Tucson observes forty years. See story on page 10
"The missile comes off with a lot of punch. It actually rocks the airplane," explains Lt. Tim Sundvall of his first live firing of an AGM-88 High-speed Antiradiation Missile. The HARM took off from the rail of his F-16 the day before and hit a radar target on the desert floor of the Utah Test and Training Range near Hill AFB. Sundvall, an F-16 pilot with the 14th Fighter Squadron of Misawa Air Base in Japan, launched one of many precision-guided munitions fired and dropped as part of an evaluation program for air-to-ground weapons. The program is known as Air-to-Ground WSEP or Combat Hammer.
Only a handful of F-16 pilots can describe a HARM shot from actual experience. The missile is limited to newer Block 50/52 F-16 aircraft and is very expensive. Furthermore, only a very few ranges can support HARM shots. Combat Hammer is the only opportunity, outside of combat that is, for operational F-16 pilots to fire a HARM. Interestingly, though, this first-hand description comes from a pilot with less than 500 hours in the fighter. Sundvall has been his squadron's low-hour F-16 pilot since arriving in Misawa over a year ago for his first operational assignment.

Still, Sundvall has quite a bit of experience with the HARM and the HARM targeting system. “Almost as much as anyone else in the squadron,” he explains. “But we normally practice this mission without a missile.” In other words, when Sundvall hits the pickle button, he has to watch the tape later at the squadron to see if he met all the right parameters. “Here, I got to see the missile come off the rail,” he says. “That experience is a real confidence builder. As advertised, the targeting system does work on the F-16.”

The HARM targeting system, or HTS, consists of a sensitive detector that detects, classifies, and ranges ground radar threats. It is carried in a small pod on the right chin station of Block 50/52 F-16s. HTS passes targeting information to cockpit displays and to the missile. It can also pass targeting information to non-HTS-equipped F-16s via internal data modems, a feature that was validated in separate tests during Combat Hammer.

Twelve pilots from Misawa fired HARMs during the one-week Combat Hammer exercise in April. The exercise also included Block 40 F-16s from Hill’s own 34th Fighter Squadron (which dropped GBU-10 and GBU-24 laser-guided bombs), F-15Es from Lakenheath Air Base in England (which dropped GBU-10s and GBU-15s), and F-117s from Holloman AFB in New Mexico (which dropped GBU-10s and GBU-27s).

Combat Hammer exercises take place throughout the year. The schedule includes one concentrated two-week period at the Utah range and three or four evaluations at Eglin AFB’s test range near the Florida panhandle. Other exercises this year had A-10s, F-15Es, and F-16s firing AGM-65 Maverick missiles; F-15Es firing AGM-130 rocket-powered glide bombs; and B-52s firing AGM-142 standoff missiles. This latter air-to-ground missile, also called Have Nap, has a fifty-plus-mile range and a 2,000-pound warhead. (Only the Maverick carries a functioning warhead in these evaluations.)

“I would like to come out to the Utah Test and Training Range more than once a year,” says Lt. Col. George Clark, the commander of Eglin’s 86th Fighter Weapons Squadron. The 86th conducts Combat Hammer, ultimately for Air Combat Command. “Utah’s biggest advantage is its large shoot area,” Clark says about the airspace and directional requirements that must be met on the range before a weapon can be released. “This range is a jewel. The Utah Test and Training Range is a big chunk of uninhabited DOD land. Here we can shoot HARMs, drop Paveway IIs, and fire Mavericks from a variety of altitudes. We can also perform multiship attacks. The range at Eglin, though, is suited for high-humidity and green terrain testing and training.”

About half of the aircrews participating in Combat Hammer are like Sundvall: They have never fired or dropped live versions of these weapons before. “One of the objectives of air-to-ground WSEP is to give the first timers experience shooting live weapons,” says Maj. Kelly Ranger, Combat Hammer’s program manager for Air Combat Command. “We try to invite as many first timers as we can. Providing this initial experience is a secondary goal of WSEP. But it does relate to a more fundamental goal—to produce realistic operational numbers to ACC planners. Evaluating only the most experienced aircrews would distort the data derived from this evaluation program.”

And this data relates to the primary mission of Combat Hammer—to verify the combat capability of precision-guided weapon systems. “ACC is interested in anything this program can reveal about the ability of a weapon system to do its job,” Ranger notes.

Weapon performance at both Air-to-Ground WSEP and at Air-to-Air WSEP, called Combat Archer, is tracked statistically by the Air Force. “Both WSEPs fall into a class of tests called follow-on test and evaluation,” Ranger says. “In fact, most of this FOT&E in the combat Air Force today is being done at WSEP. Our statisticians look at each phase of the mission—from building up the weapons, to loading on the plane, to flying to the target area, to launching the weapon, to fuzing, to hitting the right target, to assessing the resulting damage.” The mathematical product of the probability of success calculated for each phase determines the overall probability of success, or Pso, for a particular weapon.

“After every WSEP,” Ranger continues, “we categorize this performance in a final report, which is forwarded to the field. We look at how a weapon’s Pso changes over time. The information feeds into a document that aircrews eventually see, the Joint Munitions Effectiveness Manual.
Navy A-6B jammers (lower left) provide realistic electronic countermeasure support for the combat scenarios.

**Combat Hammer** at Hill AFB included Block 40 F-16s from Hill’s own 34th Fighter Squadron (which dropped GBU-10 and GBU-24 laser-guided bombs), F-15Es from Lakenheath Air Base in England (which dropped GBU-10s and GBU-15s), and F-117s from Holloman AFB in New Mexico (which dropped GBU-10s and GBU-27s).
This manual gives them the statistical reliability of a weapon and the types of targets that weapon works best against. The information is also fed into models used to determine force structure."

"Another major statistic is hit rate," adds Lt. Col. Clark. "Hit rate is the measure of success given a release. It accounts for the time an aircrew hits a pickle button until the weapon hits the target.

"But the success of a weapon depends on much more than the weapon itself. It depends on the guys delivering it, the guys putting it on the airplane, and those building the weapon," explains Clark. "We have the units come in a few days ahead of time so we can evaluate their munitions build crews, testers, and loaders. We make sure they're using the latest equipment and technical orders. Our calculations of Ps, though, start on day one with a jet ready and the crew stepping."

ACC mandates these statistics be maintained to an eighty percent confidence level, "meaning we are eighty percent confident that our statistics will equal real-world results," Clark says. "An eighty percent confidence level statistically translates into about forty data points or weapons. A highly successful weapon, though, requires fewer points. If the first twenty of twenty shots hit the target, for example, we don't need all forty data points. Over time, we can also reach a confidence level where we can refresh the hit rate by looking at fewer test points, fewer weapons. The probability of success we see here tends to approximate real-world results closely. Our results have compared very well, for example, with recent operations in Bosnia."

This statistical relationship between the real world and the test world accounts for the existence of Combat Hammer. The first air-to-ground WSEP came about in 1986 when Paveway II laser-guided bombs were not performing as expected. The weapon's performance in training and exercises was not replicating the near-perfect performance in testing. ACC, Tactical Air Command at the time, wanted better analysis. Air-to-ground WSEP was the result.

The first Combat Hammer involved three aircraft types (A-10, F-4, and F-111) and two air-to-ground weapons (AGM-65A/B Maverick missiles and GBU-12 laser-guided bombs) in eight aircraft-weapon combinations. The program now evaluates twenty-six aircraft-weapon combinations. The overall goal of the program is to evaluate any new aircraft-weapon combination within one year of operational fielding.

The combination of F-16 and the hefty 2,000-pound laser-guided GBU-24 is one such relatively new combination. "The F-16 community in general doesn't have a lot of experience dropping GBU-24," explains Maj. Lee Hall of the 34th Fighter Squadron at Hill AFB. "When I left the airplane three years ago for a staff assignment, there was very little laser-guided bomb activity in the F-16 community. In fact, I had never even heard of the GBU-24 until I came back to the F-16. Now the airplane is dropping GBU-10s, -12s, and -24s."

Hall and other members of the 34th FS dropped a total of twelve GBU-24s during the exercise in April. "We've had a big learning curve from last year when our sister squadron, the 421st, dropped these weapons for the first time in this exercise," Hall says. "We tried not to repeat their mistakes. Before the exercise, we practiced GBU-24 drops for about two weeks in simulated attacks on local buildings."

Those simulated attacks can't duplicate the physical sensation associated with releasing more than a ton of metal from a small fighter. "Having that big bomb drop off the airplane is a big jolt in itself," Hall
explains. "To balance the load, we carry a 2,000-pound Mk-84 on the opposite wing. When the GBU drops, the airplane banks to the heavy side, the trim is way off, and the airplane rolls. That is an eye opener. We can't simulate these reactions."

In addition, the pilots get to see what the bomb does. "We get to see how the attacks we think will work actually work," continues Hall. "We can see how the complete system works and how our targeting and navigation pods work together to get the bomb on target."

Hall's advice to future participants: "Don't come here and expect to drop GBU-24s on the first day and have everything work out. Have the tactics developed and all the numbers crunched before getting here. It's a big learning curve. We learned a lot over the last month."

"A lot of these pilots get a world of experience in a very short time here," adds Capt. Mark DeVane. "They go through the entire process of dropping the weapon for the first time here rather than experiencing it for the first time in combat."

DeVane is the 86th FWS project officer for the HARM portion of the exercise, his third term as a WSEP project officer. "The 86th FWS does all the coordination," DeVane explains. "We set up all the threats and weapons. We try to tailor the threats for what they see in theater. We want them to fly and fire these weapons like they train to."

DeVane and test range personnel monitor the missions in a control center at Hill. The center receives and records telescopic infrared video from tracking stations set up around the test range, aircraft location information from transmitter pods mounted on the aircraft, and telemetry data from the weapon itself. Both weapons and aircraft are tracked by radar. Large screens in the center display video images of the target area.

The flight scenarios present a dose of realism. Participants must deal with adversary aircraft and a number of simulated surface-to-air threats and antiaircraft artillery on their way to the target area. "We have shot HARMs for three years at Combat Hammer," DeVane explains, "and every year the missions become more realistic. The first year the radar targets were located close to each other and we had a smaller shoot cone. The second year we opened up the shoot cone, but the targets were still pretty close together. This year we had a large shoot cone and a variety of targets, for example SA-2 and SA-3 sites. The targets are also better dispersed. RC-135 Rivet Joint and EA-6B Prowler jammers are involved this year as well. We built an entire electronic countermeasure scenario."

"The HARM targets get better every year," adds Clark. "They are not bunched up. We would love to have a complex target with a 360-degree shoot cone. So if winds are adverse in one direction, we can come at a target from another direction. Such an option may not be realistic for war, but it would allow us to use wind as a variable in these evaluations."

Operational scenarios have also become more realistic and more challenging this year. "Units operated as two ships in the past," DeVane explains. "This year they are operating as four ships. Since the following four ship overlaps the previous group, we have up to eight airplanes out there at one time. We try to vary the shot parameters from simple to complicated as the week progresses. We have more off-axis HARM shots by mid-week."

Lt. Col. Clark has some long-range ideas for improving the realism of
Combat Hammer. "Ultimately," he explains, "we would like to integrate this program into Red Flag exercises. With the proper instrumentation on the Nellis range, we could make WSEP a transparent part of the Red Flag training. They already have plenty of threats and emitters. And they have a realistic training set. But they don't have the end game instrumentation to assess weapon drops properly."

While this integration effort may be years off, WSEP is addressing new operational issues this year. For example, 1996 is the first year that Combat Hammer actively sought out high-time weapons for testing. "When these weapons were designed, no one envisioned that they would be used in so many patrol missions," Ranger explains. "Some weapons at Aviano, for example, have been carried captive from 100 to over 1,000 hours. This trend presents potential problems. We could see rivets coming loose, weathering problems, and cracks related to stress or temperature gradients. We want to test weapons that are representative of what we will encounter in the field. This year, WSEP is evaluating high-time air-to-air missiles and laser-guided bombs from southern Europe and southwest Asia. We will expand the program next year for HARMs and Mavericks."

Combat Hammer is also addressing slight inaccuracies in laser-based target designators. "A small percentage of our misses are caused by the laser not matching the line of sight as displayed to the pilot," explains Clark. "Some pods are not boresighted well. Pilots cannot perceive this inaccuracy from the aircraft because they cannot see their own laser spot. And they don't get an indication when the system is out of tolerance. In fact, we won't find the inaccuracy until the next time the pod is calibrated. We are looking at systems that allow pilots to check their own laser designators. Basically, the pilot aims the laser at a ground target from the air. Someone on the ground or the target itself then verifies the precision of the laser spot."

"We get a lot of satisfaction out of finding problems with these systems and fixing them before someone takes the weapon into combat," DeVane says. "We want to make sure the Air Force has the best equipment. We are becoming a focal point for techniques for these weapons, a repository of information for increasing the overall combat capability of the Air Force. We don't want people continually relearning these techniques."

"A lot of this technology is portrayed on television and in Tom Clancy novels as being foolproof," adds Ranger. "If it were foolproof, we wouldn't need a program like WSEP. The public can't see all the ways to mess up a shot. So many extraneous factors are involved: the weather, the pilot, the airplane, the fog of war, and all the mechanical steps."

"Right," confirms Clark. "Regardless of what people saw on CNN, not every bomb dropped in the Gulf War was a direct hit. That perception of accuracy may have had a useful psychological effect during the war, but it distorts the public's expectations for these weapons. These munitions are not pinpoint accurate 100 percent of the time. Our job is to provide the DOD and theater commanders with realistic expectations."

While commanders get data from Combat Hammer, aircrews benefit more directly from the experience of firing and dropping actual weapons. "Simulation is a great way to train and it is cost efficient," Ranger explains. "But the first time you drop a real weapon, you don't want to do it in the heat of battle. Here, we help pilots get over any jitters that may accompany that first time."

"The meat of this exercise for us is testing the GBU-24 and making sure that we can deliver the weapon," says Hall, who dropped his first GBU-24 the day before. "The organizers throw in some realism with threat emitters and adversary aircraft. The GBU-24, though, is not a high-threat type weapon. We would have to have air superiority and SAM suppressors out there. Still, I'd rather have the learning curve occur over the range rather than over North Korea or someplace like that."

What about those first-time jitters? "No jitters," answers Sundvall. "But it is always somewhat of a surprise when something as big as a HARM comes off your airplane for the first time. A lot of training and a thorough understanding of the weapon system keep those jitters away."

Eric Hebs
TUCSON
Forty Years Young

BY DOUG RITTER
Several F-16s rest quietly on the spotless epoxy-coated floors of the two maintenance hangars at the 162nd Fighter Wing of Arizona’s Air National Guard near Tucson. The aircraft and the modern expansive hangars are a far cry from the F-86A Sabre Jets parked on the dirt floors in creaky wooden hangars here forty years ago. While the aircraft and facilities have improved vastly since 1956, the 162nd celebrates its fortieth birthday with a constant and singular emphasis on its people—people who made this Arizona Guard unit one of the premiere units in the ANG.
But this reserve unit didn't start out with such high rank. "When we started the Arizona Air National Guard, not many thought it would amount to much," recalls former Senator Barry Goldwater, himself once a brigadier general in the Air Force Reserve. "But the Tucson unit in particular has sure proved them wrong."

The Tucson unit traces its roots to the 197th Fighter Squadron at Luke AFB in Phoenix. Maj. Gen. Donald E. Morris, the founding commander of the 162nd, was one of ten pilots and nineteen airmen who transferred down from Phoenix in May of 1956 to form the nucleus of the new 152nd Fighter Interceptor Squadron, predecessor to the 162nd. "We leased the old hangar across the field and used it for maintenance and parts storage," explains Morris, who was a thirty-one-year-old major forty years ago. "We took over a nearby adobe two-bedroom ranch house for offices. We had to walk through the desert to get to the hangar."

Morris and his modest staff faced an immediate need to recruit enough members to meet federal requirements to become a recognized unit. "It wasn't that easy. We ended up transferring thirty Guardsmen down from Phoenix just to stand in ranks and be counted," he says. "My biggest concern was whether the bus was going to make it down here in time for the review." From those humble beginnings, the unit soon won the first of many honors with their Sabre Jets. In the first year, Morris himself claimed the Goldwater trophy for setting a new record in a gunnery competition. He went on to command the unit through 1971.

The 152nd transitioned from sixteen F-86 fighters into twenty-four F-84F Thunderstreaks in 1957 and then to the F-100A, the first of the Century series of supersonic fighters, in 1958. SMSgt. Barry Solvie, who joined the unit in 1957 and is still a member today, recalls a sense of family and purpose throughout his career in Tucson. "I still know everyone by name," he says. "The biggest difference back then was that everyone did anything that needed to be done. Today, we have to be much more specialized because of the more sophisticated aircraft and because we're so much larger. Back then, we thought those F-86 and F-84 jets were awfully complicated compared to the reciprocating engines we were used to working on. But those early jets were simple compared to the F-16."

On the heels of receiving an "outstanding" grade on its first tactical evaluation inspection, with the highest marks ever received by an Air National Guard unit, the Tucson squadron was upgraded to group status in May 1958. The 152nd then became a squadron of the 162nd Fighter Group.

Soon after becoming a fighter group, the unit said good-bye to the dirt floors. A spacious hangar, complete with an Air Force-mandated roof to support a twelve-foot snow load, went up alongside a three-story office building. In 1959, the 162nd became the first Air Guard unit to receive the Sidewinder missile. An operational readiness inspection in 1960 resulted in the highest score ever awarded to date to any unit by the Continental Command, the Air Force, or by the Air National Guard. In 1965, the F-100s were replaced with F-102 Delta Daggers. The unit received an Air Force Outstanding Unit Citation for converting to the new interceptor in only ten months. The citation was the first of five such citations awarded the 162nd.

Despite the effort, or perhaps because of it, the Daggers stayed only a short time in Tucson. In 1969, the unit reverted back to the F-100 and became the 162nd Tactical Fighter Training Group. The transition to a school house would begin a new era for the unit, a role that would carry it into the future.

"Some might have viewed becoming instructors as taking a step back," notes Morris, "but we saw it as an opportunity. The transition was the start of the unit's real growth. We didn't know it at the time, of course, but we felt it was a significant change. We just didn't realize how significant." The 162nd's development of the ANG's Fighter Weapons School shows how the unit capitalized on its growing expertise in instruction and...
on its advantageous location, good weather, and unrestricted airspace nearby for training.

In 1976, the 162nd began transitioning to the A-7D Corsair II. For two years, the unit instructed in both the F-100 and the A-7D, an unprecedented effort that won the 162nd its second Air Force Outstanding Unit Citation. The first brand spanking new A-7K two seaters arrived in 1978. The airplanes were a big change from the Air Force hand-me-downs Guard units were accustomed to.

“One of our strengths is our experience, both as a group and with each aircraft,” says Chief MSgt. Don Shelor, who joined the unit 1969. “Most of those new A-7s began their flying careers with us, and they were retired to the boneyard under the care of a single crew chief. That experience makes a world of difference. Nothing can substitute for the pride and sense of purpose that such continuity engenders.”

That pride helped the unit win the Spatz trophy for the outstanding Air National Guard unit in the United States in 1982 and another Outstanding Unit Citation in 1985.

Having successfully done it once, the 162nd was once again tasked with the difficult and unique mission to instruct in two dissimilar aircraft concurrently, the A-7 and the F-16A. The 162nd struck another feather in its cap in 1987 by winning the Safety Award of the Americas, the only Air National Guard unit ever to do so.

In 1989, the 162nd became the first Air Guard unit to train foreign pilots. This assignment was a harbinger of things to come: another Outstanding Unit Citation in 1990 proved the

unit was still on a roll. The last A-7 was retired in 1991. For the first time in years, the 162nd was flying a single type aircraft, the F-16A. While the A models were being retired from active Air Force use and slowly being phased out by the Air National Guard, more and more of the aircraft found their way overseas. As a result, demand grew for additional foreign military training. The 162nd was uniquely qualified for the job. The unit began training Dutch pilots in the F-16A in 1990.

The Republic of Singapore started training in 1992. Singapore was followed by Bahrain in 1993. Portugal’s pilots began training in 1994. Thailand signed on in 1994 along with Indonesia and Turkey. Already in 1996, Belgium pilots have started training. The 162nd expects more foreign nations to come to Tucson as this year progresses.

While the 162nd offers a core curriculum for four basic courses, the different needs of the countries involved result in a total of thirty different courses, each tailored to the pilots of the individual countries. The basic course takes newly minted pilots and turns them into effective F-16 fighter pilots in seven months. A conversion course for experienced fighter pilots lasts three months. A specialized course for instructor pilots runs six weeks. The Fighter Weapons School lasts four to five months and includes live fire exercises. At any one time, the unit has about fifty students in training.

Having to train pilots from other cultures presents its own challenges. “Communication is always a concern,” notes Col. Joe Mensching, who commands the 162nd today.

“For most of our foreign pilots, English is a second language. They still think in their native tongues. We must take extra care and time, when necessary, to be sure the student understands. The instructors also have to be diplomats at times. It is a very demanding job.
Today, Tucson’s ramp is packed with F-16s.

“Pilots know when they come here that they are going to be teaching,” Mensching continues. “Not everyone is suited to the special challenge of teaching. Our instructors are mature, and they understand the importance of what they do and of the unwavering quality they must maintain. The pilots we train here today may some day be flying on the wing of one of our own pilots in some future conflict. We are responsible for ensuring they are up to the task.”

The instructor pilots bring impressive credentials to the job. Over sixty percent are Weapons School graduates or instructors and over eighty percent have had combat tours. The average instructor has over 3,000 flight hours. About seventy percent of the instructor pilots have over 1,000 hours in the F-16. No surprise then that the 162nd’s pilots beat their peers from Luke at the 1994 Top Flight competition and that they did it flying the original Block 10 F-16As.

The instructor pilots suffer no shortage of stick time. For fiscal year 1996, over 15,000 flying hours have been allocated, nearly four times that of a typical ANG unit. In the past, this number has been as high as 19,000 hours. All those F-16s flying all those hours require outstanding maintenance and consistent quality. The 162nd Logistics Group delivers the highest sustained sortie rate in the Guard, an enviable eighteen-plus for the older A and B models and twenty-plus for the newer C and D models. Moreover, the 162nd’s high standards for instruction dictate that every single aircraft system be functioning fully for every flight, a self-imposed higher standard most units do not have to meet.

“We have the finest men and women in the world,” boasts Col. Richard Rose, Logistics Group Commander. “They have created an aggressive work ethic that spurs people on to the highest levels of achievement.” The average mechanic at the unit has eighteen years experience. This experience shows. The pride is palpable when touring the comprehensive and spotless maintenance facilities. “We have the best facilities in the Guard because our people have earned it and deserve it,” Mensching comments. “The figures speak for themselves. They are simply the best. We can’t fly 130,000 hours without an accident unless the maintainers do their job to a higher standard.”

When you take into account that the 162nd is flying some of the oldest F-16s around, this success is all the more remarkable. The fifth production F-16 (tail No. 78-005) is still on active flying status with the unit. It is the oldest F-16 still flying operationally.

Everyone eventually relates the 162nd’s success to the same attributes. Mensching echoes a theme that runs through any discussion of why the unit performs as well as it does: “It’s the people. It’s that simple. We have over 900 full-timers and over 1,500 total personnel. Despite how much we’ve grown, we are still a family.” Mensching’s statement is true both figuratively
and literally. Eighty-seven families have more than one member in the unit. Numerous second- and third-generation Guardsmen and women work on the base. “It’s the sort of work environment people don’t mind recommending to a close friend or family member,” Chief Shelor notes. “Our people feel good about the unit, about the work they do, and about their future here.”

That future looks bright. The unit is currently renovating a neighboring facility that will soon house foreign military training missions for the 152nd FS and 195th FS. No one will shed a tear when the temporary trailers currently housing parts of the mission and the Fighter Weapons School are hauled away. The renovation is being done in typical 162nd fashion, with much of the labor provided by members of the wing.

The 162nd is also home to the Air National Guard - Air Force Reserve Test Center. The AATC is more than just a tenant; the 162nd supports its six dedicated F-16 aircraft and its mission with all its resources. The focus of the AATC is the development of low-cost, off-the-shelf solutions to requirements of the Guard and Reserve flying units for improved tactical capability and maintainability. In addition to the F-16, they also develop systems for the A-10, B-1, B-52, C-130, F-15, KC-135, and HH-60. It’s an excellent fit with the Tucson unit, given the 162nd’s penchant for developing low-cost and more efficient methods of doing its job, many of which have been adopted by the Air Force and by other Guard units.

“A lot of the best of everything in the world I found in Tucson,” says Maj. Gen. Donald Shepard, Director of the Air National Guard at the Pentagon. Shepard flew as an instructor with the 162nd from 1974 through 1986, first in the F-100, then in the A-7.

“To be an instructional unit,” he continues, “you have to have the best of the best pilots and the best of the best maintenance. I don’t know of any other unit in the Air National Guard that has been through more change, more turmoil. Yet they seem to get through it effortlessly because of their pride, their expertise, and the quality of their people and their culture. They simply exemplify everything that makes the Guard strong. They have taught pilots from all over the world, and they have had a significant influence on the good things that have happened in tactical fighter aviation. They have always been a center of innovation, even more so now with their support of the ANG AFRES Test Center. They are the best of the best.”

“They don’t come any better than the 162nd,” declares former Sen. Goldwater. “The Air Force is damn lucky to have ‘em.”
The F-16 Wild Weasels

Misawa Air Base Japan
Much fanfare greeted the F-4G when the aircraft began replacing aging F-105 Wild Weasels in the late 1970s. The modified Phantoms arrived highly recommended from the USAF test community to assume the mantle of USAF’s suppression of enemy air defenses, or SEAD mission. Behind the scenes, however, operators were skeptical. The F-105 had proven itself in Vietnam, reducing attrition to surface-to-air missiles by seventy percent between 1965 and 1968. The F-105’s “Wild Weasel” moniker was a proud tradition that would not be given up easily, certainly not before the capabilities of the new system were fully tested in an operational environment.

But this reluctance was rapidly overcome by a new generation of aircrews. Not knowing any better, they proceeded to push the envelope of F-4G capabilities well beyond what was possible in the F-105.

“One situation is very similar today as it was in the 1970s,” says North. “We have many people throughout the SEAD community who are reluctant to acknowledge the tremendous capabilities of the USAF’s latest Wild Weasel. At the same time, our F-16 pilots don’t understand the emotional attachment to the F-4G. We are focusing not on the past but on the F-16 and the HARM Targeting System, or HTS. We are reconceptualizing the Air Force SEAD role.

“We’re going ‘back to the future’ but with a difference,” North remarks. “The difference is the F-16’s phenomenal potential. Both concepts of operation for employment and modernization roadmaps will require almost continuous adjustment for us to fully realize the incredible possibilities of this system. We must maintain a constant dialogue between planners, acquisition experts, test staff, and warfighters to capitalize on and effectively integrate the capabilities of the F-16 Wild Weasel.”

Originally intended to fill a void between F-4G retirement and development of a dedicated follow-on system, the F-16 is now the only SEAD platform the Air Force budget will support through the end of the century. The F-16 has proven itself a benchmark fighter. And timely modernization of the F-16’s subsystems will guarantee that it remains formidable well into the next century. On top of the basic F-16 platform, Misawa’s F-16 Wild Weasel boasts the new GE-129 engine that produces 29,500 pounds of thrust. The aircraft carries the HTS pod on its right chin to locate surface-to-air radar threats. The cockpit incorporates advanced avionics for targeting threats and for providing situational awareness both on threat arrays and on the relative positions of supported aircraft. Finally, the F-16 Wild Weasel includes an improved data modem for datalinking targeting information to and from other IDM-equipped aircraft.

The typical Wild Weasel loadout includes either two AGM-88 High-Speed Antiradiation Missiles, two Maverick missiles, or two general-purpose bombs along with the F-16 standard of two AIM-120 and two AIM-9 air-to-air missiles. The F-16 Wild Weasel is deadly in all counter-air roles. The challenge is how to best train and exploit these new capabilities. And the 35th FW at Misawa has set an excellent example.

Misawa completed its eighteen-month conversion to the Block 50 F-16 in August 1995. The wing’s two Wild Weasel squadrons, the 13th FS and the 14th FS, represent about one third of the USAF’s Wild Weasel capability. Although the 35th FW was the last
active unit in USAF to receive the HTS-equipped F-16, it was the first to achieve initial operational capability with the system. During its transition, the wing overcame maintenance obstacles and paved the way for smoother integration across the Air Force. Exceptional maintenance and logistical support has allowed the wing to achieve the lowest break rate for the aircraft, the lowest abort rate, the highest scheduling effectiveness rate, and some of the best supply rates in the Air Force.

“The transition to the single-seat Weasel mission required us to incorporate some extremely sophisticated aircraft subsystems,” explains Col. Robert McMahon, who commands the 35th’s logistics group. “These subsystems, in turn, demanded new standards of excellence for effective logistical support. Even though Misawa is at the end of the supply system’s food chain, we have been extremely successful in predicting these needs and reacting to unforeseen requirements.” McMahon’s commitment to strong support is highlighted by his group’s recent nomination by PACAF for the Gerrity Award (USAF’s highest honor for a logistics group).

The wing’s operational performance has been similarly remarkable. A four-ship of F-16 Wild Weasels from the 35th led a composite force of eight different types of aircraft that represented PACAF in Gunsmoke ‘95. The team employed aircraft from bases stretching from Alaska across the United States on a six-hour mission against targets defended by advanced threat arrays in Nevada. The mission commander for the team, Maj. Jim Post of the 35th, led both the PACAF Team and Misawa’s F-16 team to world championship honors in the
prestigious event. Misawa's Weasels also chalked up an outstanding performance recently at Green Flag, where the F-16 Weasel day after day destroyed and suppressed surface-to-air missiles and antiaircraft artillery and effectively supported blue packages with lethal air-to-air ordnance.

Following Green Flag, Lt. Col. James Moschgat, the commander of 14th FS, deployed his unit to Combat Hammer for live-fire HARM exercise. Pilots from the 14th shot twelve HARMs during tactical scenarios and took the first operational live-fire HARM shots using targeting data from the IDM. Immediately upon their return to Misawa, the wing demonstrated to PACAF its combat readiness during a combat employment readiness inspection. The 35th FW record has not gone unnoticed. Last year, the 13th FS received the Association of Old Crows Outstanding Unit Award as the top SEAD unit in USAF. This year, the entire wing has been nominated by PACAF for this award. PACAF also has selected the 35th FW along with F-15s from the 18th FW at Kadena AB, Japan, to represent the command at William Tell, USAF's premiere air-to-air competition. This summer, Lt. Col. P. K. White is leading Weasels from the 13th FS to Southwest Asia in support of Operation Southern Watch.

Brig. Gen. Paul Hester, the 35th FW's Commander, explains Misawa's success this way. "We've had explosive growth because the right people are leading our charge. Our average pilot has over 700 hours in the F-16, and a large number have combat experience. My commanders are superb operators and visionary leaders. Two of them are former recipients of the USAF's Sijan Leadership Award. Two are graduates of the Air Force School of Advanced Airpower Studies. And our chief of weapons and tactics, Maj. Jim Post, is PACAF's nominee for the Chennault and Shine Awards for the best tactician and fighter pilot in USAF.

"Across both our operations and logistics groups," Hester continues, "we have an abundant amount of incredible talent. Our people have pulled together as a team to put Misawa on a bullet train." Small wonder the F-16 Wild Weasels are flying back to the future with a big difference.
Fifty years ago, the XB-36 lumbered to the end of a long runway west of Fort Worth, Texas. Shortly before noon on a torrid Thursday the eighth day of August 1946, with Consolidated Vultee's chief test pilot Beryl Erickson and co-pilot Gus Green at the controls, the silver behemoth rolled past the Fort Worth Army Airfield hangars, accelerated to 110 knots, and lifted into the bright blue for a successful thirty-eight-minute maiden flight. This painting by Price Randel depicts the historic flight and pays tribute to those gathering in Fort Worth this August to share memories of the days when giants ruled the skies.
Linda Poole and "Jack" go to work in the virtual JSF factory.
Joint Strike Fighter

PERSPECTIVES

Lockheed Martin employees with a wide variety of backgrounds and experience have been hard at work for the last several years on the design and technologies for the Joint Strike Fighter, an airplane to meet the needs of multiple services well into the next century. In the last issue of Code One, we provided an overview of the JSF program from a higher-level perspective. This follow-up article gives a more detailed look at the airplane from an assortment of perspectives.

What follows shows that a new aircraft program can be viewed from many angles. A design engineer may see it in terms of outside shape and how that shape affects aircraft performance. A manufacturing engineer, in terms of processes for forming certain materials. A flight test engineer, in terms of a flight test plan or test points in a particular flight regime. A manager may see it in terms of a schedule and deadlines. Each person reflects his or her specialty and function on the program. Taken as a whole, the thirteen perspectives that follow form a single foundation for an impressive family of aircraft.

Linda Poole

Virtual Development Environment

Linda Poole is a part of a modeling and simulation team that is creating what's called a virtual development environment, a computer-based system for revolutionizing the way aircraft are designed and produced. "We're good at designing aircraft," Poole says. "We've been designing aircraft for a long time. The key is designing affordable, producible aircraft." Poole and others on her team are developing an impressive collection of integrated computer-based tools and capabilities to achieve that end. The capability will be used across Lockheed Martin's Aeronautics Sector.

"Everything we are doing is focused on reducing development cycle time and cost," Poole explains. "For example, we are addressing manufacturing issues earlier in the design cycle, before we begin detailed design. Historically, products are designed and then much later someone discovers that some of the features of the products are very expensive to manufacture or, in the worst case, difficult to build. Redesign and rework are very expensive. We want the entire development team, which includes operations, manufacturing, tooling, and engineering, to verify that the weapon system is producible before we begin detailed design."

One major method of achieving this capability is through rule-based design support. In very simple terms, it is an extensive database of guidelines integrated with design software and available to everyone working on the program. "Drawings are now being replaced with electronic representations that will not only show geometry," says Poole, "but also highlight other information associated with that geometry, such as material attributes, cost, and weight. Rule-based design support combined with features and solids modeling provide tremendous insight into the design, producibility, and support aspects of the product."

The development environment will also include automated access to lessons learned from previous programs and knowledge accumulated over fifty years of experience throughout Lockheed Martin. "The system will include access to information associated with key program decisions," Poole continues, "such as who was involved in the decision, the requirements, the ground rules and assumptions, and the data and trade studies that supported the decision. Producibility guidelines and query systems will be used for dealing with specific materials and vendors. We want that accumulated knowledge used throughout the entire development process and available on-line to everyone on the team across our aeronautics sector." The integration of these and other visualization and simulation tools form the foundation for the virtual development environment.

Poole's team is placing the environment on the company's intranet. The functionality of the system will span the entire product development cycle from requirements through the factory and into operational use. "We are developing virtual prototypes that allow us to validate and verify manufacturing concepts. That's where the real payoff is. We validate our concepts prior to the development of any real or physical hardware," she says. "We are also working to minimize and perhaps even eliminate physical mockups, which have significant cost implications."

The virtual development environment integrates management, schedule, cost, design, and manufacturing tools. It is structured to take advantage of the best capabilities across Lockheed Martin's Aeronautics Sector. "We can use simulation to assess the ergonomic implications of manufacturing and assembly processes as well as optimize these processes to minimize risk of injury," Poole explains. "In addition, we can optimize robotic painting processes and then transfer the software generated from the analysis directly to the robots on the factory floor."

"Experience has taught us volumes about manufacturing processes," she continues. "And modern technology provides exceptional tools for linking manufacturing with design. These tools will change the way we design and build aircraft. I'm looking forward to putting them to even greater use for the JSF."
Joe Sweeney has been a company F-16 test pilot since 1985. He worked on and flew all the initial flights of the F-16 digital flight control system. He has done Block 40 integration work and was a project pilot on the Israeli F-16 program. Since 1991, he has been the manager of flight operations. He flew the multi-axis thrust-vectoring F-16 in 1993 and F-16 conformal fuel tank tests in 1994. In his earlier role as a Navy test pilot, he directed the F/A-18 operational evaluation.

"Lockheed Martin may suffer some from the perception of a lack of Naval Aviation experience," Sweeney says. "With the exception of the S-3, we don't have a lot of Navy aircraft flying out there. But it is only a perception. We have a lot of Navy design experience from other programs. More importantly, though, we have many people with broad operational and test backgrounds in Navy aircraft.

"For example," Sweeney continues, "Ken Grubbs from Lockheed Martin in Marietta, Georgia, flew the initial sea trials of the F/A-18 and knows as much about carrier suitability testing as anyone out there. Dave Palmer, Lockheed Martin's deputy program manager for JSF, has both fighter operational and test pilot experience in the Navy, including a command tour. My counterpart on this program from Skunk Works, Tom Morgenfeld, was a Navy test pilot. Our program manager, Dave Wheaton, has an operational Navy fighter background.

"Many of our lead engineers on the JSF program have Navy backgrounds," Sweeney adds. "Steve Weatherspoon, who does systems engineering, was a Navy test pilot and an F-14 squadron commanding officer. Tom Frey, who heads up our JSF cockpit design, was a Navy operational test and evaluation pilot. I'm leaving a lot of people out. But my point is that perception is not reality—we have a good group of people with strong Navy backgrounds in all the functions."

Sweeney has supported simulations and flying qualities work for the JSF's integrated flight and propulsion control system. He has also supported work on cockpit concepts for the airplane. He is part of a company carrier suitability advisory group led by retired admiral Jack Ready, a former carrier commanding officer and commander of the Naval Air Test Center.

"For the next phase of the program, concept demonstration, we've taken the test objectives and have put together an
affordable test plan that allows us to
demonstrate critical items to eliminate as
much risk as we can," Sweeney explains.
"Our plan is to use two concept demon-
strator airplanes to flight-test all three
variants. Our first demonstrator will start
off as the conventional takeoff and land-
ing, or CTOL, variant. We'll fly it first at
Edwards AFB. We then convert it into
the carrier, or CV, variant by modifying
the wings, tails, and control surfaces.
The conversion will demonstrate the
commonality of our design. We fly a few
more months at Edwards AFB and then
take the CV variant to Patuxent River,
Maryland, to finish up the flight tests.
"The second demonstrator is config-
ured from the start as a STOVL aircraft," Sweeney continues, "but it, too, could
easily be converted to one of the other
two variants. It has a lift fan driven by the
main engine and a vectoring nozzle. We
fly it for the first time at Edwards.
We begin these flight tests with a lot of
hover and vertical takeoff and landing
tests and then perform transitions to
airborne flight. Because the STOVL and
CTOL airplanes have a common external
configuration, much of the data we get
from performance and handling qualities
tests for the CTOL variant applies to the
STOVL variant. We'll also transition this
aircraft's test program to Patuxent River
for the final months."

Sweeney emphasizes that the technical
challenge of the CV and STOVL variants
should not overshadow the significance
of the CTOL variant. "Lockheed Martin
has two premier operational CTOL
programs," he says, "The F-16 is an
unmatched performer. No other airplane
accelerates and climbs as fast and has the
raw performance of the Block 50 F-16.
And the F-117 is an extremely capable
low-observable aircraft. No airplane flying
today combines these capabilities without
compromising one or the other quite a
bit. The F-22 will, but it is an air-superi-
orty machine and won't have the JSF's
multirole tasking. The challenge for the
CTOL variant is to wrap into one basic
airframe F-16-class performance and F-16
cost with the best of the low-observable
features from our experience with the
F-117 and F-22."

Tammy McNeley
Operations Research

Tammy McNeley has been in operations
research for the last twelve years. She
specializes in analysis using manned flight
simulations. She worked on an automated
maneuvering attack system demonstrated
on the AFTI/F-16. She has also worked
on feasibility studies for embedded train-
ing concepts for the F-16.

Embedded training uses software placed
in the avionic system to stimulate cockpit
displays so they mimic realistic ground
and air threats. Pilots can then train
against realistic threats whenever and
wherever they want without the expense
and availability constraints of ground-
based threat ranges. These feasibility
studies provided the groundwork for the
embedded training concepts being
proposed for both the F-22 and JSF.

For JSF, McNeley has been supporting
design trade studies for some of the
critical aircraft attributes, such as
signature, countermeasures, and maneu-
verability. "Designers might want to
change the wing sweep five degrees," McNeley says, "which affects
the aircraft's signature and maneuverability.
We tell them how these changes in
turn affect the aircraft's lethality and
survivability. With simulation models,
we can evaluate these effects on single
engagements, entire missions, or on a
full campaign."

Simulations fall into two primary
categories, constructive and virtual.
"Constructive simulations do not have
a pilot in the loop," McNeley explains.
"These simulations often involve
prerecorded flight paths through a given threat environment. Virtual simulations, on the other hand, have persons interacting with the simulation models. We can insert people into both our aircraft and the threats. For example, the aircraft flight path is generated by a pilot in a tactical aircraft simulator, and the surface-to-air missile system is controlled by an operator sitting in front of a simulated radar scope. Virtual simulations are more realistic, but they tend to be more expensive and introduce more variability into evaluations. We have to be careful in experimental design so that the most information is achieved in a minimum of test runs."

The JSF program is one of the first aircraft programs to standardize the models for both constructive and virtual simulation. Each defense contractor uses a standard toolset consisting of core models defined by a team of representatives from the services, various government labs, and from the defense contractors themselves. Working together, the team defines the models, databases, and scenarios in which the JSF will be evaluated.

"In this program, everyone models particular threat systems and battlefield scenarios the same way," McNeely says. "We define our weapon system in terms of inputs into those defined model sets."

"Up until now," continues McNeely, "we've been using constructive simulations to help resolve outer mold line issues, such as wing sweeps, number of tails, inlet geometries, and payload size. Over the next four years, we will be complementing our constructive analysis with virtual analysis. This analysis gets more interesting because we can provide both operators and engineers a hands-on tool for maturing our JSF weapon system concept. We want our design to reflect as much operator input as we can."

Bob Ruszkowski

Design

Bob Ruszkowski was hired in 1985 into the company's advanced design department, where he has worked on conceptual and preliminary aircraft designs ever since. When he first arrived, he worked on all sorts of advanced design concepts. Later, he concentrated on close air support studies and on Air Force multirole fighter designs. About seven years ago, Ruszkowski even worked on a STOVL aircraft design concept for the Army.

"Most of my experience, though, is with multirole fighter projects," he says. "For a long time, our company had a two-pronged approach to future multirole fighters—F-16 derivatives and new airplanes. I've always worked on the latter. We call them 'clean sheet' designs. When I first got here, the term still applied. That is, we actually started with drawings on clean sheets of paper. Today, we start with a blank computer screen."

What designers do on those blank screens has a major influence on the entire program. "Designers have to think of the big picture up front," Ruszkowski says. "We have to work with the big pieces of the airplane like the weapons, the crew station, the engine, landing gear, and some of the avionic components. We have to integrate them into a total design and shape the aircraft around them."

"We also have to account for many particulars," he continues. "We have to think like a structural designer to have a good idea of where the structure will go. We have to think like a supportability engineer to anticipate the likely
placement for an environmental control system. The best designers have a solid understanding of a broad range of concerns that will be fleshed out later in the design process. That initial step can affect everything else.”

Ruszkowski has been working on designs for a JSF from the beginning of the JAST program in 1994.

“Interestingly,” he says, “our early baseline was a wing-tail airplane very similar to what we have now.” When the government merged the JAST and ASTOVL programs in late 1994, that baseline shifted to a wing-canard design that the Skunk Works had been developing for several years.

“We had a contest between wing-canard and the more conventional wing-tail design,” Ruszkowski recalls. “The wing-tail turned out to be the better approach for a variety of reasons, primarily because it was a lower risk approach and much more forgiving aerodynamically. Once that contest was settled, we evolved the wing-tail design. Before this contest, though, we had a family of airplanes that looked very different. The Air Force and STOVL variants were tailless, delta wing designs. And the Navy variant had a stretched fuselage and wing-tail planform. Affordability factors pushed our approach to a much more common family of aircraft.

“The biggest challenge is to deliver a balanced design that satisfies all four services,” Ruszkowski says. “Another challenge is to design the aircraft so it can be built on a single assembly line. Our design meets both of these challenges very well. We are confident that we can meet requirements for carrier approach and takeoffs. Our successful tests on the large-scale powered model form a strong foundation for our STOVL propulsion system.”

Ruszkowski’s plans for the next phase are to keep refining the operational aircraft design, which will enter the EM&D phase in the year 2001. “The government will not solidify the requirements until 1999,” he explains. “So between now and then, I will be working on design trade studies and changes and then use the results from testing and other studies that will substantiate those requirements.”

Linda Carter
Subsystems Integration

Linda Carter’s specialty is subsystems integration. She worked for almost seven years on the National Aerospace Plane program. She also worked on the F-22, a Navy F-22 variant for the AFX program, and on the Korean KTX-2 trainer program. She spent fifteen months with the Koreans teaching subsystem integration.

“What’s categorized as a subsystem often depends on the size and organizational structure of a program,” Carter explains. “Normally, subsystems are all of the other systems except weapons and propulsion. These are considered to be primary systems. Subsystems include hydraulics, pneumatics, fire protection (fuel inerting), fuel system, electrical power, emergency power, and sometimes landing gear, crew, and life support systems. We have a subsystems integration interface to the primary systems as well.”

Carter’s job is to make sure that all the aircraft’s subsystems are properly balanced. “A big part of my job is packaging subsystems into the airframe,” she says. “I do it at a volumetric, not a detailed, level. Other people insert all the brackets and tubes into the design.”
I also coordinate trade studies. We may look at four or five options for a particular system. These options often involve several disciplines and types of designers. I make sure that everyone affected by a trade study gets an input.

"Subsystem integration prevents one system from overpowering the others," she continues. "We can't have five engineers independently optimizing their systems because their design may lower the total performance of the aircraft. Their designs, for example, could take up too much space in the aircraft or require too much bleed air from the engine. And a particular combination of subsystems may not be the best choice for an airplane. The design effort needs a neutral party making sure the combination benefits the airplane the most."

Carter also manages all the functional interfaces between systems. "For example," she explains, "I make sure avionics has all the cooling and power it needs and that their requirements match our design. The job requires a lot of communication. Engineers like to sit at their desks, get a task, and get it done. I have to make sure that the right engineers are talking to each other, that everyone is aware of what others are doing. Subsystem integration is the mortar between the bricks."

Carter's expertise will play an important role in the final JSF configuration. "We won't fly new technologies if they make the airplane too heavy or too costly," she explains. "Every system has to show a benefit. The JSF is such an integrated and performance-tight aircraft. We are not so sold on new technologies that we will sacrifice performance for them. We are putting the best, the lightest, and the most affordable systems on the airplane."

Jim Eshleman
Wind Tunnel Testing

Jim Eshleman has been working on ASTOVL programs in one form or another since graduating from college in 1982. His expertise in wind tunnel testing of powered lift aerodynamics comes from four years at NASA/Ames and ten years at the Skunk Works.

"STOVL jet effects have been studied for over thirty years," Eshleman says. "It is hard to get people to understand the integrated nature of STOVL flight. What might normally seem like a small change in the configuration can have major effects on propulsion-induced aerodynamics, which, in turn, can have a significant impact on vehicle performance. Evaluating vertical flight is more than just pointing a jet at the ground and watching where the air goes. We have lots of different interactions that vary with height, airspeed, and just about everything else. I have learned not to be surprised by trying to second-guess the air."

Many of these interactions are peculiar to vertical flight and have their own terminology. A wall jet is a sheet of air that flows along a surface, such as the ground. A fountain is formed when two or more wall jets meet and flow upwards together. Suckdown results from ambient air being pulled or entrained into the jet stream. Suckdown creates low pressure below the aircraft, sucking it downwards. The intensity of suckdown increases as the aircraft nears the ground where even more air can be entrained by the wall jet. Hot gas reingestion occurs when hot air from the combustion process enters the inlet. Reingestion reduces engine performance and can ultimately lead to engine stalls or flameouts.

"Our STOVL design may use the weapon bay doors to control the fountain and prevent hot gas reingestion," Eshleman explains. "Our high wing also helps to reduce the effects of suckdown. The shaft-driven lift fan design makes
this process much easier since it has intrinsically low hot gas reingestion temperatures.

"I've seen a lot of good STOVL configurations in the past," he adds, "but once out of the low-speed arena, they don't perform well. They have short range, small payloads, and low top-speeds. The trick is to balance the various design drivers—supersonics, maneuver, mission range, payload, STOVL performance, and signature—with weight and affordability. Our design does this very well. It is the best modern STOVL configuration I have ever seen. The shaft-driven lift fan propulsion system is long and skinny, so it packages well and doesn't require pumping air all over the airplane like many other configurations."

Much of Eshleman's confidence derives from his recent success with a large-scale powered model of the STOVL variant of JSF. The model structure, built at the Skunk Works, included a lift fan built by Allison, an aft nozzle and roll offtake system built by Rolls Royce, and a modified F100 engine provided by Pratt & Whitney, which also assembled the entire propulsion system and performed functional tests in West Palm Beach, Florida. The entire model was tested at two facilities at NASA/Ames in California. "A significant objective of the large-scale model was to demonstrate that we know how to put data from a variety of sources into a force-moment accounting system and get the right answer," Eshleman explains. "As a result of this testing, we don't have to do a large-scale model in the next phase. Our JSF configuration has not changed enough to require us to do this all over again. Instead, we will be working with small-scale models similar to those we are currently using. Our two demonstration aircraft, then, become our large-scale validation for the small-scale model tests."

Eshleman says the test results were better than predicted. "Suckdown was very close to what we expected," he explains. "Inlet performance was better, too. Most impressive, though, were the results from measuring hot gas reingestion. Those results alone justified the test program. Our outdoor hover tests provided about 1,500 additional pounds of hover margin for our design. We have hard data from many different sources that support our design."

---

**Barbara Faggart**

*Reliability, Maintainability, and Supportability*

**Barbara Faggart** has been a maintainability engineer for twelve years. She has worked the last five years as a project engineer for reliability, maintainability, and supportability, or RM&S, on a variety of aircraft programs, including advanced F-16 derivatives and Peace Marble IV (an Israeli F-16 program). She spent six months in Japan working on avionics supportability for the JSF.

For JSF, Faggart is applying her RM&S skills to the aircraft's low-observable treatments and avionics. "At this stage in the program," she says, "most people are making sure that the aircraft flies. I'm making sure that when it breaks it can be repaired in a cost-efficient and timely manner."

Faggart's initial task on the program was to develop a model for predicting maintenance associated with low-observable technologies. "We're looking at the whole aircraft, at its doors, external components (for example, antennas and air data probes), edges, and surfaces," she explains. "We're avoiding low-observable treatments that require maintenance personnel to remove and restore material from high maintenance areas. Such treatments have to be reapplied and could be
both time-consuming and costly. We're looking at door treatments that are basically transparent to the maintainer. In addition, we've minimized the number of access doors and panels by strategically locating the equipment. Our JSF has about two-thirds the number of access doors and panels of an F-16. And the majority of the JSF's panels are accessible from the lower surface.

"Our JSF design has a lot of good RM&S features," Faggart continues. "Our avionics are similar to those on the F-22. They are modular, lightweight, and highly reliable. In addition, we have as much commonality between and within our avionic subsystems as possible to reduce both design and support costs. Most of the avionic equipment is installed in accessible areas and can be removed and replaced by one person."

The multiservice nature of the JSF program is presenting its own challenges and rewards for choosing the best support equipment. "Interoperability doesn't necessarily make our choices any more difficult," Faggart says. "We have to decide which customer has the harshest environment when it comes to evaluating support equipment. Often, it's the Navy environment that drives these choices. But the other services end up benefiting from the design because these choices make their jobs much easier."

In the next phase, Faggart will be refining her analyses, as well as supporting the concept demonstrator aircraft. She will be involved in avionics and low-observable demonstrations as well.

"In the past, RM&S was considered to be a fallout of the design," Faggart says. "The situation has changed. RM&S people are now part of the design team. The subject has to be considered up front because it ends up saving a lot of money and avoids expensive redesigns in later program phases. Life-cycle cost is a big driver for this program. And our customers understand the role RM&S plays in determining those costs."

### Paul Bevilaqua
**Lift-Fan System Inventor**

Paul Bevilaqua could claim that he has been working on the Marine and Royal Navy variant of the Joint Strike Fighter since 1985, when he began researching short takeoff and vertical landing technologies on a NASA project at the Skunk Works. His subsequent work led to a patent in 1990 for the lift-fan concept used in the Lockheed Martin STOVL variant.

"The goal of those early studies was a supersonic STOVL aircraft," Bevilaqua explains, "but at that point, we were designing airplanes, not inventing propulsion systems. Several companies were conducting similar studies. Everyone was reworking old concepts or looking at new concepts that didn't provide any real advantage. NASA was disappointed in the lack of innovation."

As these studies ended, the Advanced Research Projects Agency asked the Skunk Works if it could come up with any new ideas. "We started from the beginning," Bevilaqua recounts. "First, we looked at all the old ideas that hadn't worked and tried to understand why they hadn't worked. From that study, we made a list of requirements for an ideal supersonic STOVL propulsion system.

"Then we used a variety of brainstorming and creativity exercises to come up with a new concept," Bevilaqua continues. "The technique that worked broke the problem down into its fundamental elements. Since modern fighters have a thrust-to-weight ratio greater than one, the basic problem is to get half of the thrust from the back of the airplane to the front. The simplest solution is to duct it there, but ducting makes the airplane too wide to go supersonic. So we looked for other ways to extract energy from the back, transfer it to the front, and produce lift."

---

*30 July 1996*
“We generated a lot of wild ideas involving energy beams and superconductivity,” Bevilacqua says, “but none worked out until we looked at a variable-pitch turbine to extract power from the jet exhaust. From that point, everything just started falling into place.”

From these ARPA studies, the Skunk Works recommended two STOVL approaches: a gas-driven fan and a shaft-driven fan. ARPA liked both of them. “We thought the shaft-driven fan was the better concept,” Bevilacqua says. “However, the gas-driven fan was perceived as being less risky. Propulsion engineers are familiar with ducting gases through an airplane. But the idea of shafting 25,000 horsepower was new. People were uncomfortable with the magnitude of the number. But there’s really little to fear. The shaft inside a jet engine is already transferring around 75,000 horsepower.”

A lift fan concept solves two STOVL-related problems at once. “The lift fan system efficiently transfers thrust from the back of the airplane to the front,” Bevilacqua explains. “At the same time, it increases the total thrust of the engine because it increases the bypass ratio from a relatively low one associated with fighter engines to a high one for vertical flight. In other words, it makes the airplane more like a helicopter in the vertical mode.

“The Harrier takes a similar approach,” Bevilacqua continues. “It has a large fan to augment the thrust of a small engine core. But the airplane has to live with that fan in the cruise mode. Because the fan is so large, the airplane can’t go supersonic.

“Our lift fan approach is like taking one large fan on the Harrier’s engine, breaking it into two smaller fans, and turning off one of the smaller fans when the airplane converts to the cruise mode,” he explains. “The concept doesn’t compromise the other JSF variants. Our STOVL concept requires twin inlets, what we call bifurcated inlet ducts, to create the space needed for the lift fan. That is the only design requirement. And bifurcated ducts have low-observable and performance advantages that improve all of our JSF variants.”

Troupe Trice
Composite Manufacturing Technology

Troupe Trice has been researching and developing composite technology for over ten years at Lockheed Martin. “Our actual group name is producibility,” says Trice, who is a manufacturing engineer in the group. “Our goal is to keep airplanes affordable and easy to build.”

Each engineer in Trice’s group has a technology for which he or she is responsible. Trice’s specialty is fiber placement, a computer-controlled process for laying up composite materials. “The process will play a pretty big part in the composites for JSF,” Trice explains. “The inlet ducts, a lot of the skins, and a lot of the complex contours of the airplane will likely be fiber-placed.

“Composites normally equate to higher material costs,” he continues. “We need inexpensive fabrication methods to offset those costs. And the process has to offer other advantages as well. Fiber placement minimizes recurring fabrication costs. And the quality is more consistent. It is better at meeting engineering specifications, like fiber orientation.”

Trice views composite technologies with a cautious eye. “We don’t want to automate for the sake of automation,” he says. “We want to selectively use new
technology to reduce cost. We want to use the technology for what it is best intended. We're trying to automate repetitive tasks, so people can perform more flexible and less repetitious assembly work. We're avoiding one-of-a-kind manufacturing machines. We want to use commercially available equipment. Designing the part and simultaneously developing the process to manufacture it can cause problems.

"Most of the manufacturing processes we are looking at are fairly mature," Trice continues. "We're not developing processes. We are figuring out how to apply them to specific parts."

The JSF's inlet duct is a prime candidate for fiber placement. "We're keeping the inlet duct as simple as possible," Trice says, "which goes with our unitized structure philosophy. That is, we want bigger and fewer pieces that can be assembled more quickly. Unitized pieces have other attributes. They produce a structurally stronger airplane because they result in fewer seams. And fewer seams gives the aircraft better low-observable qualities."

Trice's work becomes more refined in the next phase of the JSF program. "We're doing more detailed trade studies," he says. "We're using what we have learned from the trade studies to select the best processes for manufacturing specific portions of the airplane. And we're using those processes to actually build portions of the demonstrator aircraft.

"I'm really looking forward to the next phase," Trice says. "We will start seeing more hardware. We will see our demonstrator aircraft fly. I'm working on the next airplane, a fighter my son could end up flying. Manufacturing engineers are going to have a lot to do."

Bill Saathoff

*Airframe Affordability Demonstrations*

Bill Saathoff has been working to improve manufacturing methods and technologies for over ten years. He spent several years applying his talents on the National Aerospace Plane program.

Saathoff will be working on an airframe affordability demonstration in the next phase of the program. The demonstration is one of several unique demonstrations for the next phase of the JSF program. These unique demonstrations address risk areas that do not need to be addressed on the flying demonstrator aircraft.

Saathoff's demonstration involves the construction of wing structures and extensive studies on low-cost manufacturing methods on sections of the fuselage. "We will try to replicate the way we will eventually build the aircraft—down to the tools, materials, and processes," he explains.

"In the old days we made everything in the factory," he notes. "We even made our own rivets. It would be unthinkable, given this approach, to build an F-16, AV-8B, and an F-18 on the same assembly line. Having an Air Force
a aircraft coming down a single assembly line with a Navy and a Marine airplane right behind it forces us to focus on commonality in the design, integration, and assembly. So, we’re not looking at a single production line for the JSF in a classic sense. It is more accurately called a single assembly line.

“Our F-16 production team deserves a lot of credit for our JSF approach,” says Saathoff. “By streamlining production and working with quality vendors, they managed to lower costs significantly even as production rates plummeted. No other aircraft program can make that same claim. We plan on building on this experience in our demonstration and on the JSF program in general.”

This pragmatic approach to production applies to the design as well. “We don’t have to shock the customer with the latest technology,” Saathoff says. “We’re making some conventional design and manufacturing decisions because they are the most affordable and will do the job. Our design has a lot of machined aluminum and proven composite technology. We may improve the process for machining the metal if it lowers the cost, but that doesn’t necessarily imply some super-advanced high-risk process either. Some may see this approach as boring. But it’s smart.

“Low risk is not normally associated with fighter aircraft,” Saathoff continues. “And neither is affordability, unless you’re talking about the F-16. We can improve a lot on the F-16 by simply being smarter in our design process. The airframe affordability demonstration serves this purpose. We are, essentially, re-engineering the engineering process to make it more streamlined and efficient. My demonstration represents an opportunity to try out many of the new processes for the next lightweight fighter.”

Mike Skaff

Mike Skaff, a former USAF F-16 pilot, has been working pilot-vehicle interface, or PVI, since he joined the company seven years ago. His initial work was on the Block 50 F-16. He has also worked on the F-16 Mid-Life Update program for the Europeans, the F-22, and F-16 night attack cockpits.

“PVI concerns the cockpit displays and how pilots interact with them and with the cockpit controls,” explains Skaff. “We have to work hard in a single-seat airplane not to overtask the pilot. Pilots are quick learners, but that doesn’t give us liberty to do anything we want because they can figure it out. As the F-16 integrates more sensors—targeting pods, navigation pods, and better radars—pilots can turn into sensor managers, almost like computer operators. My job is to make sure pilots can be tacticians. In other words, I want to give them the information they need to take tactical decisions. We define tactics as the operations the pilot executes that result in victory.”

Skaff and his coworkers have used a mission reconfigurable cockpit at the company’s simulator lab to integrate a variety of advanced fighter cockpit concepts. They have investigated touch screens, three-dimensional audio, voice control, virtual head-up displays, and color displays, to name a few technologies.

“A lot of pilots have flown these systems in our lab to help us differentiate the good from the bad,” says Skaff. “Three-dimensional audio shows great promise. Virtual head-up displays incorporated in a helmet-mounted system also show promise. Voice control works extremely well for controlling what we call housekeeping functions, things like changing radio channels and displays.”
Voice control doesn't work well for tactical operations in the heat of battle."

Much of Skaff's work involves incorporating existing technologies into a fighter environment. Active noise canceling is one example. General and civilian aviation have used this technology for several years to lower the sound levels in aircraft. Color displays are another example. Skaff is looking at a variety of color display sizes and placements in the JSF cockpit.

He is also closely reviewing PVI issues related to specific services. "In hover mode," says Skaff, "the pilot does not have much time to make the decision to eject. The Russians have used auto ejection systems successfully on their STOVL aircraft for several years. That system will make for a good JSF trade study. We are also looking at an auto approach and auto landing mode. This flight mode is nothing new for the Navy, but it has never earned its way onto an Air Force fighter."

For the next phase of the program, Skaff will be focusing on the head-up display for the demonstrator aircraft and on the handling qualities simulator. "We have just finished getting the F-16 head-up display certified as a primary flight reference," he says, "so we have studied the issue in depth and have worked with the USAF to write military standards for it. In the next phase, we will continue our work with fighter pilots from all service branches and from our own flight test department. Our biggest challenge is getting all the services to agree on a single set of PVI requirements. We want to satisfy everyone with an airplane that can perform and survive, which is everyone's primary objective."

---

**Dennis Eicke**

*Integrated Subsystem Technologies*

Dennis Eicke calls himself a subsystems guy. He's worked most of his fifteen years at Lockheed Martin on preliminary aircraft designs in the advanced design department. He was involved in the early stages of the Advanced Tactical Fighter program and on several new aircraft and F-16 derivatives.

Eicke is the chief engineer for the JSF Integrated Subsystem Technologies program. Very simply, those involved in this program are replacing thirteen systems found in conventional fighter aircraft with five. They are also eliminating most of the hydraulic lines from the aircraft.

"Advances in power electronics, generator technology, and software development make this simplification possible," Eicke explains. "We've been working on integrated system technology for the past nine years. The technology is seen as aggressive, and that's what caught the attention of the JSF program. Integrated subsystems is the number one technology maturation activity for JSF. The government is supportive and impressed with our work so far."

Lockheed Martin's part of this integration effort involves two major systems—switch reluctance starter/generator and electric actuation. The government has selected Lockheed Martin to do a flight demonstration of the systems on the AFTI/F-16. Eicke's team starts integrating the systems on the aircraft in mid-1998. The first flight is scheduled for the first quarter of 1999.

"The F-16 is called 'the electric jet' because of its fly-by-wire flight control
system,” Eicke notes. “The AFTI/F-16 will become the world’s first ‘more-electric jet’ when we replace its hydraulic system with a power-by-wire flight control system.”

The electric actuation system will replace all five of the AFTI/F-16’s primary flight control actuators. Each electric actuator has its own motor and pump and is controlled by signals sent through a wire. “At a component level, this doesn’t look like a simplification,” Eicke notes. “We are replacing a very simple integrated servoactuator with a more complex actuation system that contains its own motor, electronics, and pump. We are not simplifying the actuation system. But we are eliminating a big distribution system and all the hydraulics associated with it.”

Electric actuation, power generation, and the integrated subsystems technologies shave about 400 pounds of weight from the aircraft at the system level. Since integrated systems require less space and less airframe structure to support them, the approach saves about 2,200 pounds at the aircraft level.

“But our biggest savings come from reduced support requirements,” Eicke says. “Our studies show a three to five percent life-cycle cost reduction by incorporating these technologies. That translates into billions of dollars over a twenty-year operational life.”

Electric actuators have been around for a long time. Lockheed Martin has flight-demonstrated them on a C-130 and on a C-141. But the hardware is just now getting to the point of sufficient capacity and density to be used in fighter aircraft. The challenge facing Lockheed Martin engineers is similar to the one they faced when integrating the fly-by-wire system on the F-16. Eicke expects similar success.

Pat Tait
Flight Control Systems

Pat Tait has been working on flight control systems at the Skunk Works since 1983. He worked on the F-117, YF-22, and on the ASTOVL effort that preceded the JSF program. He has also worked on the flight controls for Lockheed Martin’s single-stage-to-orbit program. His work on the JSF focuses on the low-speed flight control system for the STOVL variant.

“These days airplanes have a lot of control surfaces,” Tait explains. “To get the best flying characteristics out of a design, we have to determine which surfaces to use and how much to use them in a variety of flight conditions. More simply, the airplane may have six things to wiggle but it moves in only three axes. Our STOVL design, for example, has to control thrust split between the forward fan and the aft engine, thrust differential from side to side through the roll ducts, nozzle angles, yaw thrust angle, and positioning of the ailerons, horizontal tails, and rudders. Some of these control effectors, as we call them, play a large role at higher speeds. Others are critical at lower speeds. We have to blend their contributions to get the desired effects.”

Another part of Tait’s job is determining how the control of these effectors are automated for the pilot and integrated into the cockpit. “Someone once said that the goal of a flight control designer is to irritate all pilots equally,” he says. “Pilot integration is a real challenge. We have to balance our ability to provide better handling qualities and simpler pilot-vehicle interfaces with vehicle performance and flexibility. We want the controls to be as simple as possible. However, we don’t want to sacrifice flexibility. The Marine STOVL community has seen a lot of research for optimizing the cockpit.”

Much of the research has involved what is called two-inceptor approaches to vertical flight control. An inceptor is any device, such as a throttle controller, used by the pilot to control the airplane. The standard AV-8B uses three inceptors in the hover mode—a throttle, stick, and a thrust diverter. “We started out with two and a half inceptors in our earlier ASTOVL program,” Tait explains. “We used a stick, throttle, and a thumbwheel on the throttle. Since then, we have been focusing on a three-inceptor approach for our flight demonstration aircraft to reduce risk and to make sure we maintain flexibility. We’ve had some good results.

“In the next phase of the program, we will mature our design,” Tait continues. “We will be looking more closely at blending vertical and up-and-away flight control architectures. We’re going to be quite busy.”
Events

DC F-16s Deploy To Middle East

The 113th Fighter Wing of the District of Columbia Air National Guard became the first ANG F-16 unit to deploy to Operation Southern Watch last March. The mission is to uphold United Nations resolutions through surveillance of Iraq below the 32nd parallel and to reinforce Iraqi compliance of the coalition-directed no-fly zone. Active USAF units, US Navy carrier battle groups, and air forces from Britain and France are also involved in the operation. The 113th sent aircraft and pilots from its 121st Fighter Squadron as well as its own maintenance, operations, and ground crews. In theater, F-16 pilots averaged over ten combat missions each and accumulated 400 hours in more than 100 combat sorties.

While deployed to the Middle East, the 113th also participated in a ten-day joint exercise with the United Arab Emirates. The exercise, called Iron Falcon '96, demonstrated flying capabilities and practiced command and control with UAE partners. The 113th maintained an impressive 99.6 percent fully mission-capable rating during the deployment.

Egypt Orders More F-16s

The governments of Egypt and the United States signed an agreement in May providing for the sale of twenty-one new F-16 aircraft to the Egyptian air force. “We are proud that Egypt has again selected the F-16 to continue the modernization of its air forces,” said Dain M. Hancock, president of Lockheed Martin Tactical Aircraft Systems. “This is Egypt’s fifth order of F-16s over the last fifteen years, which makes an unmistakable statement about customer satisfaction. In fact, there have now been twenty-two occasions where previous F-16 international customers have returned for additional orders of F-16 aircraft. This says a lot about the quality, performance, and supportability provided by the USAF/Lockheed Martin team and the F-16.” The new Egyptian aircraft will be manufactured in Fort Worth. Deliveries begin in 1999.
First XF-2 Delivered To JASDF

Mitsubishi Heavy Industries Nagoya Aerospace Systems delivered the No. 1 prototype aircraft of the F-2 support fighter to the Japan Defense Agency in ceremonies in March at Mitsubishi's Komaki South Plant in Japan. The aircraft was flown from Gifu Air Base on 26 March by XF-2 project test pilot, Maj. Teruyoshi Miwa, a graduate of the USAF Test Pilot School. Government and industry officials from Japan and the United States were present at the delivery ceremonies. The Japanese Cabinet approved a 130-aircraft production program and designated the FS-X production aircraft as the F-2 in December 1995. The four prototype aircraft are designated XF-2.

The fourth XF-2 made its initial flight on 24 May from Nagoya Airport. The No. 4 aircraft is the first to fly with a cocured composite wing box manufactured by Lockheed Martin Tactical Aircraft Systems in Fort Worth.

Lockheed Martin is the principal US subcontractor for Japan's FS-X program. MHI is the prime contractor. All of the aircraft are being assembled at its Nagoya Facility. Lockheed Martin is also the licensor of the original F-16 design that represents the baseline from which the new fighter has been developed.

The wing box demonstrates successful transfer of the innovative cocuring technology from Japan to the United States. In cocuring, composite parts are bonded together without conventional metal fasteners, promoting weight savings and simplicity in final assembly.

Manufacturing experience from the FS-X development program already has been applied to F-22 parts production and development projects related to Lockheed Martin's next-generation Joint Strike Fighter.

Belgian 1st Fighter Wing Hosts Its Last TDPU

The Tactics Discussions and Procedures Update, hosted by the 1st Fighter Wing of Beauvechain AB, Belgium, brought together an impressive gathering of NATO's finest air forces in early March. Belgium, the United States, Britain, Germany, Greece, the Netherlands, and Portugal participated in the event. These countries sent a variety of aircraft, including F-16 Fighting Falcons, F-15E Eagles, F-104 Starfighters, MiG-29 Fulcums, F-3 Tornados as well as KC-135 tankers, AWACS aircraft, and Sea King helicopters. The purpose of TDPU is to align the air defenses of NATO countries, to standardize procedures, and to combine, evaluate, and modernize tactics. The exercise, which involves composite air operations and dissimilar air combat training, highlights NATO's ability to combine assets from various air forces into effective strike packages. The TDPU was the last big exercise for the BAF's 1st Wing before it was dissolved under a restructuring plan. F-16s from the wing will move to Belgium's two other existing F-16 bases—Kleine Brogel and Florennes.
Capt. Cline, Maj. Post, Maj. Mortell, and Col. North (left to right) pose in front of the flagship for the 13th FS after their record-breaking flight.

Misawa Breaks Four-Ship Record

Four experienced pilots from the 13th Fighter Squadron Misawa AB, Japan, took off together on 31 May and broke the record for the most F-16 hours in a four-ship by an active duty squadron. The 9,295-hour mark was set by
Col. Gary North (3,012 hours)
Maj. James Post (2,244 hours)
Maj. Dave Mortell (2,230 hours)
Capt. Mark Cline (1,809 hours).
The record (8,517 hours) was previously held by the 555th FS at Aviano Air Base, Italy.

Col. Maple and Majs. Loida, Undhjem, and Henabray (left to right) relax after their record-setting flight.

Luke Sets Another USAF Four-Ship Record

Four F-16 pilots from the 944th Fighter Wing at Luke AFB, Arizona, established a new USAF record for the most F-16 flying hours in a single four-ship. The 10,729-hour mark was set by
Maj. Lance Undhjem (3,125 hours)
Maj. Kevin Henabray (2,861 hours)
Maj. Michael Loida (2,587 hours)
Col. Dennis Maple (2,155 hours).
The record flight was achieved during Maple’s retirement flight on 9 March.

F-16 “ST” Tail Code

F-16s at Sheppard AFB in Texas acquired the latest F-16 tailcode last March. The ST code, which stands for “Sheppard Team,” is displayed by the ground-based F-16s of the 82nd Training Wing. The aircraft are used to train maintenance personnel.

Berlin Air Show

Lockheed Martin Test pilot Steve Barter demonstrated high-performance maneuvers daily in an F-16 Block 50 at the ILA ’96 Air Show in Berlin in May. Barter’s F-16 came from the 52nd Fighter Wing based at Spangdahlem AB, Germany. A second F-16 from Spangdahlem was on static display at the show. Pictured is one of the Spangdahlem show F-16s next to a Russian Su-35.
Six More 3,000-Hour F-16 Pilots

Since our last issue, six fighter pilots have joined the exclusive 3,000-hour F-16 club. Total membership stands at ten. Maj. Max Wilhelmsen of the Danish air force reached the mark on 24 January 1996. Wilhelmsen, who is forty-eight, started his flying career in 1968 and has amassed a total of more than 5,100 hours in a variety of fighters. Most of the F-16 pilots flying for the RDAF today have been trained by Wilhelmsen, who began flying the F-16 in 1980.

On 21 March, Maj. Russ Prechtl of the F-16 Combined Test Force at Edwards AFB, California, became the first test pilot to reach the 3K mark in the F-16. His milestone occurred during a flight test mission in a Block 50 F-16C.

Lt. Col. William Rew, the F-16 division commander at the USAF Weapons School at Nellis AFB, Nevada, reached the mark on 27 March during a training mission at Nellis. Rew began flying the F-16 in 1980 at Hill AFB in Utah. He accumulated all of his last 1,000 hours at Nellis at the Weapons School.

Col. Gary North, operations group commander for the 35th Fighter Wing at Misawa AB, Japan, hit 3,000 hours on 19 April. "Aviators clock things in 1,000-hour increments," noted North after his flight. "One thousand hours in a fighter is a right of passage. Two thousand hours means you've been in it for a long time. Three thousand hours means you're getting old."

The ninth and tenth pilots to reach 3,000 hours in the F-16 did so in the same flight. Majs. Doug Dean and John Adkisson, both ANG instructor pilots at the 114th FS at Klamath Falls, Oregon, have been flying the F-16 since 1981. Upon landing, their total hours differed by only six minutes. (For those keeping the "list," Dean reached the mark first.)

Lockheed Martin
Meets ISO 9001
Quality Standards

Lockheed Martin Tactical Aircraft Systems has been certified by the British Standards Institution as meeting the requirements of the ISO 9001 quality standard, following an intensive audit process conducted at the Fort Worth, Texas, plant last April.

"We are told that we are the first US fighter manufacturer to receive ISO 9000 or ISO 9001 registration from an outside, independent third-party," said Dain M. Hancock, president of Tactical Aircraft Systems.

ISO 9001 is an internationally recognized standard for quality and is being used in lieu of military specifications, which are being phased out under DOD acquisition reform initiatives. "Implementing an ISO 9001 quality management system ensures that our customers can maintain trust in our products as we move toward commercially based, non-military manufacturing and procurement practices," Hancock said. "Registration by an independent organization, such as the British Standards Institution, strongly validates the integrity of our quality system."
**F-22 Mid-Fuselage Takes Shape**

The third of three modules comprising the mid-fuselage of the F-22 is mated at Lockheed Martin Tactical Aircraft Systems in Fort Worth. The modules will remain in the pictured mate fixture until the entire mid fuselage is moved as a single structure to an installation station where electrical, hydraulic, and environmental control systems as well as the auxiliary power unit and various other systems will be installed.

The mid-fuselage will be trucked to Lockheed Martin Aeronautical Systems in Marietta, Georgia, in August for mating with other portions of the first F-22 engineering manufacturing development aircraft. First flight of the EMD aircraft is scheduled for mid-1997.

---

**Semper Viper Nominations Due**

Nominations are now being accepted for this year's Semper Viper Award for Outstanding Airmanship. The award pays tribute to pilots demonstrating airmanship skills noteworthy of its namesake, the late Joe Bill Dryden. A selection panel from Lockheed Martin Tactical Aircraft Systems will evaluate candidates who carry on Joe Bill's tradition of excellence in airmanship and system knowledge.

The winners of the 1995 award were Maj. Robert Nolan and Capt. Gerald Swift of the 39th Flight Test Squadron at Eglin AFB, Florida. Candidate applications for the 1996 award should be mailed to the Code One editorial office (see page 1 for the address). Applications should include complete information describing particular missions or outstanding aviation skills demonstrated by the nominee.

Receipt of nominations will be acknowledged by the selection panel. The award will be presented this year at the Viper Driver Reunion and Symposium on 25 September at the Wigwam Hotel in Litchfield Park, Arizona.

---

**F-111F Goes To USAF Museum**

An F-111F from Cannon AFB, New Mexico, headed to Wright-Patterson AFB, Ohio, last May for its final flight. The aircraft will eventually be placed on permanent display at the USAF Museum there. This particular F-111F (Tail No. 70-2390) was selected to represent the Aardvark at the museum because of its extensive and distinguished combat record. The F-111F was the lead aircraft in Operation Eldorado Canyon, the attack on Libya from bases in England in 1986. The aircraft was assigned to the 495th TFS at Lakenheath AB at the time.

Tail No. 390 was also the lead F-111 that deployed to Taif, Saudi Arabia, on the first day of Operation Desert Shield in August 1990. During the Gulf War, the aircraft completed twenty-nine combat sorties and destroyed fifty-eight targets in confirmed hits. The aircraft was flown to the museum by Lt. Col. Bob Brewster of the 27th FW logistics group and Maj. Fred Cheney of the 27th FW operations support squadron.

On a related note: A farewell celebration for the F-111 is scheduled for 26 to 28 July in Fort Worth. More information will be available through Cannon's 27th FW's homepage on the Internet (www.cannon.af.mil) or by calling (505) 784-4131.
**Turkey Makes History**

During the first part of March 1996, the Turkish Air Force made history as the first foreign air force to ferry F-16 aircraft from the United States to its homeland, using only that country’s resources. Two F-16Cs returned home following a long-term loan to USAF for weapons testing.

I was very pleased to be a member of the all-Turkish air force team supporting these aircraft on their long journey, including five air refuelings by a Turkish KC-135R tanker. During the trip, I was able to take a few photos from the boomer’s window. One is enclosed.

Hakki Bacalsiz
Six Jet Base
Bandirma AB, Turkey

**Technical Insight**

I want to congratulate you on the great job you did in the April Code One article “F-16 Reconnaissance at Richmond.” Tactical reconnaissance is a unique specialization and I spend a large part of my day explaining to customers, operators, and users the intricacies of this technology. It is, therefore, a great pleasure when an article such as yours is published. It clearly presents the reconnaissance mission and provides concise insight into the technology that makes it happen.

The F-16 reconnaissance pod program required true team spirit. Pilots, photo interpreters, and technologists all had to do their part. Your article captured that spirit. We at Recon/Optical are proud to be part of the team.

Andy Larea
Recon/Optical, Inc.
Barrington, Illinois

**Fulcrum Fallout**

I am an aviation writer and the former editor of *World Air Power Journal*. I am currently preparing a book on the MiG-29 Fulcrum and an article assessing the combat capability of the aircraft for *World Air Power Journal*. The article will be based partly on interviews I conducted with John Fatley, a former BAe Harrier project pilot and chief test pilot, and Bob Wade, former Canadian air force F/A-18 pilot. Both men have flown the MiG-29, albeit not in combat or in a combat environment.

Your photo feature in *Air Force Magazine* [September 1995] prompted a great deal of thought and action, as you can imagine. As a result, I interviewed Lt. Col. Gary West, Capt. Will Sparrow, and Capt. Mike McCoy at some length.

Shortly after interviewing Sparrow, I saw your piece in a recent issue of *Air Force Monthly*. May I offer you my sincere congratulations on a job well done?

Jon Lake
Benson, England

*Editor's note: Congratulations accepted. Our article on the MiG-29F-16 encounter in Italy last year generated several reprints in various forms. Lt. Col. West is still recovering from all the attention.*

**Consolidated Memories**

When I hired in at Consolidated-Vultee in mid-1951, the last of the B-36 bombers were on the assembly line and the last one was started at the fifty-foot aisle. I climbed into the wheel well of one of the aircraft on the assembly line when we tested the landing gear fold-up. So I saw the airplane up close, but never got a ride in one.

I retired from the company in 1990. I still have, somewhere in my collections, a first flight cover of the B-36. Only twelve were made. I’ll have to dig it up for the reunion.

Thank you for including more information on the upcoming 10 August celebration.

Emmett C. Hinckley, Jr.
Fort Worth, Texas

*Editor’s note: The reunion is still slated for 10 August at the Will Rogers Round-Up Inn in Fort Worth. The reception begins at 7 p.m. Tickets for the event are $15 per person. Call 817-777-8400 for more information.*

**Good As Ever**

Thank you for an excellent magazine. Having been on your mailing list almost since Volume 1, when my company at Kongsberg in Norway integrated and tested the Penguin antiship missile on the F-16A/B, I wondered what the Lockheed Martin “takeover” might portend for your publication. The answer: *Code One* is as good as ever!

One thing is sorely missed: Joe Bill Dryden's *Semper Viper* articles. Please tell me whether copies are still to be had of the special edition of his work.

Per Nyhus
Kongsberg Gruppen ASA
Kongsberg, Norway

*Editor’s note: Some copies are still available for $7.50, which includes shipping.*

**P-3 Cola**

I took a copy of *Code One* home to share with my husband, who is an airplane buff. He read the entire issue with great interest. Now that he is retired, he indulges in his hobby of building airplane models out of beer and soda cans. He has sold several P-3 models to personnel at the Brunswick, Maine, Naval Air Station. We understand that two of those models were taken to the Pentagon when their owners were transferred there.

He asked me to send along the enclosed photograph. I believe the P-3 is a Lockheed Martin product. Because authenticity would be so difficult to achieve, he has avoided trying to build jet planes. He has, however, built P-47s, B-17s, helicopters, and a few triplanes.

Lorraine Stickney
Gorham, Maine

We’d like to hear from you. Send letters to: Editor, *Code One* Magazine
Lockheed Martin TAS
PO Box 748, Mail Zone 1224
Fort Worth, Texas 76101