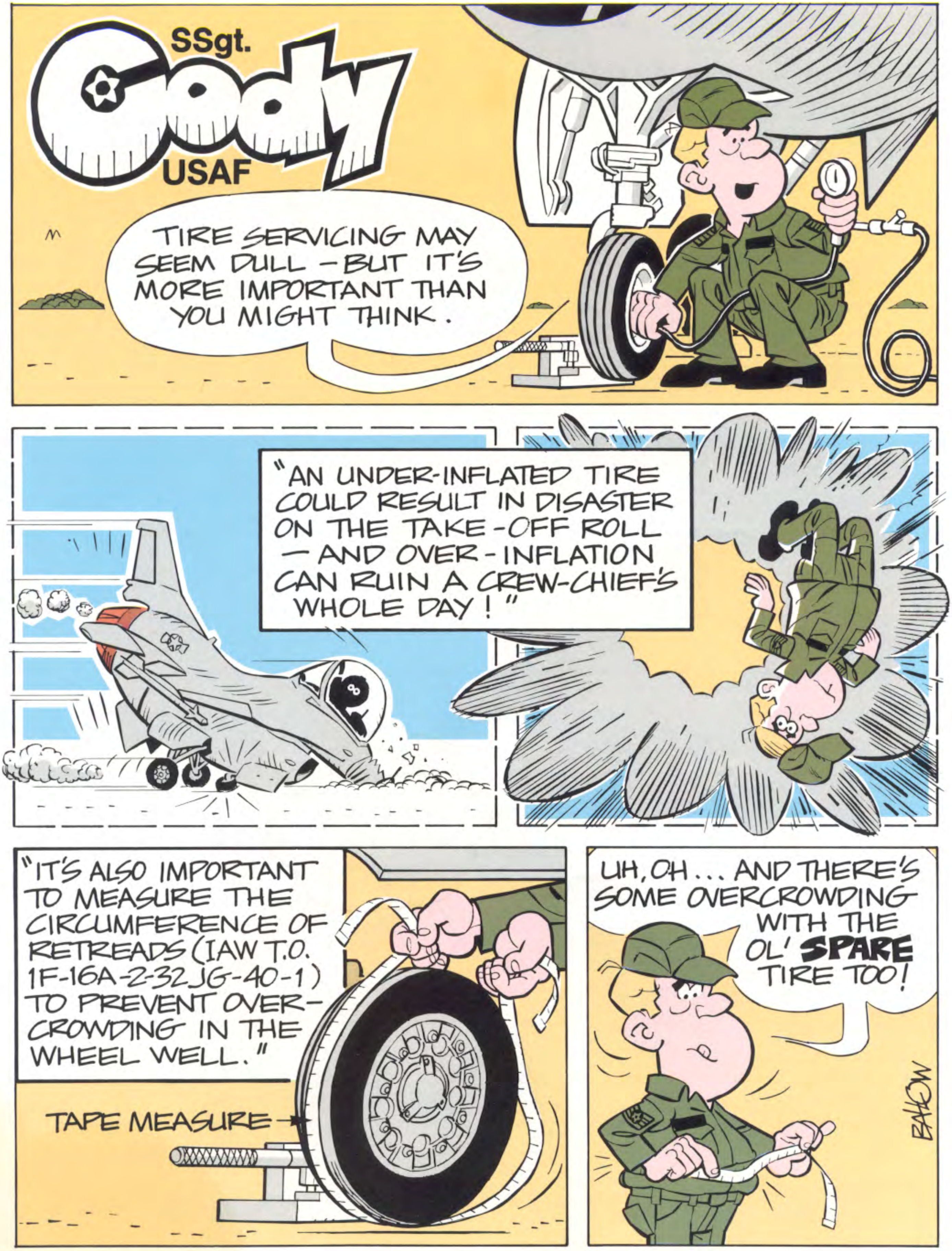
The 50th enjoyed a 100-point lead in the CAP competition until the 52nd made a comeback in the academics category to edge the Hahn team by 10 points and take the CAP title.

This marked the first year that CAP events were a part of the loadeo competition. And the annual event's name was accordingly changed from "Loadeo" to "Munitions."

In Loadeo, the 50th won the air-to-ground category and did well enough in the other categories to win the overall Loadeo title. However, what appeared to be a clean sweep of the entire 1986 USAFE Munitions competition was thwarted on the final day when the 50th TFW turned in an outstanding academic score to overcome the 50th's 100-point lead. The 52nd finished with 13,780 points to edge the 50th by a mere 10 points.

In other areas of the competition:

- The 401st TFW, an F-16 unit from Torrejon AB, Spain, won the Loadeo Academic Excellence award and placed third in the overall Loadeo competition.
- The 20th TFW, an F-111E unit from RAF Upper Heyford, England, took the Academic Excellence Award in the CAP competition.
- The 50th TFW, while finishing second in the CAP overall, won the Munitions Breakout category and shared top honors in the Tools and Equipment Inspection category with the 81st TFW, an A-10 unit from RAF Bentwaters, England (both units had perfect scores).


SSgt. Cody USAF
TIRE SERVICING MAY SEEM DULL – BUT IT'S MORE IMPORTANT THAN YOU MIGHT THINK.
"AN UNDER-INFLATED TIRE COULD RESULT IN DISASTER ON THE TAKE-OFF ROLL – AND OVER-INFLATION CAN RUIN A CREW-CHIEF'S WHOLE DAY!"
"IT'S ALSO IMPORTANT TO MEASURE THE CIRCUMFERENCE OF RETREADS (IAW T.O. 1F-16A-2-32JG-40-1) TO PREVENT OVERCROWDING IN THE WHEEL WELL."
TAPE MEASURE
UH, OH ... AND THERE'S SOME OVERCROWDING WITH THE OL' **SPARE** TIRE TOO!
BAHOW

Honoring a great lady . . . 1886-1986

The Light Still Shines