JANUARY 1991/$2

AIR FORCE MAGAZINE

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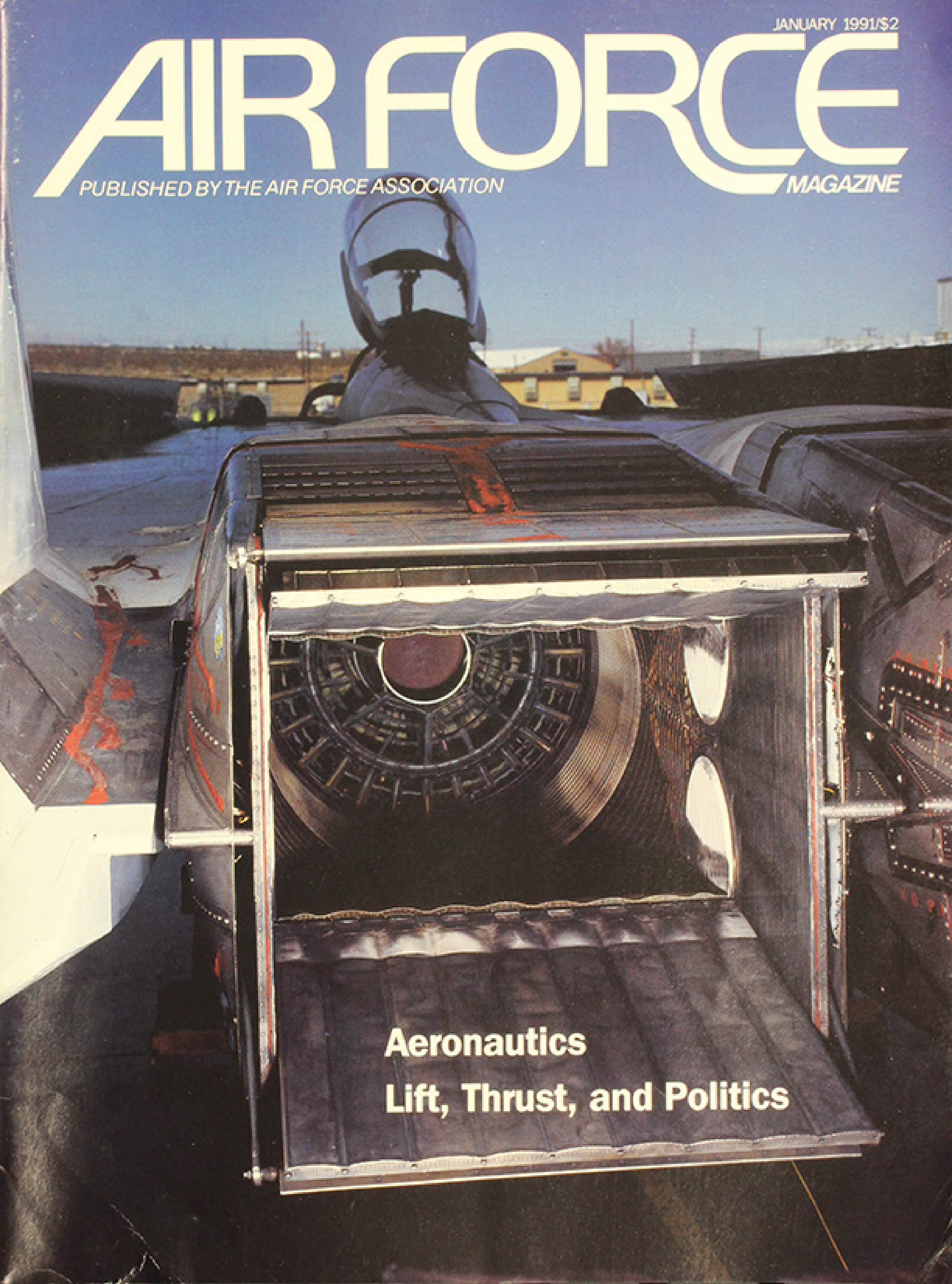
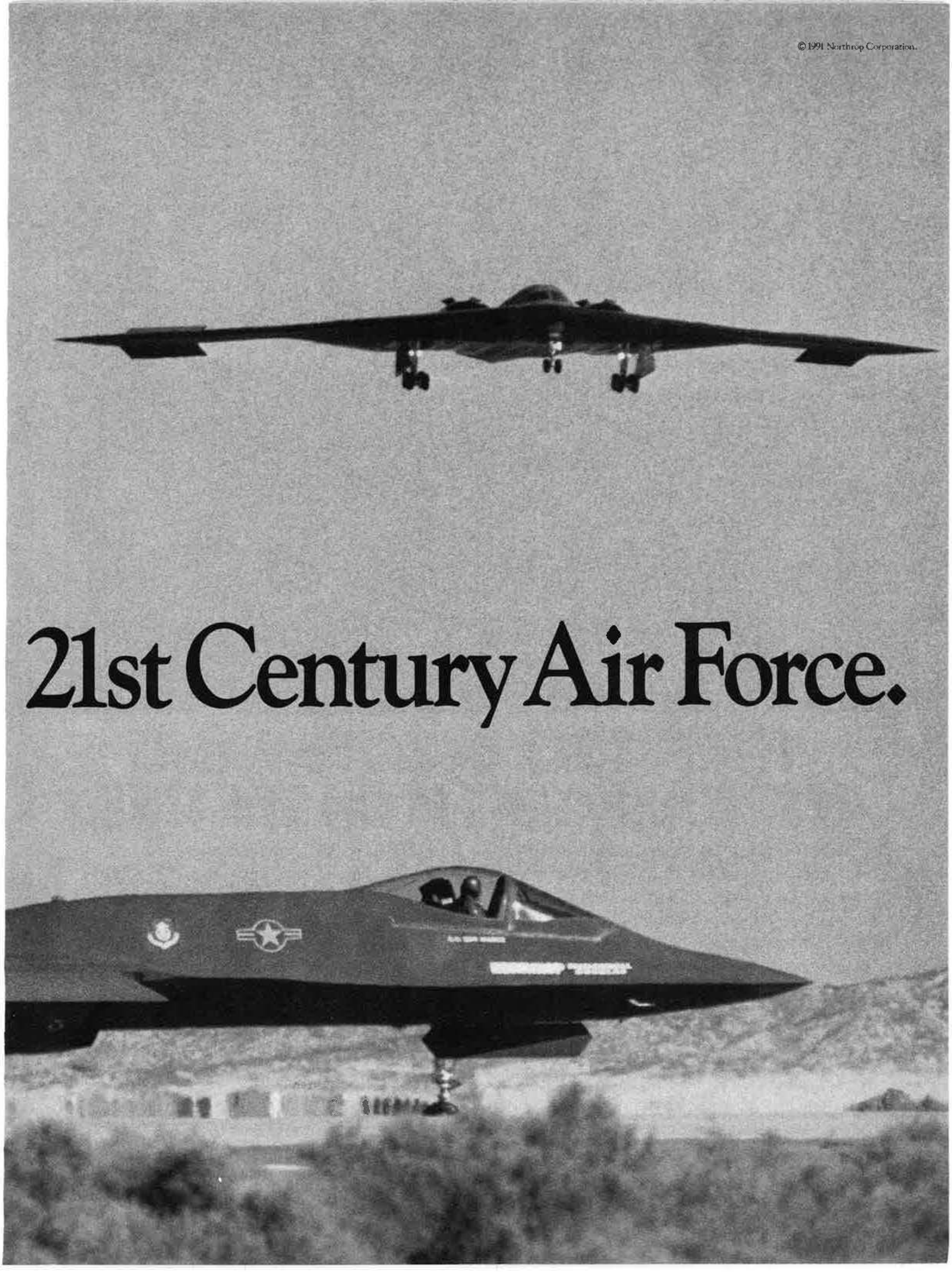


Aeronautics

Lift, Thrust, and Politics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January 1991, Vol. 74, No. 1

AIR FORCE MAGAZINE

PUBLISHED BY THE AIR FORCE ASSOCIATION

Departments

About the cover: This month's cover shows a two-dimensional, vectored-thrust nozzle on the F-15/Eagle STOL Maneuvering Technology Demonstrator. For more on the possible applications of vectored thrust, see p. 54. Photo by Anand Singhkhalsa/Arms Communications.

Aeronautics: Lift, Thrust, and Politics

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Editorial

By **John T. Correll,** Editor in Chief

The Indictment of Airpower

THE AIR FORCE, a separate service since 1947, is still answering basic questions about its legitimacy and effectiveness. In the past year, the indictment of airpower has been strident.

The military reform analyst Dr. Jeffrey Record ticked off a whole laundry list of accusations in "Into the Wild Blue Yonder: Should We Abolish the Air Force?" in the Spring 1990 issue of the Heritage Foundation *Policy Review.* Since then, other critics have picked up the theme.

Surveying Persian Gulf strategy options in the *National Journal,* David C. Morrison sneers at the Air Force's performance in three wars and wonders why "this history of costly failure does not deter airpower advocates." In a September column, strategist Harry G. Summers warns against "the fanciful notion that a war can be won quickly and decisively by the use of airpower alone."

Summing up for the prosecution in the Baltimore *Sun* October 5, Dr. Record charges that "the history of Air Force claims for what airpower can do has been one of inflated expectations followed by postwar alibis."

This might be shrugged off as media speculation except that it corresponds with a certain chariness about airpower that seems to be developing among some in Congress and elsewhere in government. Ignoring it would be a mistake.

The main allegation is that *airpower is not decisive.* What exactly is this supposed to mean? That the Air Force did not win all by itself in World War II, Korea, and Vietnam, or merely that its contribution was marginal?

If the criterion is single-handed victory, then no arm of service is decisive in modern warfare. If the definition is something else, the commentator-critics have not made a convincing case. In support of their point, whatever it is, they dig up again the tired old theory that the strategic bombardment of Germany in World War II was irrelevant.

Among those who repudiated that notion was Albert Speer, Hitler's Minister of War Production. He said the bombing was tantamount to an additional front, destroying nine percent of his total production capacity and tying up 900,000 troops, 10,000 pieces of artillery, a third of the optics industry, and half of the electronics industry. To that add damage done directly to German forces, logistics, and railroads.

Would you rather fight an enemy on the ground before or after the Air Force hits him from the air?

Dr. Record tells us that "Germany's decision to capitulate came only with its conquest on the ground." Well, yes, but it took a combined arms effort to put Allied armies on the Oder and the Elbe. The Normandy invasion, for example, would have gone much harder had not a three-month air campaign almost completely neutralized the Luftwaffe before D-Day.

It is outrageous to claim, as Dr. Record and others do, that subsequent wars, especially Vietnam, demonstrated a failure of airpower. Vietnam did not prove much of anything about war except that politicians make poor generals.

In measuring decisiveness, the commentators might ask themselves two questions: Would the absence of airpower tend to make a difference in modern warfare, and would they prefer to fight an enemy on the ground before or after the Air Force hits him from the air?

The second allegation is that *airpower has been oversold.* There is some truth to that, particularly if one uses seventy years of hindsight to punch holes in Giulio Douhet's *Command of the Air,* published in 1921. Douhet and other early thinkers did promise too much, but their vision was closer to reality than that of their traditionalist contemporaries who said military airpower was no more than a novelty.

Some advocates of airpower overstate their case on occasion, but the same is true of those promoting seapower, land power, and any other social, political, economic, or military concept you can name. Even analysts and newspaper columnists have been known to push a point to excess.

The real issues are whether today's Air Force leaders claim airpower can win alone and if they promise more than they can deliver. In the estimation of this magazine, which has followed the subject more closely than most, the Air Force has *not* made such claims.

Dr. Record, analyzing the Persian Gulf problem in August, found airpower "the single most important comparative military advantage we have over Iraq." In a later epistle, he describes airpower as "absolutely indispensable to military power as a whole. Airpower may not be able to win wars by itself, but try winning one without it." That is approximately what the US Air Force has been saying all along.

No one seriously questions the value of airlift or the advantage of air superiority over a battlefield. The importance of speed, range, and flexibility in military strategy should be obvious. These qualities are intensified in airpower. Projecting force over long distances is useful not only in fighting wars but also in deterring them.

The other combat arms have important qualities, too. Talking with this magazine in August, for example, Gen. Michael J. Dugan, former Air Force Chief of Staff, cited persistence as a special strength of armies and recognized the mobility of naval forces but added that nothing beats airpower when you need to "deliver a big punch between the eyes."

It is pointless to argue about single-dimension strategies or whether individual services are "decisive" in isolation. Wars are not fought that way. The longer you look at the rambling indictment of airpower, the less sense it makes. ■

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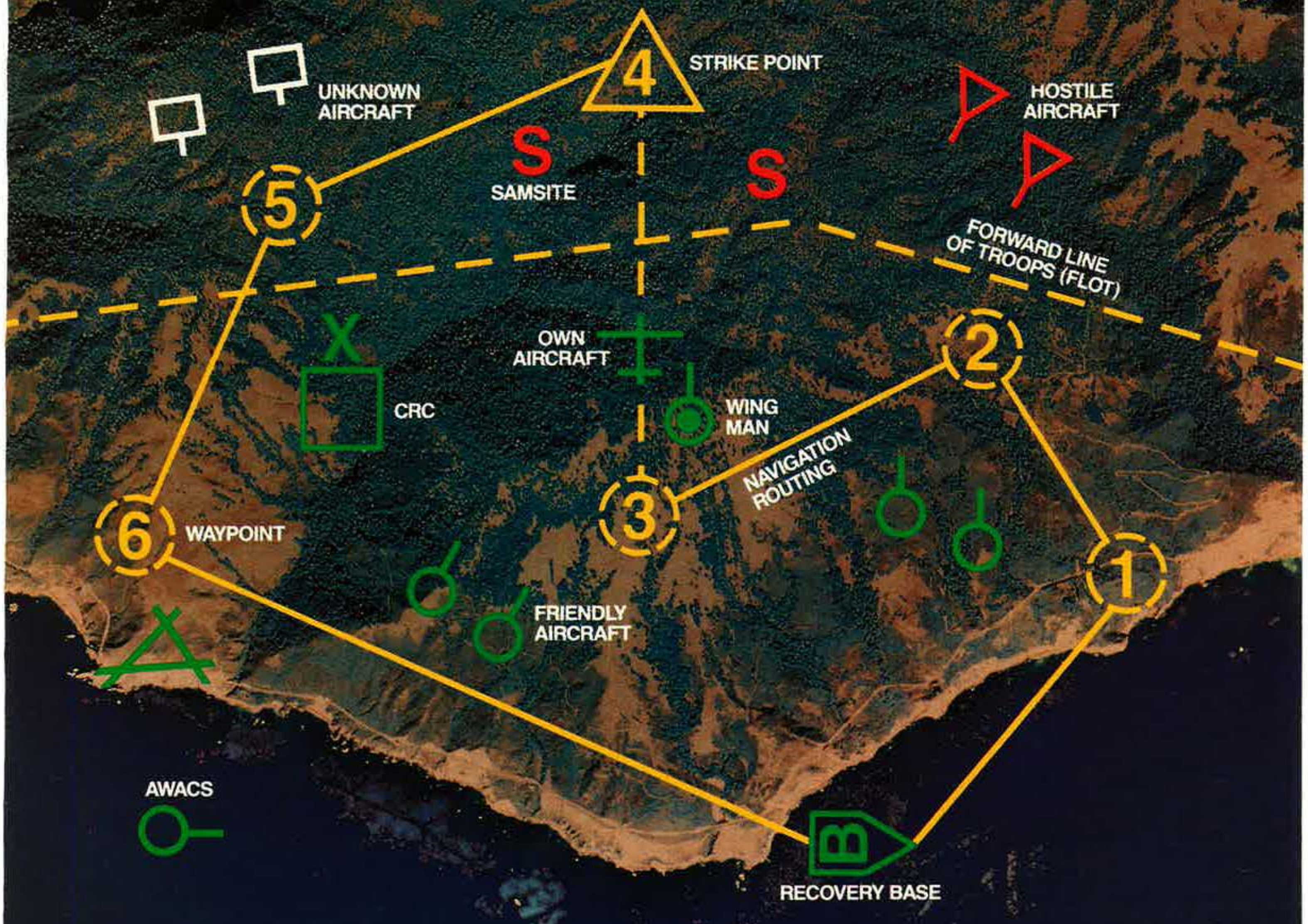

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Letters

Ends and Means

Even for the pages of Air Force Magazine, Col. Dennis Drew's statements are too strong *[see "We Are an Aerospace Nation," November 1990 issue, p. 32]*. They have the air of salesmanship rather than of well-argued advocacy. If the military profession has learned anything from the Mahans and the Douhets, it is that no one factor or theory is decisive above all others. Aerospace power is no exception. It is but one element of a broad palette comprising (to borrow a phrase) the "correlation of forces" over which the US must always be vigilant to ensure the security of our national interests.

Colonel Drew makes valid points about the capabilities of aerospace power that should not be overlooked. However, it is national interests and objectives that are the keystone of military power—indeed, of national power—not airpower, as he argues.

Very few of our stated national interests and objectives are closely associated with our status as the predominant aerospace power in the world. Colonel Drew is trapped by the age-old "ends vs. means dilemma." One must never forget that national security objectives (ends) drive the choice of means (possibly aerospace power) to determine what element of national power may be decisive in any given situation. It is quite conceivable that there are situations where the employment of airpower may be the least attractive policy option. In that case, even though we may be the predominant aerospace power, our strength is negated.

The search for simply stated, bold prescriptions for the complexities of the world has gone on through recorded history. I'm afraid Colonel Drew has not brought that quest to its conclusion.

Maj. C. J. Krisinger, USAF
US Naval War College
Middletown, R. I.

Missing MAC

"Back to the Future" *[see October 1990 issue, p. 32]* was seriously flawed. In reporting USAF's new "Global Reach, Global Power" strategy, you concentrated almost exclusively on what the Air Force normally concentrates on: TAC and SAC, to the detriment of MAC.

MAC was dealt with only indirectly, most visibly by the two pictures of C-5s in Saudi Arabia. This obvious snub to the 90,000 very able men and women of MAC simply showed not only how your article was superficial and grossly lacking, but also how TAC and SAC run the Air Force, sometimes putting their priorities—like the ATF and B-2—ahead of our real national defense priorities—like the C-17.

Operation Desert Shield proved once again the critical role of airlift. Does it always take a conflict to prove what everyone has been saying for years—that we need more strategic airlift rather than "glamor" weapons that cost more than their weight in gold?

A few interesting facts illustrate the importance of MAC:

- During the defense drawdown, TAC will lose eleven fighter wings while MAC will lose zero strategic airlift squadrons.
- MAC was in Saudi Arabia first, not TAC. The 438th MAW Airlift Control Squadron received elements of the 1st Tactical Fighter Wing.
- More than seventy-five percent of all military operations since Vietnam have included MAC.
- There are more pilots with combat time in MAC than in either TAC or SAC.

A little more research and soul-searching would have precluded the need for this letter, just as a little common sense would have prevented the shortage of airlift and sealift we are experiencing in the current Persian Gulf crisis.

Capt. Philip A. Bossert, Jr., USAF
McGuire AFB, N. J.

Do you have a comment about a current issue? Write to "Letters," Air Force Magazine, 1501 Lee Highway, Arlington, VA 22209-1198. Letters should be concise, timely, and preferably typed. We cannot acknowledge receipt of letters. We reserve the right to condense letters as necessary. Unsigned letters are not acceptable. Photographs cannot be used or returned.—The Editors

Havoc with the Facts

"Aviation Cadets" by Bruce Callander in the November 1990 issue *[see p. 98]* was interesting but played havoc with the facts about the Aviation Cadet program between World War I and World War II.

I have a roster of all the Flying School classes from September 1922 to February 1933, after which it was no longer printed. There were many more cadets than officers in most of the classes, except some of the October classes, and the March Field classes in 1927, 1928, and March 1929 were solely cadets, no officers.

The worst error was the statement, "The Army let a few cadets enter, but the standards were so high that few qualified and most who did washed out." Lindbergh was not just one of a handful, but one of many pilots who became great leaders both in and out of the military. Another was Curt LeMay. The aviation industry was, and still is, loaded with former cadets. The percentage of graduates was about the same for officers and cadets, and the percentage of cadets who became general officers was comparable, showing clearly that the cadets were of good caliber, many being college graduates before being accepted as cadets.

There was not enough room for all graduates to remain in the Army, due to congressional limitations, but the overflow is one of the main reasons that the US has always had such an outstanding aviation industry, in which former cadets have played such an important part.

C. R. Bullock
San Antonio, Tex.

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standing, "Patches" by Jeffrey P. Rhodes in the October 1990 issue reminds me that unit patches can bring a measure of good luck and fortune to many, not just to those who wear them.

While serving as a forward air controller (FAC) flying O-1s in the 23d Tactical Air Support Squadron at Nakhon Phanom Royal Thai AB in 1966, I wrote the Disney studios to see if they would help us design a unit insignia. Since we were called "Operation Cricket," I suggested a design incorporating Jiminy Cricket in a pose symbolizing our mission: visual reconnaissance and airborne control of fighter strikes over the Ho Chi Minh Trail network.

A few weeks later and to my surprise, I received a beautiful artist's rendering of Jiminy Cricket floating through the air grasping his open umbrella and excitedly pointing at the ground. The umbrella's handle was a stylized walkie-talkie. Disney's design was right on target, an excellent rendition of our mission and a perfect symbol for FACs. We were also given permission to reproduce the design for the sum of $1, "prepaid."

Although I thought our squadron had one of the most unusual patches ever in the Air Force, it seems Jiminy Cricket has had tours of duty with other units. I'm struck by how much the design made for the 3d Mobile Aerial Port Squadron at Pope AFB in 1959 is like ours. Disney's magical cricket has served us, the Air Force, and who knows how many others well.

Lt. Col. John C. Taylor,
USAF (Ret.)
Puyallup, Wash.

Whose History?

"Patches" was outstanding. However, I wish to correct the inaccurate statement made concerning the 91st Strategic Missile Wing. Although the 91st does trace its lineage back to the 91st Strategic Reconnaissance Group, its history goes back even further, to April 15, 1942, when the 91st Bombardment Group (H) was activated at Harding Field, La.

"The Ragged Irregulars" established several claims to fame while operating from Bassingbourn, England, from October 1942 to June 1945. These include suffering the highest losses of all Eighth Air Force bomb groups, being the first group to attack a target in the Ruhr (Hamm, January 4, 1943), leading the August 17, 1943, Schweinfurt mission, being the first Eighth Air Force bomb group to complete 100 missions, and having the first Eighth Air Force B-17 crew to complete twenty-five missions (the crew of *Memphis Belle*).

The bomb group was redeployed to the US in June 1945 and then inactivated November 7, 1945. It was activated again in 1947 as the 91st Strategic Reconnaissance Group, only to be inactivated again in the late 1950s. The 91st again came to life for the Vietnam War as a B-52 wing flying sorties over Vietnam. In 1968, the 91st became the 91st Strategic Missile Wing at Minot AFB, N. D.

Capt. Michael J. Petersen,
USAF
Offutt AFB, Neb.

• *It depends on whom you talk to. According to the USAF Reference Series's* Lineage and Honors History, *the 91st SMW has no connection with the earlier bomb group. The wing's unit history, however, states, "In 1954, Air Force headquarters agreed to bestow, or loan, the histories of World War II groups to identically numbered wings, [allowing] the 91st SMW to keep alive the history of the 91st Bombardment Group."*—THE EDITORS

Flying at Ellsworth

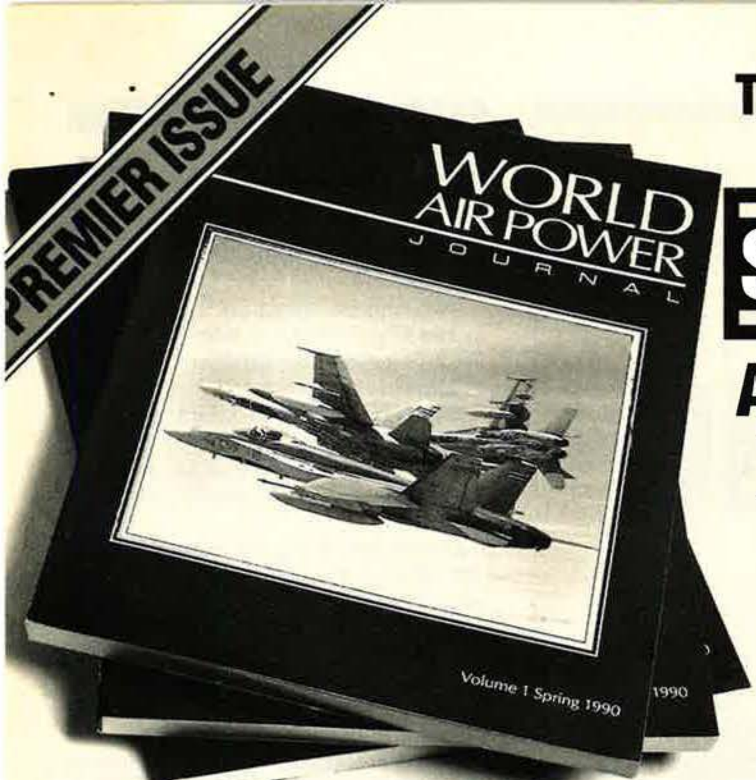
"Patches" was quite enjoyable—both from the perspective of an aviation history enthusiast and that of a member of a new organization submitting a patch design through the AFHRC at Maxwell.

On p. 68, your caption claims that "the 25th Strategic Training Squadron [is] the only flying unit directly assigned to Strategic Air Command's Strategic Warfare Center at Ellsworth AFB, S. D." That's just not true.

The Strategic Weapons School was activated on October 1, 1989, and assigned (like the 25th STS) to the 99th Strategic Weapons Wing. Though we didn't exist "on paper" until that date, the initial cadre began arriving as early as December 1988 to begin writing the curriculum. One of our early tasks was to create a school insignia, and Mr. Godwin and his office were most helpful to us in getting our patch design approved. . . .

All our flying is done on "borrowed" airframes, since the 99th Strategic Weapons Wing doesn't own any. The support of all nine operational B-52 wings has been crucial to getting us airborne and keeping us there.

As you can see, the 25th Strategic Training Squadron has some partners in the flying training business here at Ellsworth. In addition to mentioning the Strategic Weapons School, I would be remiss if I failed to mention



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- Front-line aircrew candidly discuss USAF's hot new interdictor, the F-15E Eagle. Find out how they view the role, performance and characteristics of McDonnell Douglas' awesome new war machine.
- The wraps come off Northrop's controversial B-2 'Stealth Bomber', in a feature illustrated with superb photographs and a unique, highly accurate, color 'three view'.
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Maj. Brian C. Rogers,
USAF
Ellsworth AFB, S. D.

Mistaken Identity

We would certainly like to take credit for the great-looking cadets pictured with Secretary Rice on p. 59 of the November 1990 issue. However, they are Senior ROTC cadets (college level) and not Junior ROTC cadets (high school level).

Dr. Ken Daly
Chief, Junior Program Division
Maxwell AFB, Ala.

Going Bats

I have just read "The Bat Bombers" by C. V. Glines *[see October 1990 issue, p. 88]*. This would have been a riveting, great article for *Audubon* magazine and was worthy of the information and pages taken up for the reader's information. But some questions remain:

Two million spent on this project? In 1943? A dental surgeon from Irwin, Pa.? Three armed services involved? President Roosevelt OK'd it?

Come on, AIR FORCE Magazine, help us believe in your credibility.

Florence M. McCabe
Doylestown, Pa.

• *Outlandish though they may seem, the facts in the article are backed by sources as diverse as Edgewood Arsenal, the National Speleological Society, and the National Archives.*—THE EDITORS

Turning Inward

I have enjoyed AIR FORCE Magazine for most of my twenty-two-year career, but the September issue was even more special than most. Its theme, "The Way It Was," captured the essence of our profession. I sincerely hope that its message was not lost on a generation more at home with a computer than with colleagues.

In recent years it has been increasingly difficult to get people to participate in a variety of social activities that in the not-too-distant past were part of our Air Force heritage. Hangar flying "war stories," Friday "happy hour" camaraderie, and even squadron picnics seem to have fallen victim to an inward-oriented attitude.

I fear that many of the traditions that give our profession its special flavor are being lost. Worse, a generation that could have built on these traditions is now content to abandon them in favor of isolation.

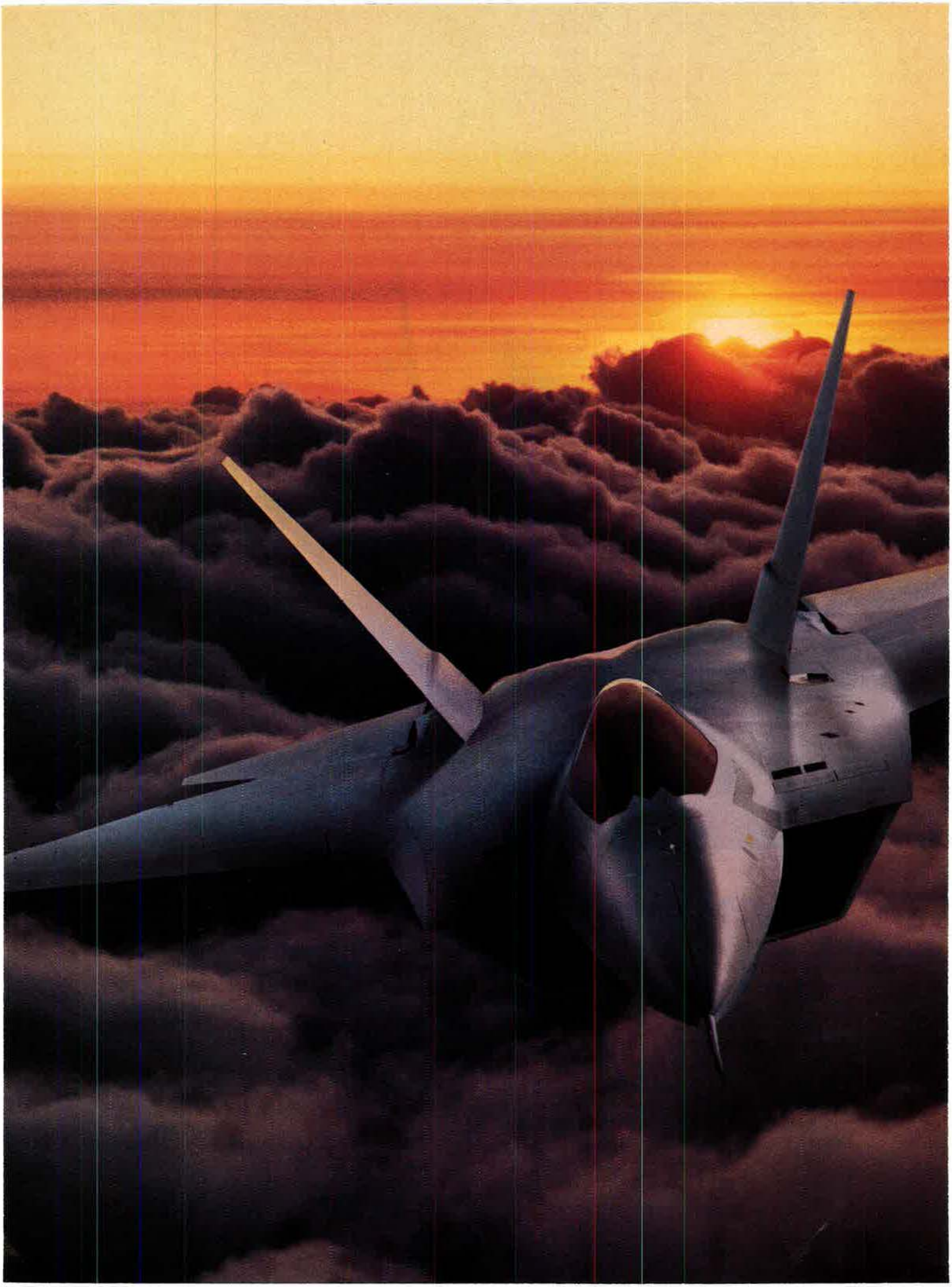
Lt. Col. Doug Schott,
USAF
Rapid City, S. D.

Wrong Year

In the November Anniversaries section of "Aerospace World," the date listed for the first flight of the B-58 is incorrect. First flight was on November 11, 1956, not 1955. I was newly assigned to the B-58 Weapon System Program Office (WSPO) at the time, but unfortunately I did not witness this historic occasion.

Your excellent magazine is my main contact with events in the present-day Air Force, since I am now living in a predominantly Navy city. Keep up the good work.

Lt. Col. Hans J. Petermann,
USAF (Ret.)
San Diego, Calif.



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UNITED TECHNOLOGIES
PRATT & WHITNEY

By James W. Canan, Senior Editor

The Future Is Stealth

In the Air Force's view, modification might make existing airplanes faster and more maneuverable, but it cannot make them stealthy enough to get the job done.

The Air Force is staking its future on stealth and is determined not to turn back. USAF's commitment to stealth is central to its plans and ambitions for new bombers and fighters and is the cause of much of the controversy surrounding its programs for building those planes.

When the Air Force says it cannot do without the B-2 bomber and the Advanced Tactical Fighter, it is really saying, in effect, that it cannot do without stealth. In the final analysis, stealth is what sets those airplanes apart from bombers and fighters now in the force. There are other differences between the present and future generations of aircraft, but none so profound and lasting.

With the B-2 and the ATF, the Air Force claims, it will be able to do the jobs that the nation expects of it well into the twenty-first century. Without them, it claims, it will not.

Much as the Air Force swears by its top-of-the-line B-1B bomber and F-15 fighter, it insists that time is fast running out on them. It sees them as still useful in the years ahead, but in decreasingly demanding roles.

Their only major drawback, where the future is concerned, is that they are not stealthy or, in the case of the B-1B, not stealthy enough. That is drawback enough. Although they can be upgraded in all other respects, there is no way to make them sufficiently stealthy, and so they just won't hack it.

To the Air Force, it's as simple as that. In recent years, many Air Force leaders have said as much, if not quite so baldly.

Taken together, the low-observable technologies that make a plane or a missile stealthy are widely acclaimed as the most revolutionary military aeronautics technologies since the jet engine and the swept wing. Those technologies reduce the radar, infrared, visual, and noise signatures of aircraft and missiles and make them hard to detect and even harder to track and destroy.

Critics of Air Force programs for stealthy flying machines have no quarrel with stealth itself. Their quarrel is with the need for the prowess, pegged to stealth, that the Air Force claims those planes must possess.

The critics suspect that Air Force performance requirements for the planes are overblown and that the Air Force should be able to upgrade existing planes to do the necessary missions for a long time to come, even though those planes cannot be made stealthy.

Not a chance, counters the Air Force.

The B-2, USAF maintains, will be the only bomber able to penetrate the increasingly formidable air defenses of the Soviet Union, which are expected to remain in place, cold war or no cold war, and of many other potential adversaries around the world. Abandoning the B-2 would be tantamount to giving up on the bomber leg of the time-honored triad of strategic weapons, the Air Force claims.

A political decision to do that very thing is always possible, particularly at a time of tighter defense budgets and of seemingly diminishing strategic threats. The nation's future needs for the triad, for manned penetrating bombers in general, and for the B-2 in particular are open to question in some political and military circles, if not in the Air Force, and are fair game for debate.

No Argument

Such is clearly not the case with the ATF. It is on much firmer ground with respect to its mission. There would seem to be no argument, political or military, about the need for air superiority in all tactical arenas and for fighters capable of gaining and maintaining it. When is the last time anyone advocated conceding control of the air?

As to air superiority, only the ATF will do, the Air Force insists. Why? The short answer: stealth.

The ATF is expected to improve on existing Air Force fighters in all important respects, but by an unbridgeable margin in only one respect—its stealthiness. Contemporary fighters can be upgraded with new avionics and engines, for example, to rival the ATF in speed and maneuverability. But they cannot be made stealthy, an attribute that will distinguish the ATF.

The Air Force cites computer gaming of air-war scenarios in support of its case for the ATF. The computer models show that the relatively new Soviet-built MiG-29 "Flanker" and Su-27 "Fulcrum" fighters might be a match for the F-15 in air-to-air combat but would be convincingly outclassed and overmatched by the ATF.

By replacing the F-15 with the ATF, "we would go from rough parity with the Flanker and Fulcrum to a dramatic increase in exchange ratios—to five to one in our favor, on the low side, to twelve to one or fifteen to one on the high side," declares Lt. Gen. John E. Jaquish, principal deputy to the Assistant Secretary of the Air Force for Acquisition.

He cites two main reasons for this: "signature and sustained speed."

"The ATF's avionics and maneuverability will be better than the F-15's, but they are not the cause of the dramatic increase that we see in exchange ratios. What causes that is the ATF's combination of stealth and supercruise," General Jaquish says.

Supercruise—exceeding Mach 1 without using afterburners—is a capability unique to the ATF, but not necessarily so. Supercruise can be built into existing airplanes that lack it. Stealth, on the other hand, cannot be.

Engines built for the ATF by Pratt & Whitney and General Electric have demonstrated supercruise propulsion in both the Northrop/McDonnell Douglas and Lockheed/Boeing/General Dynamics ATF prototypes. Production versions of those engines could be retrofitted into existing fighters, enabling them to go supersonic without lighting the fires.

"We could move the F-15s beyond parity [with the Soviet fighters], but not to the revolutionary extent of the ATF, and any new advantage could be quickly countered. With supercruise, their kill ratios would improve, to two to one or maybe three to one, but not into the ten-to-one bracket."

To come anywhere near matching the ATF in that regard, the F-15 would need stealth, General Jaquish stresses.

Will Air Force fighters really need to be all that capable? There is suspicion in some quarters that the ATF may be overqualified for the tasks it would undertake in the post–cold war world, and that there may be no need for it, or no urgency about bringing it along.

Capitol Hill is the seedbed of the growing skepticism about the ATF program.

Congress sent mixed signals on the ATF this year. It appropriated $200 million for the Air Force to move the program into full-scale development, but its defense authorization bill, expressing reservations about the program, defers FSD beyond Fiscal 1991, which will end next September 30. *[See "Scorecard From the Budget Wars," p. 64.]*

The bill also authorizes $100 million for the Air Force to put by in case it decides to develop the F-15XX, an enhanced air-superiority variant of the fighter.

The Air Force did not request that funding and sees no point in developing the F-15XX. It studied the F-15XX proposal in 1988 as part of its normal requirement-setting process, and again last year as part of the Pentagon's Major Aircraft Review (MAR), and concluded that the fighter, while more capable than any F-15 type yet built, would fall far short of the Air Force's requirement for the ATF.

Not the Point

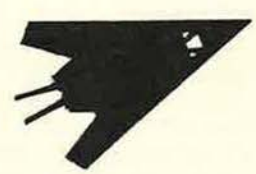
That is not the point, argue members of Congress who question the need for the ATF.

Prominent among them is Sen. William Cohen (R-Me.), an influential member of the Senate Armed Services Committee. Speaking for a substantial number of like-minded colleagues on the committee, he told the Senate late last year that the Air Force should "not hold the F-15 or the F-15XX up against the ATF to see whether it meets its performance criteria."

"We know what the outcome will be if that is the case," he said. "We are saying perhaps the ATF performance requirements are incorrect."

What the Air Force should do, Senator Cohen claims, is to "take a look at . . . whether we can modernize the F-15 and the F-16" to serve the purpose "in an environment that is less hostile" than the one—featuring a full-blown Soviet threat—that was anticipated back when the ATF requirements were defined and delineated.

The Air Force argues that the environment will not be less hostile and that it cannot, in consequence, compromise on its requirement for the ATF. It warns that first-class fighter aircraft are making their appearances in air forces of nations all around the world and that the US can ill afford to let many of those nations get the jump



on air superiority. Twelve of them now fly the MiG-29, which, according to USAF, would give the F-15 all it could handle.

Secretary of the Air Force Donald B. Rice makes the point. He asserts that "no major conflict since the advent of airpower has been won without control of the air," and he takes note of "a trend over the last twenty years" that could spell trouble for the United States in that regard.

"Our fighter inventory has declined slightly," Dr. Rice says, "but that's not true elsewhere." In nations outside NATO and the Warsaw Pact, and excluding China, "we have seen a fifty percent increase in the numbers of fighter aircraft deployed from 1970 to 1990."

For example, "Libya's air force grew from seven aircraft to 500, and Iraq increased its inventory by 117 percent," he says. He also claims that fighters everywhere are more capable as well as more numerous.

"In Iraq, we're facing MiG-29s and Su-24s, and there's every reason to believe nations like Iraq will continue upgrading," says the Air Force Secretary.

Nations intent on upgrading can look forward to a growing supply of "advanced fighters in various stages of development," including "the European Fighter Aircraft, the Swedish Gripen, the French Rafale, and the Taiwanese Indigenous Defense Fighter," says Dr. Rice. "All could compete on the global market. And don't forget the Soviets. They need hard currency and are hawking Fulcrum brochures from Tripoli to Tehran, from Cuba to Algeria. They're not about to be left behind in the fighter business."

The Air Force Secretary asks, "Why put ourselves in a position of trying to seize control of the air from an opponent in the Third World equipped with more advanced aircraft than our own? It's an unacceptable position."

The Air Force is convinced that the only way to avoid getting into that position is to field stealthy fighters, particularly ATFs. Only they will be able to win the day against the growing numbers of increasingly formidable weapons that future fighters will come up against, the Air Force maintains.

At the Air Force Association's National Convention in Washington, D. C., last fall, Gen. Ronald W. Yates, commander of Air Force Systems Command, discussed the global proliferation of potent air defense systems. He called attention to "the very capable, very mobile systems that the Soviets built and that the Iraqis have, along with a number of other Third World countries."

In the Defense Department's MAR of last year, the US intelligence community made a point of those highly sophisticated defenses. The MAR pointed out that even though "we may not be nose-to-nose with the Soviets, that does not lessen our need for the ATF and the B-2," says General Jaquish.

The MAR "clearly demonstrated our need" for the ATF and clinched the case at the highest levels of the Department of Defense, the General claims.

None Too Soon

The review also made it clear that the ATF will come on the scene none too soon, he says. The Soviet fighters that the ATF was conceived to counter have long since been deployed. Now come their presumably much more capable successors, under the generic names of Air-Superiority Fighter (ASF) and Counter-Air Fighter (CAF), which are said to be well along in development.

"Our justification for the ATF was not the emergence of the ASF and the CAF. It was the development of the Flanker and Fulcrum, which are roughly equal to the F-15 and the F-16," explains General Jaquish.

Secretary of Defense Richard Cheney spoke out strongly for the ATF in delivering the results of the MAR to

Congress. He said the study convinced him that the ATF will be crucial to the Air Force's ability to control the air in future tactical scenarios, a superiority that it must assert in order to carry out other missions.

In the MAR, the Defense Department "specifically analyzed alternatives to the ATF, including the F-15XX and several variations of the F-16, in terms of reducing signatures and upgrading engines and avionics," General Jaquish says. DoD concluded that "it would be just as expensive to do that as it would be to build the ATF" and that all of the upgraded fighters would be "woefully inadequate in terms of doing the [ATF's] mission." Even with slightly better kill ratios, they would suffer unacceptable attrition and would not be able to sustain air superiority over the long haul, he claims.

The answer, again, is stealth. It helps aircraft to kill as well as to avoid being killed.

"Stealth's defensive contributions are widely understood, but one of the big things people don't realize is that stealth provides tremendous leverage on the offensive side of the equation," General Jaquish declares.

"In air-to-air combat, stealth makes it possible for your sensors to find the enemy and for you to bring your weapons to bear on him before his avionics can tell him you're there.

"In the case of the ATF, its combination of stealth and supercruise, together with radar that is also stealthy and with AMRAAMs [advanced medium-range air-to-air missiles], will enable it to get in there, find the enemy, target him, shoot at him in multiples [of missiles], and pull away before ever being seen."

At the rollout of an ATF prototype in 1990, Maj. Gen. Joseph W. Ralston, USAF's director of tactical requirements, emphasized the significance of stealth on the offense. He said stealth had not been "a survivability issue" in ATF design.

"The real interest in low observables is to be able to see the other guy before he sees you and to get an offensive advantage," General Ralston declared.

Stealth's contribution to survivability of aircraft against surface-to-air threats is also significant. Says General Jaquish: "In air-to-ground operations, stealth dramatically reduces the threat from air defenses—by more than fifty percent under ordinary circumstances. When stealth is coupled with speed, such as supercruise in the ATF, there's a synergistic effect that reduces the threat in excess of ninety percent."

The Air Force used stealthy F-117As sparingly in Panama in Operation Just Cause at the close of 1989 and deployed them in much larger numbers to Saudi Arabia in Operation Desert Shield last summer. Their job is to attack high-value, heavily defended targets on land. Stealth is their key to lethality and survivability, in equal measure.

General Jaquish notes that the maiden flight of the F-117 took place nearly ten years ago, in 1981, during full-scale development of the aircraft. "We'd been working stealth even prior to that, so we're not exactly Johnny-come-latelies in our understanding of it. We know how it works and what it will do."

On the Lookout

The Air Force is always on the lookout for fatal flaws in stealth and for realistic ways to foil stealthy aircraft. It says it has yet to find any. Now and then, it is confronted with accusatory claims that this or that radar has caught a glimpse of a stealthy flying machine somewhere in the sky. In response, USAF notes that it has never claimed that stealth makes airplanes invisible to radar and to other sensors, only that stealth makes them impossible, or virtually impossible, to track and kill.

Stealth has many applications that may not immediately meet the eye. It is a major means of electronic combat, for example. Air Force officials make the case that passive avoidance of electronic detection is as vital to EC as is the active jamming of enemy radars.

The Air Force is preparing to bring stealth to tactical land-attack missions in a big way in years to come. If all goes as planned, the vehicle for this will be an Air Force variant of the stealthy A-12 attack plane developed by the Navy.

There are signs that, as a general rule, the Air Force is moving toward greater reliance on stealth and less on jamming to enable attack aircraft to penetrate enemy air defenses. There is also reason to believe that this course will prove more cost-effective, as well as more militarily effective, in the long run.

Once stealth pervades the tactical force, more aircraft can be devoted to the attack, and fewer to their support, than is now the case. As it lowers the defense-to-offense ratio of aircraft, the Air Force should also be able to devise new tactics to make its stealthy attack planes even deadlier than before.

Stealth also has a synergistic effect on aircraft not equipped with it. Notes General Jaquish, "One of the major contributions of stealth is that when we have an ATF and a B-2 and an A-12 doing their stuff, we introduce a level of chaos in the [enemy's] command and control system throughout the battle. And that takes a lot of the heat off our nonstealthy aircraft.

"So the presence of the B-2 and the ATF will enhance the ability of the B-1B and the F-15 to do their missions and will make it easier for all our airplanes to penetrate air defenses," General Jaquish claims.

The advent of the ATF "will not mean that the F-15s will fall off the face of the Earth," he says. They will still have plenty to do, and they will be around a while. Their production is scheduled to end in 1992, but they will remain USAF's air-superiority mainstays for many years until the ATF comes along.

If the ATF program stays on schedule—no sure thing—it will be about eleven years before two squadrons of the stealthy fighters are operational. USAF's rule of thumb is that two wings of a fighter must be operational before it can be said to provide true combat capability. In the case of the ATF, that won't happen until the year 2005 under the best of circumstances.

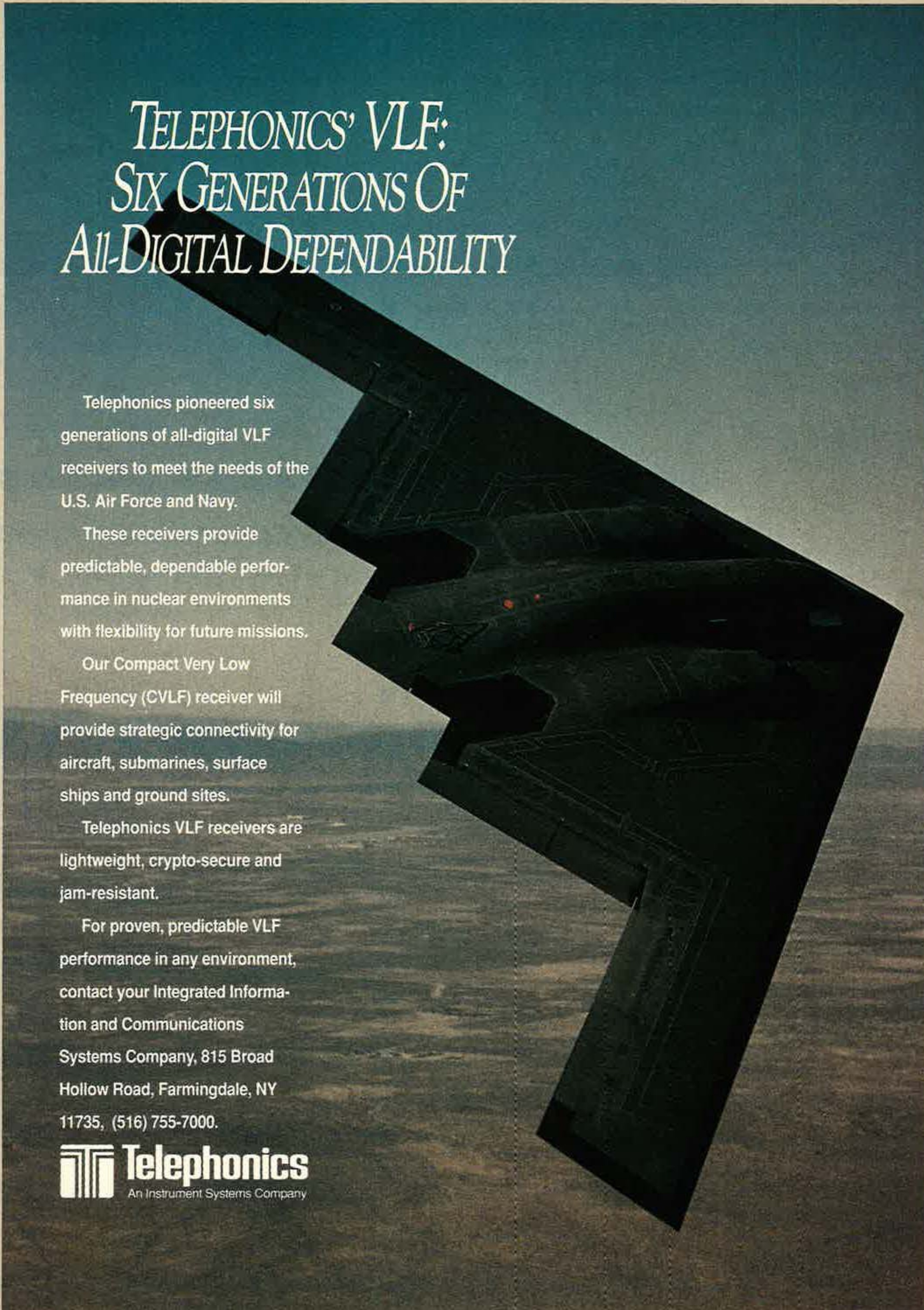
The ATF program is admittedly pricey, but this is no time to jettison it for that reason, in the opinion of Air Force officials. They claim that the long-term cost-effectiveness of the ATF will far surpass that of any upgraded fighter now in service.

Each F-15E currently coming off the production line costs $35 million. The projected flyaway cost of each ATF, adjusted in terms of the buying power of today's dollars, is $43 million, assuming a full run of 750 aircraft. The MAR concluded that the unit flyaway cost of an F-15XX, featuring new engines and avionics, would be roughly the same as that of the ATF and would be spent on an airplane far less capable.

"There is a notion that stealth is driving up the cost of the ATF. That is absolutely, categorically not true," says General Jaquish.

He declares, "We have worked on stealth and counterstealth equally hard. We understand stealth—its strengths and its weaknesses. There are no show-stoppers.

"Stealth is here to stay. It offers us military leverage that will be the key to our future weapon systems." ■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The Chart Page

Edited by Colleen A. Nash, Associate Editor

A Comparison of Deployed Technology

Key

- US superior ■
- US/USSR equal ■
- USSR superior ■
- Soviet position improving ➤

The Pentagon says that in spite of the USSR's increasing economic difficulties, it continues to produce technologically advanced weapon systems. This relative comparison of technology levels in deployed military systems shows the overall average standing. The US has superior technology levels in most deployed systems, but, as the arrows indicate, this is changing significantly in the USSR's favor in several areas.

Strategic

ICBMs	US/USSR equal	SAMs	USSR superior
SSBNs	US superior	Ballistic missile defense	USSR superior
SLBMs	Soviet position improving	Antisatellite	USSR superior
Bombers	US superior	Cruise missiles	US superior

Tactical

Land Forces

SAMs (including naval)	Soviet position improving	Antitank guided missiles	Soviet position improving
Tanks	Soviet position improving	Attack helicopters	Soviet position improving
Artillery	US/USSR equal	Chemical warfare	USSR superior
Infantry combat vehicles	US/USSR equal	Biological warfare	USSR superior

Air Forces

Fighter/attack and interceptor aircraft	Soviet position improving	Air-to-surface munitions	Soviet position improving
Air-to-air missiles	Soviet position improving	Airlift aircraft	Soviet position improving

Naval Forces

SSNs	Soviet position improving	Surface combatants	US superior
Torpedoes	US/USSR equal	Naval cruise missiles	Soviet position improving
Sea-based aircraft	US superior	Mines	US/USSR equal

C^3I

Communications	Soviet position improving	Early warning	US superior
ECM/ECCM	Soviet position improving	Surveillance and reconnaissance	Soviet position improving

Training Simulators

Training simulators	US superior

Source: US Department of Defense, *Soviet Military Power 1990,* September 1990.

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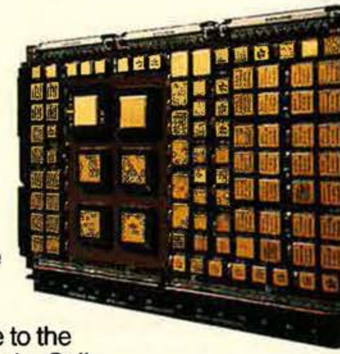

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CONTROL DATA

Aerospace World

By Jeffrey P. Rhodes, Aeronautics Editor

★ Flight-testing of the two competing Advanced Tactical Fighter designs swung into high gear in late October as both teams flew the second example of their prototypes. The end of the demonstration/validation phase is now in sight; Air Force Systems Command's Aeronautical Systems Division (ASD) released the final ATF request for proposal November 2.

The second Northrop/McDonnell Douglas YF-23A (serial number 86-801) flew first, with Northrop test pilot Jim Sandberg making a forty-four-minute flight on October 26. The plane, powered by two General Electric YF120-GE-100 engines, reached an altitude of 15,000 feet and a calibrated speed of 240 knots during the flight, which was made from the Air Force Flight Test Center at Edwards AFB, Calif.

The first flight was marred slightly by a landing gear problem. Mr. Sandberg retracted the landing gear, but on the first effort to lower the gear, only the nose wheel extended. The pilot recycled the gear, and on the second try, both the mains and nose wheel came down and locked into place.

The first YF-23, powered by two Pratt & Whitney YF119-PW-100 engines, was flown to a supercruise (*i.e.,* without afterburner) speed of Mach 1.43 at 42,000 feet on November 14. The plane had earlier hit an instantaneous speed of Mach 1.7 during flutter tests.

As of November 15, the two YF-23 prototypes had been flown by five pilots (including Air Force Majs. Ron Johnston and Con Thueson) twenty-two times for a total of thirty-three hours.

The P&W-powered Lockheed/Boeing/General Dynamics YF-22A (civil-registered N22YX) was flown for the first time on October 30. Lockheed test pilot Thomas Morgenfeld reached a speed of 240 knots and an altitude of 10,000 feet during the fourteen-minute flight from Palmdale, Calif. (where the airplane was built), to Edwards. The flight had been delayed for several days because the on-board auxiliary power unit had to be replaced.

Air Force Maj. Mark Shackelford, the first military pilot to fly the prototype, made the GE-powered YF-22's tenth and eleventh flights on October 25 and 26. Major Shackelford accomplished the type's first air refueling on the eleventh sortie, taking on 5,000 pounds of fuel from a KC-135. The aircraft was flown twice on October 31, with the afternoon sortie lasting 2.9 hours.

On November 3, an important milestone was reached as Lockheed test pilot Dave Ferguson flew the number one YF-22 to a supercruise speed of Mach 1.58 at 40,000 feet. He logged twenty-two minutes of supersonic flight in two supercruise demonstrations during the 1.2-hour flight. As of November 15, the two YF-22s had been flown nineteen times for slightly more than nineteen hours.

Both YF120-powered prototypes suffered hydraulic leaks. As a result, the YF-22 had to make a single-engine landing and one YF-23 flight was shortened. After consultation with the Air Force, General Electric removed a temperature gauge from both sets of engines. The gauge had been chafing against the gaskets on the hydraulic lines, causing them to leak. The gauge was deemed redundant, and its removal solved the problem.

ASD issued two requests for proposals for full-scale development of the ATF. One is for development of the integrated weapon system, and the other is for engine development. The RFPs contain the requirements the Air Force seeks for its ATF, as well as the Navy's requirements for the Naval ATF, or NATF. Two draft RFPs had been issued earlier, which allowed the competitors the opportunity to respond and make suggestions.

The Air Force says that one contractor will build all the ATF engines, since the planned buy of 750 aircraft makes it uneconomical to qualify a second source and have yearly engine competitions, as was done for the F-15 and F-16.

★ Two of the most successful modification and modernization programs

A Boeing KC-135R crew pulls its aircraft up under another tanker during a recent high-altitude sortie. The KC-135R modification effort and the KC-135E upgrade, two of the Air Force's most successful modernization efforts, are being performed by Boeing Military Airplanes at its facility in Wichita, Kan.

in Air Force history are the conversions of Boeing KC-135A tankers into KC-135Es and KC-135Rs. Boeing Military Airplanes produces the reengine kits and does the installation work for both of these programs at its huge facility in Wichita, Kan.

The KC-135R effort is the more complex, involving changes to the plane's powerplant and structure. The KC-135A was first flown in 1956, and the decision to upgrade the aircraft's performance with a new engine and to further reduce overall maintenance and operation costs with other modifications was announced in 1980. After four years of development work, the first KC-135R was delivered to Strategic Air Command in 1984.

The General Electric/SNECMA CFM56 engine (designated F108-CF-100) was chosen to power the KC-135R. This 22,000-pound-thrust engine allows the R model to take off with more fuel and carry it farther. The KC-135R burns twenty-seven percent less fuel than the KC-135A, so the modification allows two R models to do the work of three KC-135As. The modified tankers are far quieter and can operate from shorter runways.

At the company's modification facility, the engines (which are government-furnished equipment) are first hung on an overhead monorail. After hydraulic and electrical connections are made, the nacelle, strut, and fairing are built up around the engine. The monorail holds seven engines; one powerplant starts on the line, and one built-up engine and nacelle come off, every ten hours.

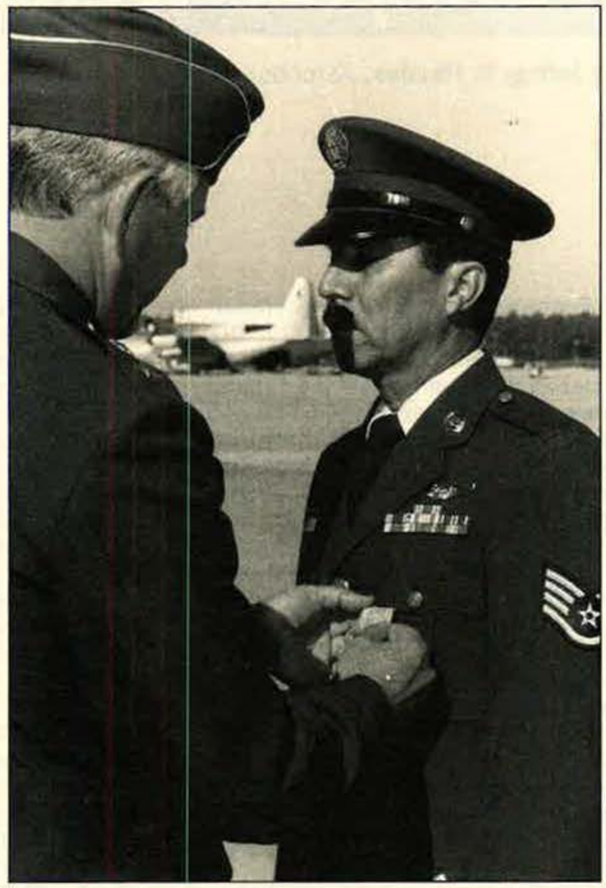
Nearby, the aircraft's vertical stabilizer (removed when the tanker arrives) lies flat so a new rudder control and hydraulic wiring can be added. The area of the fin is also increased as part of the modification effort.

Boeing Military's modification hangar holds five KC-135s. One aircraft comes in and one goes out at roughly five-day intervals. In addition to rehanging the fin and attaching the new engines, the aircraft are further modified with a reinforced wing structure and floor and strengthened landing gear, including a new antiskid system. A second auxiliary power unit is added, and the water injection system equipment is deleted. A new electrical system is installed, and autopilot modifications are also made.

Nearly 230 aircraft (of the 634 KC-135s still in service) have been brought up to the R-model standard and have been delivered. Boeing Military Airplanes recently received a $23.5 million ASD contract for forty installation kits for FY 1991. With options, installations over a five-year period could total 166 to 211 additional tankers. The reengine kits are covered under a separate contract.

The second major modification program is the KC-135E upgrade for Air National Guard and Air Force Reserve tankers. This effort takes overhauled Pratt & Whitney JT3D engines from 707 jetliners and puts them on the KC-135s. Though not as complete as the R-model modification, this upgrade is accomplished at less cost and much faster. The last of 186 tankers to be brought to the E-model standard is scheduled to be delivered this summer.

Boeing has also prepared a proposal to the French Air Force to install wingtip pods (much like those on the US Air Force's KC-10s) on its eleven KC-135FRs. This will allow the tankers to refuel up to three aircraft at a time. One possible future effort for the Air Force's KC-135s is a complete modernization of the plane's avionics to further improve maintainability. The avionics modification would also eliminate the navigator's position.



SSgt. Lorenzo Galvan, a loadmaster with the Air Force Reserve's 433d Military Airlift Wing at Kelly AFB, Tex., receives the Airman's Medal from Chief of AFRES Maj. Gen. Roger P. Scheer. Sergeant Galvan was recognized for his efforts after the crash of a C-5A at Ramstein AB, West Germany, in August.

★ **ELECTED—Randy "Duke" Cunningham,** who, along with radar intercept officer Willie Driscoll, was the first US ace of the Vietnam War, was **elected to the House of Representatives** from California on November 6. The retired Navy commander, a Republican, defeated incumbent Rep. Jim Bates (D-Calif.) by a slim 982-vote margin. Representative Cunningham will serve the San Diego area. He is one of five Navy and Air Force aircrew members to record five or more victories in Vietnam.

★ **HONORS—SSgt. Lorenzo Galvan,** the lone surviving aircrew member of the C-5A transport that crashed at Ramstein AB, West Germany, on August 29, **received the Airman's Medal** from Chief of the Air Force Reserve Maj. Gen. Roger Scheer in ceremonies held at Robins AFB, Ga., on October 30. Sergeant Galvan, one of four people aboard the C-5 to survive the crash, was recognized for his efforts in trying to save other crew members and assisting passengers despite his own injuries. Sergeant Galvan is a loadmaster with the Reserve's 433d Military Airlift Wing at Kelly AFB, Tex. The Airman's Medal is awarded for actions involving voluntary risk of life under conditions other than those of combat.

The **Air Force Academy football team claimed the Commander in Chief's Trophy** for the second straight year with a 15–3 win over Army at West Point, N. Y., on November 10. The Falcons have won the trophy three out of the last four years and six times overall. The Academy last recorded back-to-back championships in 1982–83, the last time any of the three academies playing Division 1-A football claimed the trophy in consecutive years. The Commander in Chief's Trophy is awarded to the academy with the best record against the other service schools on the gridiron. Air Force beat Navy 24–7 on October 6.

The **Thunderbird Theater** at Lackland AFB, Tex., was **renamed the Bob Hope Performing Arts Center** in ceremonies on October 28. The performing arts center is the Air Force's permanent tribute to Mr. Hope in recognition of his nearly fifty years of entertaining service members around the world. A monument to Mr. Hope was also unveiled in the theater's plaza as part of the ceremony.

★ **PURCHASES**— Air Force Systems Command's Aeronautical Systems Division awarded **Boeing Advanced Systems Co.** a $33 million "urgent and compelling" contract on October 26 for **5,300 Protective Integrated Hood/Masks** (PIHMs) for aircrews supporting Operation Desert Shield. The PIHM will be used USAF-wide to replace the MBU-13P chemical mask now worn by aircrew members. The PIHM is equipped with an intercom system, an air-filter canister, an oxygen mask and hood that fit under the aircrew member's helmet, and a blower unit that provides a continuous flow of filtered air for wear in and out of the cockpit. Boeing was under contract for development of the PIHM, but events in the Persian Gulf justified the need to bypass competitive bidding and award the production contract.

Grumman received a $523.1 million contract from Air Force Systems Command's Electronic Systems Division (ESD) on November 2 for the **third E-8A** Joint Surveillance and Target Attack Radar System **(Joint STARS) aircraft.** Two E-8s are now being tested at the company's facility in Melbourne, Fla., and the third aircraft will serve as the preproduction example. The Air Force plans to acquire twenty-two production E-8As.

The **Texas Instruments/Westinghouse** joint venture received a $7.4 million follow-on contract on October 30 for continued development of **technologies that will aid in the manufacture of active-element, electronically scanned, phased-array radar transmit/receive modules.** The contract was awarded by ASD's Wright Research and Development Center's MANTECH directorate. The goal of this program is to bring down the cost of the modules to approximately $400 each. *[For more on the T/R modules and the MANTECH program, see "The Blocks That Built the ATF," p. 30.]*

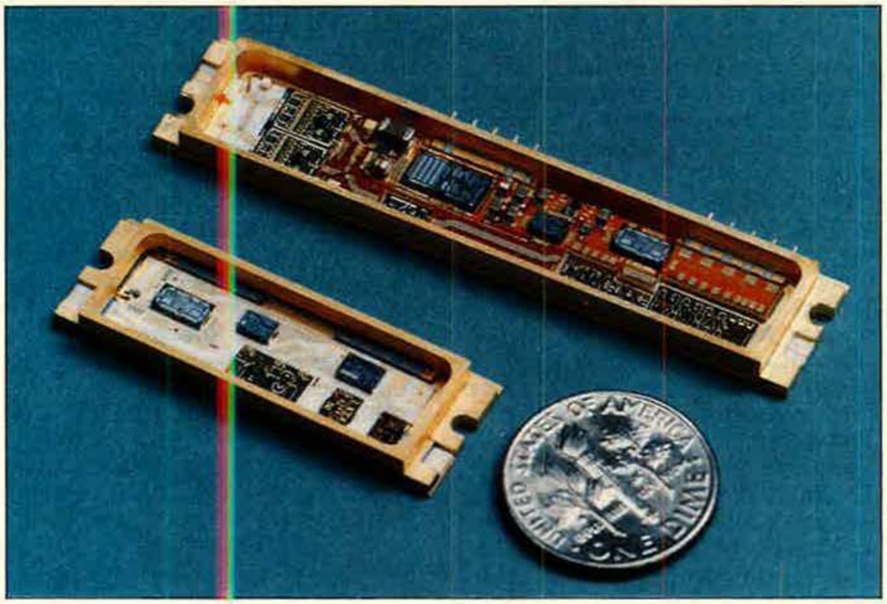
Northrop received a $55 million ASD contract in late October to **convert the B-2A Stealth bomber to operate on JP-8 aviation fuel.** Boeing Military Airplanes, already one of the primary subcontractors on the B-2, will handle the conversion. The modifications will include removal of the pressurization system needed for JP-4 fuel and changes in the fuel management and measurement system. The modifications will take nearly two years to design and implement. JP-8 has a higher flashpoint than JP-4 and is similar to the Jet-A fuel used on airliners. It also includes additives that dissipate static electricity and lower the freezing point of the fuel.

Beech Aircraft received a $17.9 million Oklahoma City Air Logistics Center contract in late October to provide **worldwide logistics support for** the Air Force's fleet of forty **C-12F operational support aircraft.** The contract runs through 1991, and work will be performed by Beech Aerospace Services, Inc., a wholly owned subsidiary. The C-12Fs, a military version of the Super King Air corporate aircraft, are stationed at locations in the US, Europe, and the Far East.

Unisys received a $452.3 million ESD contract on October 24 to build forty **AN/FPS-124 short-range, unattended radars for the North Warning System.** The FPS-124 is designed to fill gaps left between the long-range AN/FPS-117 NWS radars that are al-

Anniversaries

- *January 18, 1911:* Eugene Ely, flying a Curtiss pusher, makes the first landing on a ship. He touches down on a 119-foot-long wooden platform on the stern of the cruiser USS *Pennsylvania*, riding at anchor in San Francisco Bay.
- *January 21, 1911:* The first Army message to be transmitted from the air via radio is sent by Lt. Paul Beck from a Wright biplane at Selfridge Field, Mich., using a radiotelegraphic transmitter of his own design. The message is received at a ground station 1.5 miles away.
- *January 5, 1916:* The 1st Company of the 2d Aero Squadron sails from San Francisco, Calif., headed for the Philippines. Once in operation, it becomes the first Aviation Section unit to serve outside the US.
- *January 29, 1926:* Lt. John Macready (a pilot on the first nonstop transcontinental flight in 1923) sets an unofficial US altitude record of 38,704 feet in the experimental Engineering Division XCO-5 over Dayton, Ohio.
- *January 21, 1946:* President Harry S. Truman asks for the unification of the armed forces in his State of the Union address.
- *January 26, 1946:* The Army announces that the Army Air Forces has created the 1st Experimental Guided Missile Group at Eglin AFB, Fla., to develop and test this new type of weapon.
- *January 31, 1961:* America's first space voyager, a chimpanzee named Ham, is launched atop a Redstone booster from Cape Canaveral, Fla., in a test of the Mercury manned capsule.
- *January 6, 1966:* The first Lockheed SR-71 "Blackbird" high-altitude, high-speed reconnaissance aircraft (serial number 64-17957) is delivered to the 4200th Strategic Reconnaissance Wing (later the 9th SRW) at Beale AFB, Calif.
- *January 17, 1966:* A B-52 loaded with four hydrogen bombs collides with a KC-135 while refueling near Palomares, Spain. Seven of the eleven crew members involved are killed. Three of the four weapons are quickly recovered. The fourth, which had fallen into the Mediterranean Sea, is not recovered until early spring.
- *January 23, 1966:* The newly renamed Military Airlift Command (as of January 1) completes Operation Blue Light, the airlift of the Army's 3d Brigade, 25th Infantry Division, from Hawaii to Pleiku, South Vietnam, to offset the buildup of Communist forces there. The airlift began on December 23, 1965, and its 231 C-141 sorties moved approximately 3,000 troops and 4,700 tons of equipment.
- *January 20, 1981:* Two Air Force C-9A Nightingales are flown from Algeria to Rhein-Main AB, West Germany, carrying fifty-two Americans who had been held hostage in Iran for 444 days. On January 27, the Americans are repatriated aboard a VC-137 Stratoliner.
- *January 28, 1986:* The nation watches in horror as the space shuttle *Challenger* explodes seventy-three seconds into flight on the twenty-fifth shuttle mission, 51-L. Dick Scobee, Navy Cmdr. Michael Smith, Air Force Lt. Col. Ellison Onizuka, Gregory Jarvis, Dr. Judith Resnick, Dr. Ronald McNair, and schoolteacher Christa McAuliffe are killed. The manned spaceflight effort would be halted until 1988.



The Texas Instruments/Westinghouse joint venture has received a contract to continue developing technologies to aid in the manufacture of individual radar transmit/receive modules such as these, used in active-element phased-array aircraft radars. The goal is to reduce the price to approximately $400 each.

ready deployed. The radar pairs are designed to detect and track low-flying aircraft and cruise missiles approaching the US and Canada. The FPS-124 can track up to 200 targets and is designed to automatically monitor its performance, isolate faults, switch to redundant components, and then notify the remote maintenance facility. The company will build thirty-seven new sets and upgrade three preproduction models.

The **Center for Aviation Systems Reliability,** a collaboration between Iowa State University and Northwestern University, **was established** on October 29 under a $3 million Federal Aviation Administration grant. The center's researchers will work on developing new technologies that will give aircraft inspectors a closer look at the condition of airframes, engines, and other structures. The technicians will also seek to apply existing technologies to improve aircraft safety and inspection. The center will be located at ISU's campus in Ames, Iowa.

★ **DELIVERIES—General Electric delivered the 6,000th T700 series engine** to the Army in ceremonies on October 18. The 1,940-shp-class T700 series is used to power the Sikorsky UH/SH/MH-60 Black Hawk/Seahawk/Pave Hawk family as well as the McDonnell Douglas AH-64 Apache, Kaman SH-2G Sea Sprite, and Bell AH-1W Cobra for the US military. Since entering service in 1978, the T700 series has accumulated nearly 6,000,000 flight hours and has an engine-caused shop visit rate averaging one per 5,000 hours. The milestone engine, a T700-GE-701C, will be installed in an Army UH-60.

Litton delivered the first of four system modules for Air Force Logistics Command's new Reliability and Maintainability Information System **(REMIS)** on November 5. REMIS will replace multiple data systems currently used to analyze and report on weapon systems field data. Use of one system, connected to an on-line central database, is expected to produce significant savings over the old multiple systems. The first module monitors and reports the count, status, and use of items in the weapon system inventory. The second module will access reliability and maintainability data. The third will offer configuration status accounting information, and the fourth will access all information regarding open mission capability incidents. The modules are scheduled to be operational by 1993.

★ **MILESTONES—Col. (Dr.) Thomas C. Cook,** believed to be the Air Force's last World War II combat veteran still serving, **retired** November 9. Most recently the chief of the medical consultant branch at USAF's Military Personnel Center's Directorate of Medical Service Officer Programs at Randolph AFB, Tex., Dr. Cook enlisted as an aviation cadet in 1943. He saw action as a B-24 navigator in Europe and transferred to reserve status in 1948. He returned to active duty in 1976.

Senior Staff Changes

RETIREMENTS: M/G Fredric F. **Doppelt;** L/G Robert P. **McCoy;** M/G Alan G. **Sharp.**

CHANGES: B/G George K. Anderson, Jr., from Dir., Medical Inspection, Hq. AFISC, Norton AFB, Calif., to Cmdr., HSD, AFSC, Brooks AFB, Tex., replacing retired M/G Fredric F. Doppelt . . . **M/G Lester P. Brown, Jr.,** from Cmdr., 24th AD, TAC, Griffiss AFB, N. Y., to Cmdr., USAF Air Defense Weapons Ctr., TAC (which will become the 25th AD, TAC), Tyndall AFB, Fla., replacing retiring M/G Richard M. Pascoe . . . **M/G William P. Hallin,** from Cmdr., AFLC Log. Ops. Ctr., and Ass't DCS/Sys. & Req., Hq. AFLC, Wright-Patterson AFB, Ohio, to DCS/Material Mgmt. and Ass't to the Cmdr., AFLC, for R&M, Hq. AFLC, Wright-Patterson AFB, Ohio, replacing M/G Michael D. Pavich . . . **M/G Arlen D. Jameson,** from Cmdr., Strategic Missile Ctr., SAC, Vandenberg AFB, Calif., to C/S, Hq. SAC, and Dep. Vice Dir., JSTPS, Offutt AFB, Neb., replacing retiring M/G Donald L. Marks . . . **M/G Michael D. Pavich,** from DCS/Material Mgmt. and Ass't to the Cmdr., AFLC, for R&M, Hq. AFLC, Wright-Patterson AFB, Ohio, to Cmdr., Sacramento ALC, AFLC, McClellan AFB, Calif., replacing M/G (L/G selectee) Trevor A. Hammond.

AFRES RETIREMENT: M/G Jack L. **Lively.**

AFRES CHANGE: B/G Robert A. McIntosh, from Cmdr., 10th AF, AFRES, Bergstrom, AFB, Tex., to Vice Cmdr., Hq. AFRES, Robins AFB, Ga., replacing retired M/G Alan G. Sharp.

SENIOR ENLISTED ADVISOR (SEA) CHANGE: CMSgt. Ronald D. Allison, to SEA, Hq. AFCC, Scott AFB, Ill., replacing CMSgt. Walter D. McLain.

SENIOR EXECUTIVE SERVICE (SES) CHANGE: Dr. Chine I. Chang, from Chief Scientist, Naval Air Systems Cmd., Washington, D. C., to Dir., Aerospace Sciences, Air Force Office of Scientific Research, Bolling AFB, D. C., replacing retired Dr. Michael Salkind. ■

The Air National Guard's **108th Tactical Fighter Wing** at McGuire AFB, N. J., **set a single-day F-4 sortie generation record** on November 3. The wing's crews flew 127 sorties in just under eleven hours. For the day, the unit's fully mission capable rate "fell" to 99.2 percent because of a single ground abort. The 108th's weapons specialists loaded more than 750 practice bombs on the sixteen F-4Es used in the surge.

The **first captive-carry test of** the tactical version of the Boeing AGM-131B short-range attack missile **(SRAM-T) was successful.** During the November 5 test at the Air Force Flight Test Center at Edwards AFB, Calif., the fourteen-foot-long missile, carried on an F-15E, was subjected to a full range of aerodynamic and structural loads, including aircraft speeds in excess of Mach 1. The test round was mounted on a prototype pylon adapter (built by McDonnell Douglas) that provides the missile with vertical fin clearance of the pylon and adequate spacing to route the umbilical cable. The missile, pylon, and pylon adapter were instrumented to gather data. SRAM-T is the tactical version of the AGM-131A SRAM II supersonic, nuclear-tipped, air-to-ground missile that will equip the B-1B and B-2 bomber fleets.

The battleship **USS *Iowa* (BB-61) was decommissioned** for the second time in its forty-seven-year career on October 26 as a cost-cutting move. The ship, which took President Franklin D. Roosevelt to the Tehran conference in 1943 and suffered a tragic turret explosion in 1989, will be mothballed at the Norfolk (Va.) Naval Shipyard and towed to Philadelphia, Pa., this spring, where it will join the inactive fleet. USS *New Jersey* (BB-62) is also being mothballed, but USS *Missouri* (BB-63) and USS *Wisconsin* (BB-64) will continue in active service.

★ **NEWS NOTES**—As part of an organizational restructuring to cut costs, **Air Force Logistics Command began operating its five air logistics centers through "product" and "service" directorates** on October 31. Each ALC consists of a three-tier structure. The first level includes the center commander's special staff. The second level includes the major service directorates (contracting, financial management, human resources, inspector general, environmental management, communications, and computer systems) and an air base group. The third level is the product management directorates. Each product directorate will be as independent as possible and will have the personnel necessary to perform the full spectrum of activities to support specific aircraft, weapons, or systems. This change will eliminate AFLC headquarters involvement in specific program management and will cut several other layers of management.

Construction of the Department of Defense's largest telescope began with ground-breaking ceremonies at Kirtland AFB, N. M., on October 23 for the special mechanical support building. The 3.5-meter telescope at Kirtland's Starfire Optical Range will allow scientists at the Weapons Laboratory to track basketball-sized objects 1,000 miles from Earth. The telescope, to be the fifth largest in the US and the twelfth largest in the world, will also be used for ground-based optical research in atmospheric compensation, advanced imaging and acquisition, and pointing and tracking. Its primary mirror is being fabricated

A new wind tunnel, sponsored by the Air Force, has been installed at the Sandia National Laboratory at Kirtland AFB, N. M. Using the 220 sun-tracking heliostats of the National Solar Thermal Test Facility (shown here) and airflows of up to 240 miles per hour, the tunnel (in the tower, center) can simulate the irradiating effects of nuclear thermal flash on aircraft materials.

by the University of Arizona's Stewart Observatory Mirror Laboratory and will be installed in 1992. The telescope will be cooled by chilled water produced by melting ice in a half-million-gallon tank.

The assembly tooling surrounding the **first production McDonnell Douglas C-17A airlifter** was removed on October 24, and the aircraft **is now standing on its own landing gear.** This C-17, the second built at the Douglas plant in Long Beach, Calif., will be used in the type's ground and flight-test program at Edwards AFB. The C-17A is one of four production aircraft that will be involved in the test program. They will eventually join Military Airlift Command's operational C-17 fleet.

The **second test in the Air Force's Car Assembly Launch Test Program,** which will validate equipment for use in the Peacekeeper rail-garrison effort, **was successfully carried out** on October 26 at the Rocky Mountain Railcar Co. test center at Hudson, Colo. A 200,000-pound test vehicle simulating an LGM-118A Peacekeeper intercontinental ballistic missile was ejected from the engineering model of the rail-garrison missile launch car during the test (which employed the cold-launch technique used with the Peacekeeper ICBM) to provide engineering data to verify that the car and the railbed can withstand launch loads. The first live launch is scheduled for 1992 from Vandenberg AFB, Calif. Westinghouse is working under a $167 million contract to provide systems definition, design, development, and test of the Peacekeeper rail-garrison missile launch cars.

Two aircraft now serving as outdoor displays at the Air Force Museum at Wright-Patterson AFB, Ohio, **recently provided valuable assistance for Operation Desert Shield.** Engineers designing sunshades for operational Fairchild A-10s and McDonnell Douglas F-15s in Saudi Arabia went to the museum to take measurements from the YA-10A and the "Streak Eagle" F-15A that were retired several years ago. This saved the expense and time it would have taken to go to an operational base and take the measurements there. The museum currently has approximately 22,000 items of Air Force historical property on loan to other museums in the US and abroad. Another 6,000 are displayed at its site near Dayton, and 14,000 more are in storage across Wright Field from the museum building. Among the museum's assets are about 1,800 aircraft—about 1,400 on loan, 200 exhibited at the museum, and another 200 stored.

★ **DIED—Robert N. Thorn,** an engineer who designed more than a dozen nuclear warhead types, of unreported causes on October 25 in Los Alamos, N. M. He was sixty-six. He joined the Los Alamos National Laboratory in 1953 and became head of the lab's thermonuclear weapons physics and design group in 1962. He became head of the lab's theoretical design division in 1971 and was deputy director of the lab from 1979 to 1985. Dr. Thorn also served on advisory groups to the CIA, Defense Intelligence Agency, and Air Force before retiring in 1989. ■

Index to Advertisers

Fielding the new fighter took ten years' worth of custom technology.

The Blocks That Built the ATF

By Jeffrey P. Rhodes, Aeronautics Editor

WHEN the Air Force announced requirements for the Advanced Tactical Fighter, it became clear that building it was not for the faint of heart. The airplane had to be fast, stealthy, agile, supportable, and affordable. In short, it had to embody what seemed to be mutually exclusive design factors.

Insiders, however, knew the requirements were not quite so daunting as they appeared. By the time contracts were awarded in 1986, Wright Research and Development Center, based at Wright-Patterson AFB, Ohio, had gone far in developing technologies needed to make the ATF a reality.

"We have been linked very closely with the ATF [System Program Office, or SPO] from very early in the program," says Dr. Gary Denman, deputy director of WRDC, the laboratory component of Air Force Systems Command's Aeronautical Systems Division. "We go back to the beginning of concept definition in the early 1980s."

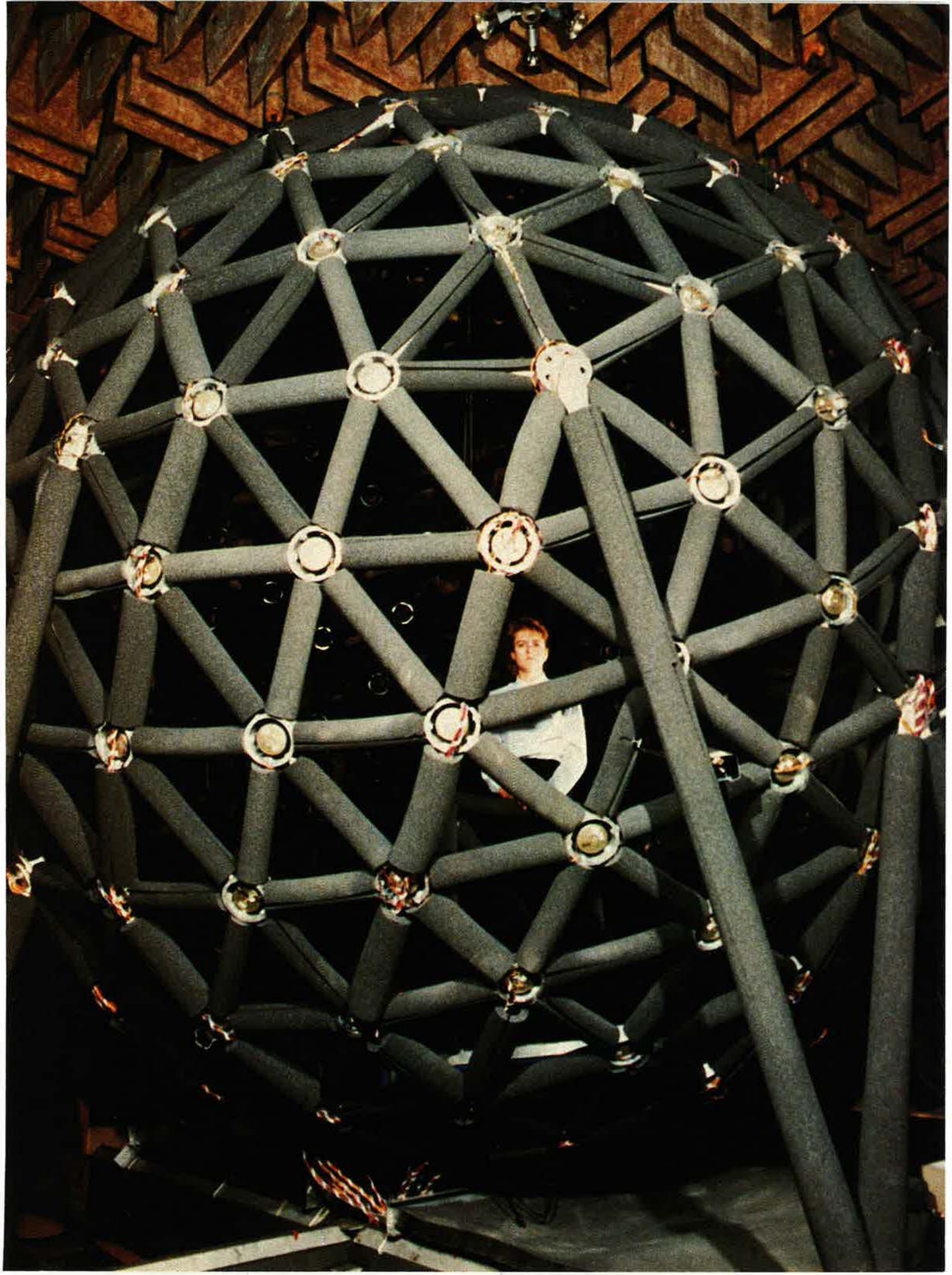
Adds Dick Matson, one of WRDC's radio systems engineers, "We did the right set of experiments for the SPO to allow them to make the necessary tradeoffs. We are not always this successful."

From active-element, phased-array radar to exotic materials, from integrated avionics using VHSIC chips to low-aspect-ratio engine compressors, WRDC has left an unmistakable imprint on the ATF. Its influence is apparent in both prototype ATF airframes—the Lockheed/Boeing/General Dynamics YF-22 and Northrop/McDonnell Douglas YF-23—and the Pratt & Whitney and General Electric demonstrator engines.

Now WRDC scientists and engineers are turning to new challenges. Much WRDC work focuses on efforts to modify and keep current what the Air Force already has on the ramp. The laboratories also are working on a number of major projects, some of which will see results in a few years and some that won't come to fruition until after the turn of the century.

WRDC has not completely cleared the decks of ATF work. The first huge challenge for WRDC was developing and validating many futuristic technologies. That part of the effort is now largely complete. The

One of the promising technologies being developed for the ATF's successors is 3-D sound. This fourteen-foot-diameter aluminum sphere at the Wright Research and Development Center at Wright-Patterson AFB, Ohio (soon to be the Wright Laboratory) contains 272 loudspeakers spaced at regular intervals for sound localization research. Lt. Denise West, a lab audiologist, is inside.



next big hurdle will be to bring to maturity all of these recently developed technologies and, in the process, bring down costs to affordable levels.

Up Front

The ATF technologies were not produced overnight. For example, the effort to develop active-element, phased-array radar for use in an aircraft actually began in 1964. In 1983, the Air Force launched its Ultra Reliable Radar (URR) program, the aim of which was to build a solid-state array using gallium arsenide devices in its active circuits.

The work took five years but was, in the end, a success. Technicians came up with a practical way to produce a radar with 2,000 individual transmit/receive antenna modules. Westinghouse, Texas Instruments, and IBM all produced portions of the X-band, multimode radar, which boasts much-improved range compared to current radars. It is also far more reliable—the expected mean time between failures for the entire array comes to 2,000 hours, and for each T/R module an astounding 8,000 hours.

Up to now, aircraft radars were based on one traveling wave tube; it either works or doesn't work. By contrast, a phased-array radar allows for graceful degradation—that is, the system fails slowly, one element at a time. On the URR, up to five percent of the modules can fail before significant reduction in radar capability occurs.

"Reliability was good; performance was very good," recalls Marvin Spector, director of WRDC's Avionics Laboratory. "We were generating power at the aperture, not behind it as on current radars." However, Mr. Spector concedes that "cost was a problem." In fact, the early 400-pound URR demonstrator cost $55 million.

Cost per module is still a great concern. However, engineering work and testing have continued, with beneficial results. T/R modules that will go on production ATFs come in two packages, each of which is half the size of the experimental URR modules. These new modules offer greater power and more functions.

"VHSIC [very-high-speed integrated circuit] was the number one priority around here for a long time," says Robert Werner, the Air Force VHSIC program manager. "It is a complex program—we had to get the basic processing technology, figure out design aspects, and do packaging and testing."

VHSIC chips offer three main advantages over conventional integrated circuits: dramatic increases in both processing speed and power and smaller size. One chip does the work of hundreds of thousands of transistors. A "super chip," now under development, will be 1.5 inches square and do the work of four million transistors.

VHSIC chips offer high reliability and are hardened against severe radiation environments. Each chip comes with a diagnostics capability. In fact, fifteen to twenty percent of the circuitry of each chip is dedicated to self-test functions. This allows maintainers to determine whether a problem stems from failure of one chip or of an entire circuit board.

These microchips are exceedingly complex. Each contains thousands of mechanical interconnections, none longer than one quarter of an inch and each at least 100 times narrower than a human hair. If all the connections in one tiny chip were placed end to end, they would extend about twenty-four feet.

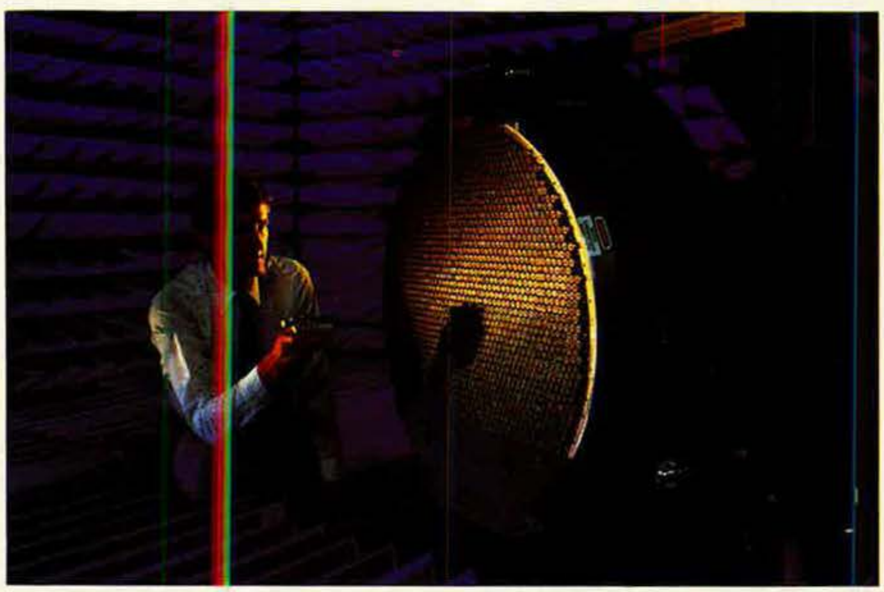
High-quality manufacturing of such devices, at economical prices, obviously poses an immense challenge.

Sensing and the Single Box

"VHSIC had to be in place for us to do anything we did on the ATF," notes Mr. Spector. "VHSIC led to common modules and shared resources. The avionics lab's role was to create an environment where common module technology could be explored."

Today's avionics systems support many functions, the most important of which are radar, electronic warfare, communications, navigation, identification of friendly and enemy aircraft, and fire control. In the current generation of avionics, each of these functional-area systems relies on circuitry contained in an individual "black box." This kind of system organization works, but it is inefficient and expensive.

In the early 1980s, WRDC set as a basic goal development of a new and better way of managing avionics functions, a goal that was demonstrated in the course of its Pave Pillar program. Under the Pave Pillar concept, avionics designers would dispense with many and varied "black boxes" and put all functions into one big box, which would use higher-level software to sort out the differences in signals and functions. This type of avionics "architecture" will be used in the ATF.

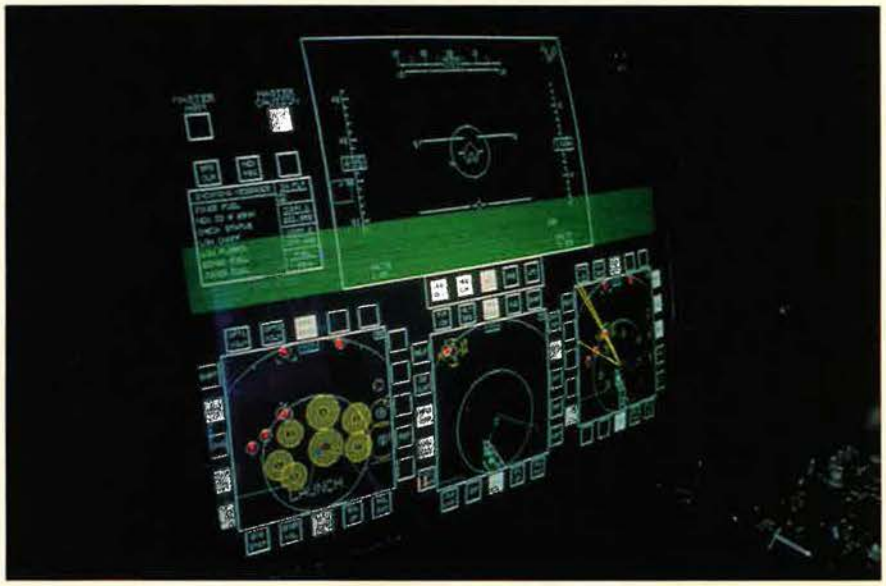


The Ultra Reliable Radar program developed a practical way to produce an aircraft radar with 2,000 individual transmit/receive antenna modules. The X-band, multimode radar has great range and reliability, but each module (such as the one held by this engineer) costs several thousand dollars. A manufacturing technology program is making progress toward reducing the cost per module to approximately $400.

The Pave Pillar–style architecture is flexible and fault-tolerant. It is based on a family of common modules that can be used in multiple applications or packaged as a unit to form an avionics upgrade. It uses high-speed data buses and a common signal processor, both based on VHSIC-type chips. The system runs on Ada, the Pentagon's common computer language.

Each module has a self-test function that will allow maintainers to know when it has failed. Module replacement will be as easy as opening the box, sliding out one module, and sliding in a new one.

Ease of repair is a key reason for development of this type of system. With the self-test feature, flight-line mechanics will only replace modules. If a circuit board fails a test, it will be sent to the depot. No modules will be fixed in an intermediate shop. Thus the Air Force eliminates an entire level of maintenance and saves money.

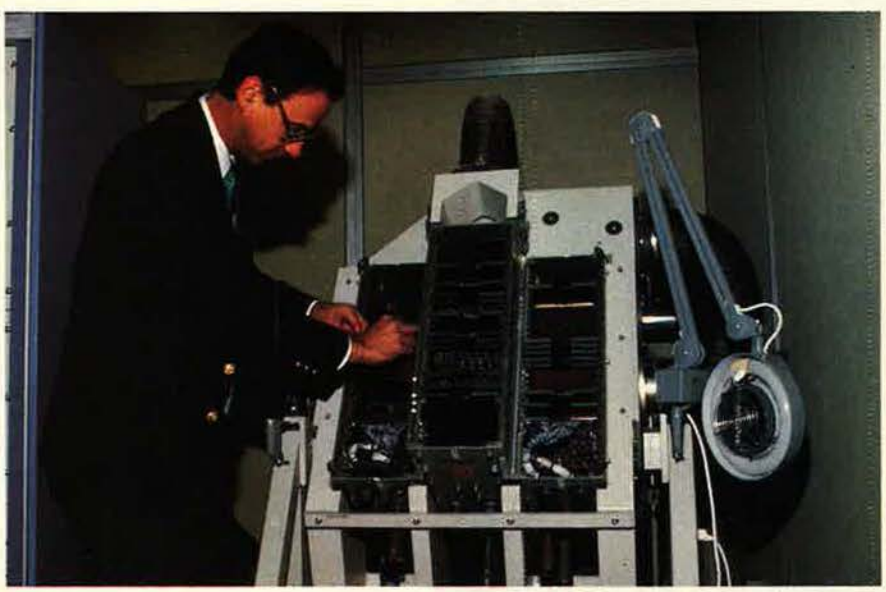


Research into flat panel displays for the cockpit has been under way for nearly eighteen years. This laboratory test article shows a "glass cockpit" display. While active-matrix, color liquid crystal multifunction displays are being introduced and promise great benefits, they can't be produced in large sizes, they sometimes need a warm-up period, and they will require a large investment in production facilities.

Size and weight requirements were also factors. Communications, navigation, and identification (CNI) equipment in an F-16, for example, takes up eight cubic feet and weighs 585 pounds. In contrast, production CNI equipment on the ATF will take up roughly four cubic feet and weigh under 320 pounds.

"Integration of functions such as CNI, electronic warfare, and the radar was difficult," says Mr. Spector. "We designed the system so it would work, would be easy to upgrade, and would be less difficult to get into production. But mainly we designed it to get the pilot the right information when he needs it."

How the pilot will see the gathered information is also being addressed in the labs. "Cathode-ray tubes [CRTs] are heavy, they are huge, they need lots of power, they have poor reliability, and they have poor sunlight readability," says Bob Michaels, a displays engineer in WRDC's cockpit integration directorate. "But they are what we use now."



Dale Van Cleve pulls a module from the common signal processor test rig at WRDC's avionics laboratory. Research into very-high-speed integrated circuits led to the successful Pave Pillar avionics architecture program. Common modules and sophisticated software allow primary avionics functions to reside in a few signal processors, rather than giving each function its own "black box."

That, however, is about to change. Research into "flat-panel" displays began in 1973. Technology is now coming out of the laboratory in the form of active-matrix, color liquid crystal displays. LCDs are everything CRTs are not—lightweight, operable on small amounts of power, reliable, small (one inch deep), and readable in harsh glare. The YF-22 was the first aircraft to use LCDs as multifunction displays.

The LCDs have some drawbacks. At present, they cannot be produced in large sizes. The LCDs need a short warm-up period in cold weather, something an alert fighter can ill afford. Finally, LCD manufacturers would have to build large, expensive "clean rooms"—pristine production facilities—to carry out the task.

The Rest of the Airplane

When an airplane is ready to go into production, a common remark is, "It's time to cut aluminum." There won't be much aluminum to cut when the ATF gets to the factory floor, at least not the aluminum currently used in airplanes. The production ATF is most likely to make extensive use of aluminum alloys and new-generation composites, both of which are products of WRDC efforts.

Several metals projects hold great promise for use on the ATF. An aluminum-lithium alloy offers substantial weight savings for such structures as fuselage frames. Elevated-temperature aluminum will be able to withstand up to 600 degrees Fahrenheit (standard-grade aluminum starts to melt at 350 degrees) and could replace titanium in keel beams and the engine area.

Thermoset composite materials have been in wide use in the aerospace industry for roughly seven years, but their replacement could already be on the way. "Thermoplastic materials will find a niche on the ATF," says Dr. Charlie Browning, the structural materials branch chief. "All of the companies have an interest in thermoplastics."

Thermoplastic composites offer three main advantages over thermosets. First, their cost of manufacturing has the potential to be far lower. Thermoplastics can be pressure-formed, so there is no need for an autoclave. Unlike the raw materials used in thermosets, those used in thermoplastics don't need to be refrigerated.

Second, thermoplastics stand up well to drilling and can be reheated and reformed, making for ease of assembly.

Finally, thermoplastics are inherently sturdy, offer better reliability and maintainability than thermosets, and can better survive crashes.

If they are perfected, thermoplastics would offer great advantages. However, it is unknown whether they will actually work on an airplane. The Materials Laboratory is running a pilot program with each ATF contractor team in an effort to find out. The first task was to build a secondary piece, such as an engine access or landing gear door, from thermoplastic composites. The second phase will be to manufacture a primary structure, such as a bulkhead or other part in the center section of the fuselage.

Building a Better Powerplant

When it comes to the ATF's technologies, WRDC officials point with pride to their work in the area of powerplants. "The biggest contribution we have made to the ATF is in the area of engines," states Dr. Denman.

Both ATF demonstrator engines propelled the prototypes to supersonic flight without afterburner—supercruise—and one major contributing factor was the radically new compressor design.

The low-aspect-ratio compressor blades on the ATF engines are short and fat, just the opposite of blades on current engines. The amount of work each blade does is increased by using lower-aspect blades so that the number of compressor stages can be reduced. The engine's overall length can also be shortened.

Increasing the blade chord increases circumferential spacing between blades, so fewer blades and parts are needed. The remaining blades tend to be hefty and rugged and thus are much better able to work in the presence of sand, the bane of fighter engine performance and longevity. This type of blade costs less and offers better resistance to birdstrikes.

A second new design feature was the addition to the blades of an aerodynamic sweep. Much like a propfan, the sweep slows the rotation of the blades' tips, further increasing the efficiency of the compressor.

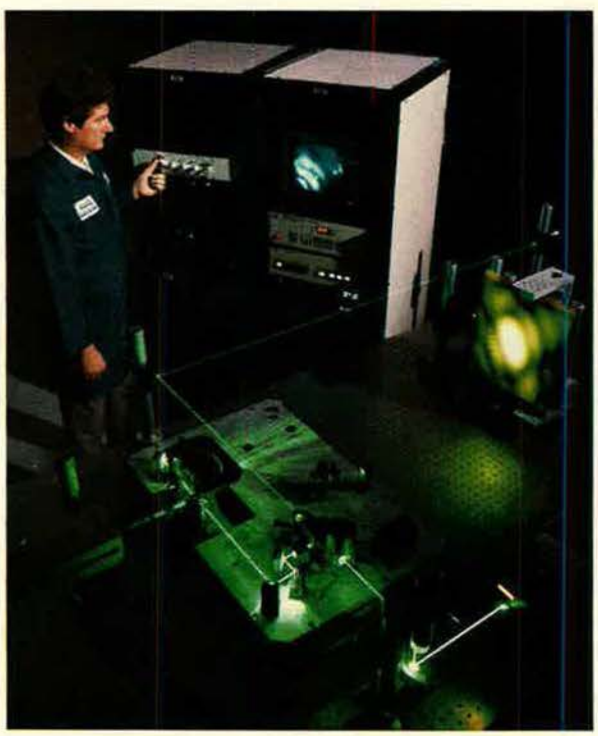
"Low-aspect-ratio compressor blades were inspired by a lot of things, not the least of which was what we saw in some foreign technology," notes Dr. Arthur Wennerstrom, chief of the compressor research group and the pioneer of this new type of compressor. "A lot of evidence said that short blades were the way to go."

A final major technology pioneered for the ATF was thrust-vectoring nozzles. The current F-15 STOL/Maneuvering Technology Demonstrator program proved the concept of in-flight thrust-vectoring and reversing, with dramatic results. These nozzles are of the first generation, while the nozzles on the YF-22 represent the second generation. A third generation, lighter and of improved design, could be used on production ATFs. *[For more details on thrust-vectoring, see "A Nudge in a Better Direction," p. 54.]*

Addressing Costs

Astounding though they may be, the technologies developed for the ATF will become little more than abandoned demonstrations unless ways to reduce their cost can be found. To this end, WRDC's Manufacturing Technology (MANTECH) directorate oversees many programs designed to bring technology from the laboratories to the factory floor.

Each T/R module for the ATF ra-



A technician at Lockheed's Composite Development Center in Burbank, Calif., tests the relative strength of a thermoplastic-resin composite with laser holography. Production ATFs may make extensive use of thermoplastic composites, which offer many advantages over the thermoset composites that have been widely used for years.

The avionics laboratory's "avionics wind tunnel"—the Electromagnetic System Simulator—can create an entire flight environment, complete with electronic warfare, communications, and sensor inputs. This allows the laboratory engineers to test equipment in a "real" situation before actual flight tests are performed.

dar costs approximately $7,000. Now under way are two projects (with a Texas Instruments–Westinghouse team and with Hughes) to explore whether processes used to make computer chips for automobiles will work with gallium arsenide. The hope is to reduce module costs to S400 or less each, an event that would virtually guarantee use of phased-array radar in the ATF.

A single piece of dust during manufacture will ruin a VHSIC chip. Instead of making the chips in a clean room, say WRDC researchers, why not put the clean room inside the machinery? They see great promise in this "factory in a bottle" concept, which calls for fabricating chips in a near vacuum.

Another VHSIC innovation is the VHSIC Hardware Description Language. VHDL has been called DoD's gift to industry because it standardizes descriptions of the function and design of the chips. Nothing is lost between manufacturers; any company can take the description and reproduce the circuits.

An innovation in the manufacturing area is the Integrally Bladed Rotor. At present, rotor blades are mechanically attached to a disc. The IBR is an isothermal forging with blades attached metallurgically to a disk. The IBR process produces a component with fewer parts, less weight, and no attachments.

Since the program was established in 1947, the MANTECH operation has produced a number of notable successes. MANTECH has invested $1.3 billion in various projects and has had a return ratio greater than ten to one.

WRDC and the ATF SPO are also taking an early look at problems and processes that can affect the performance of the ATF in the field. For example, say engineers, it is one thing to establish battle-damage repair techniques to fix the ATF's composite structures. It is quite another to make repairs that will also maintain the airplane's stealthiness. Exploration of techniques to do this is under way.

In another area, live-fire testing on composite F-16 and F/A-18 parts is providing an estimate of the kind of damage known threats may cause to the ATF.

The Future Begins Today

Even as engineers work to complete the ATF mission, they are embarking on the search for new technologies that may underpin the ATF's successor. "Our time line is expanding," notes Col. Dick Borowski, director of the Flight Dynamics Laboratory. "We are not focusing as much on specific programs like the ATF anymore. We are a little past that. We are looking at new missions and long-term technologies."

These efforts focus on both the near and far terms. Some of the near-term programs:

- Self-repairing flight controls. The Air Force has conducted one successful demonstration of this technology. Plans call for a second demonstration to take place this year. No special sensor or hardware is needed; the control reconfiguration system and on-board maintenance diagnostics use the existing flight-control software.
- Fluids. A noncombustible hydraulic fluid won't be ready in time for use on the ATF. However, a low-cost, nontoxic, environmentally safe dielectric coolant will be tested on a B-1B this year.
- Three-dimensional sound. Fitted with a headset-mounted localizer, pilots will not only be able to hear the radar warning receiver go off, they will also be able to determine from which thirty-degree section of the sky the enemy missile is approaching. This system will also aid in communications.

Further down the road are these technologies:

- Displays. By 1996, a full-color tactical display will have a limited capability "electronic backseater"—the Pilot's Associate. By 2005, a full panorama display will boast window inserts, a helmet-mounted display, and a fully mature Pilot's Associate. By 2020, the virtual world will be displayed. The pilot will have no out-of-the-window capability because of the predicted severe laser threat.
- ICAAS. The Integrated Control and Avionics for Air Superiority program is to develop an effective, real-time, knowledge-based, decision-aiding system for air combat. This system will allow even a single-seat fighter to attack and survive when outnumbered four to one.
- Metal matrix composites. Materials such as silicon carbide–reinforced titanium and ceramic-coated titanium have an endless supply of potential applications. The problem now is getting the materials to bond to one another.
- IHPTET. The three-phased Integrated High-Performance Turbine Engine Technology Initiative hopes to bring about a 100 percent improvement in aircraft engine performance in fifteen years. The baseline for the program is the ATF engine. ■

Designs for the future will be influenced strongly, but not exclusively, by stealth.

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Global Aerospace Survey 1991

By John W. R. Taylor

OVER the past year, the cloak of secrecy has been lifted from a few of the world's most advanced military aircraft. The two aircraft vying to become America's Advanced Tactical Fighter (ATF) have flown and have been illustrated in prototype form in the world's press. More has been made known about the B-2 flying-wing bomber, but its future is still debated fiercely by Congress.

Artists' renderings of the US Navy's A-12 Avenger, the next-generation advanced tactical aircraft, reveal a wholly unexpected pure delta form, a forty-eight-degree leading-edge sweep, no vertical surfaces, and a wingspan of more than sixty-six feet. Compared to the Navy A-6E that it is designed to replace, the A-12 is to have a forty percent larger payload and a sixty percent larger combat radius, plus a turn rate better than that of the F/A-18 and one-fifth of the Hornet's vulnerability.

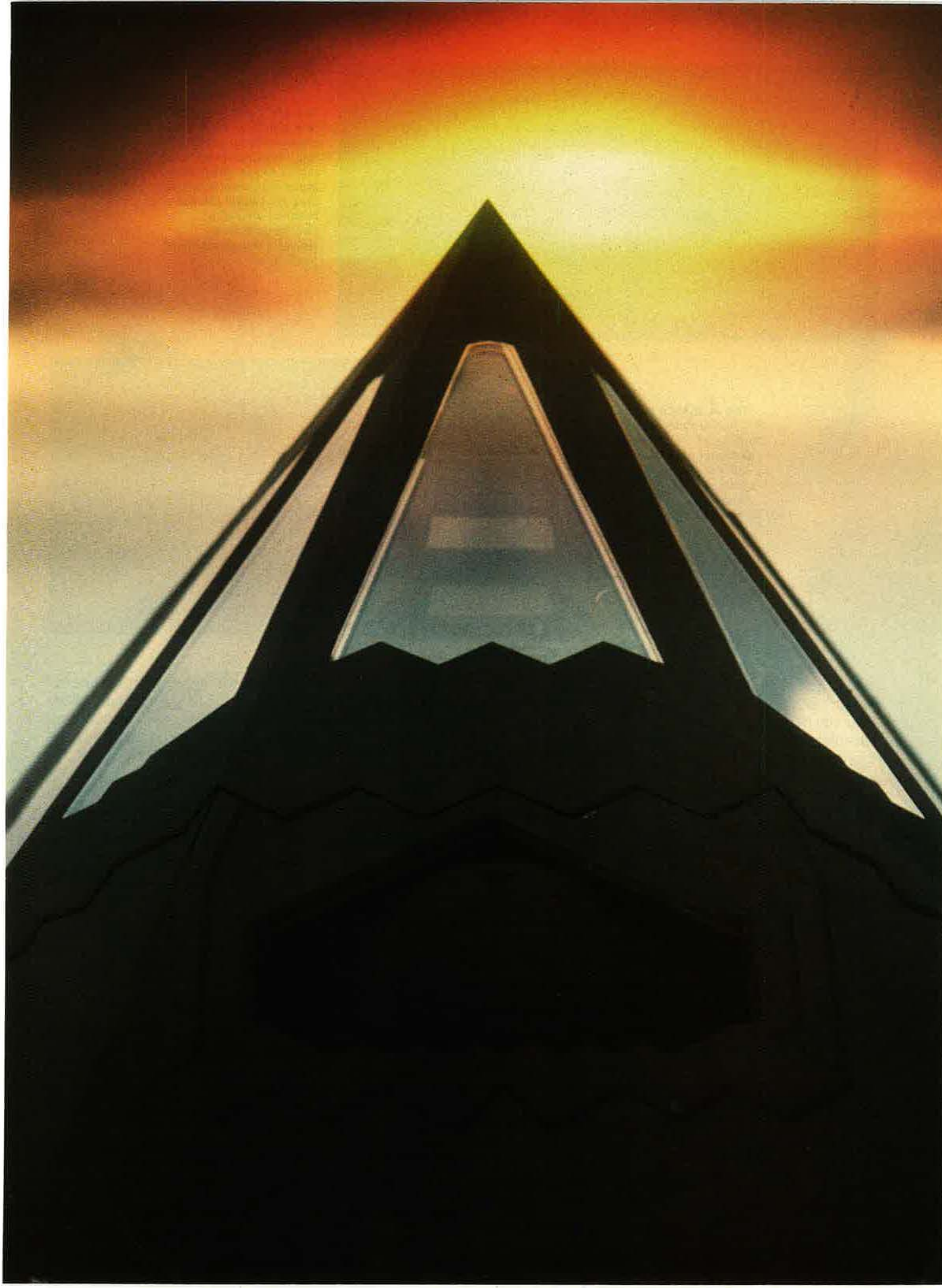
The A-12 will be subsonic, and its configuration, almost frighteningly simple in terms of pure aerodynamics, has to be proved correct. At the very least, it demonstrates that many years of costly and intensive stealth research, through the F-117, B-2, YF-22, YF-23, and other programs, have yielded no consensus on the optimum low-observable (LO) shape.

The F-117 has been deployed to Saudi Arabia as part of Operation Desert Shield. It will be interesting to see if its radar-defeating surface finish stands up better to desert sand and fierce sun than do the engines and rotor blades of Royal Air Force (RAF) and US fixed-wing aircraft and helicopters conceived primarily to match the Warsaw Pact in Europe.

F-117s (right) have been deployed to Saudi Arabia as part of Operation Desert Shield. Will they stand up to desert conditions better than do aircraft that were designed primarily to oppose Warsaw Pact forces in Europe? Meanwhile, old foes are being dismantled: above, Tu-95 bombers and Su-15 fighters at Pushkin Air Base.

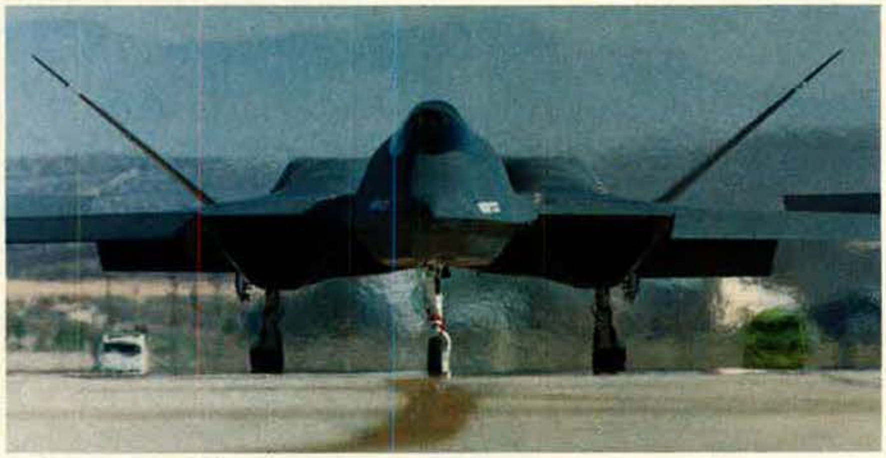
Reshaping and Retooling

With the cold war only recently interred, it would have been unrealistic to expect the armed services of NATO and the Warsaw Pact to reshape themselves overnight into air forces and armies suited to Third World conflict. Soviet-built aircraft hold an advantage in this respect, being generally less sophisticated and less specialized than those of the West but embodying the very best operational equipment that Soviet engineers can provide. Some-



The ATF's ability to maintain practical supersonic cruise without afterburning, thus greatly enhancing its range, may prove more important militarily than its stealth characteristics (at left, a Lockheed/Boeing/General Dynamics YF-22 prototype).

The heat haze behind this Northrop/McDonnell Douglas YF-23 prototype demonstrates the difficulty of hiding the hot efflux of even a stealth fighter from enemy infrared search and track systems.



times the Soviet "best" is far behind what is available to Western designers, particularly in turbojets and turbofans. Soviet engine designers have tended to offer high ratings only with times between overhauls (TBOs) that are unacceptable to anyone outside the Soviet Union and its clients.

This will change. Ilyushin and Tupolev civil transports are now to be fitted with turbofans from Pratt & Whitney and, probably, General Electric and Rolls-Royce. It can only be a matter of time before MiGs, Sukhois, and other military aircraft are similarly adapted to offer alternative Western powerplants.

If US and European aerospace manufacturers consider this a trend of little significance, they should think again. Already twelve air forces fly MiG-29s, and a recent evaluation by the German Luftwaffe showed why they do so. A MiG-29 of the former East German Air Force was flown in simulated air combat against a NATO F-16 at the Luftwaffe test center at Manching. The "Fulcrum" engaged and "destroyed" the F-16 at a distance of thirty-seven miles. A subsequent report noted that NATO pilots had not been impressed with the cockpit of the Soviet fighter but had been surprised by the capability of its radar.

They ought not to have been surprised. The capability of the radars fitted to the MiG-29 and Sukhoi Su-27 has been known and publicized for years. So has the important fact that they are fitted with IRST (infrared search and track) systems, which enable them to approach and attack targets without emitting radar or radio signals that would alert the enemy to their presence. Yet IRST systems, like some other key items of operational equipment, have been considered too costly by those who decide what the US Air Force may have.

Before its invasion of Kuwait, Iraq had bought only a small number of MiG-29s, plus equally limited inventories of other modern Soviet types such as Su-24 ("Fencer") and Su-25 ("Frogfoot") attack aircraft. It also bought more than 100 Mach 2 Mirage F1s from France, MiG-23B ("Flogger-F") ground attack aircraft from the USSR, and many thousands of the best available air-to-air and air-to-surface tactical missiles built in France and the USSR. Its MiG-23Bs and Mirages have been photographed equipped with flight-refueling probes. Iraq has developed its own counterpart of the Soviet "Mainstay" airborne early warning and control aircraft, based on the Il-76 airframe. Some of the equipment of its armed forces is superior to that in service in the nations where it was manufactured, as their governments decided they could not afford it themselves.

More of the Best

There have been suggestions that the Air Force foresees the need by 2010 for a ground-attack aircraft with short takeoff and vertical landing (STOVL) performance, just as the Marines would like to have an all-STOVL air arm by 2015. This writer believes the US and the West should move rapidly to field a supersonic STOVL combat type. The fact that the Royal Navy's current

The four-nation European Fighter Aircraft is due to make its first flight this year. Though generally similar to the F-16, the EFA will have greatly improved thrust, agility, weapons, and avionics and will incorporate stealth characteristics.

© Erik Simonsen

STOVL Sea Harrier could defeat any fighter in the world in one-to-one combat, provided it was aware of the enemy's presence, supports this view. However, twenty-one years after introduction into service of the original Harrier, it must be possible to build something better.

The two contenders to become the US Air Force's ATF are the Northrop/McDonnell Douglas YF-23 and the Lockheed/Boeing/General Dynamics YF-22. Either or both may prove to be ideal as USAF's primary interceptor of the future. These aircraft still have to demonstrate their capability and convince Air Force analysts that the high additional cost of their stealth characteristics is justified. More useful than its stealthiness might be the future ATF's unique ability to maintain practical supersonic cruise without resorting to use of afterburners, thus gaining great range.

It is unlikely that the US will share all the secrets of its most advanced combat aircraft even with close allies. In any case, the RAF knows from experience that what it receives in the way of new equipment depends on cost-effectiveness rather than absolute capability. Multinational programs continue to be controversial money-savers, but they appeal to governments. So long as they produce aircraft as good as the interdictor/strike Tornado (manufactured in Germany, Italy, and Britain), there is little need to complain.

That is one reason that the RAF has deferred any thought of getting an advanced STOVL replacement for the Harrier and for the Tornado Air Defense Variant (ADV). Originally, the plan was to use the European Fighter Aircraft (to be produced in Britain, Germany, Italy, and Spain) as a partner for the long-range Tornado ADV. When the latter's main task—it was to intercept Soviet bombers attacking the UK—assumed a lessened importance a year ago, a planned midlife update was also downgraded. It now seems likely that the EFA will eventually replace the Tornado ADV, as well as the RAF's Phantoms and close support Jaguars.

EFA Improvements

All this depends on the program's going ahead as planned. Germany's Defense Ministry was under orders to investigate cheaper ways to meet the Luftwaffe's needs, but a subsequent report stated that there is no alternative. This may seem an excessive claim for an aircraft with overall dimensions similar to an F-16, but the two fighters are separated by seventeen years, during which time much has been learned.

As a start, the EFA is a canard delta with two turbofans, which, in production form, will give fifty percent more thrust than the single F110 of an F-16C. Great agility will enable it to engage aircraft in the class of the Soviet-built Sukhoi Su-27. Its radar and missiles will make possible beyond-visual-range engagement. Stealth features will be included, though without dominating the design. Cockpit techniques will include digital fly-by-wire control, HOTAS (hands on throttle and stick), direct voice input for appropriate functions, and helmet-mounted sighting/display/attack.

One might expect such features in a fighter that will fly for the first time this year. Computer and combat simulator studies predict that the EFA would be superior in all significant ways to enhanced Soviet fighters, the new French Rafale, and all current Western fighters except the F-15C, which would still hold a small edge in radar-detection range. Such predictions will need to be confirmed when the first of eight prototypes begins a lengthy flight-test program later this year. If all goes well, the EFA will enter service five years from now and could form a highly satisfactory partner for the ATF. Currently planned European air force orders total 765.

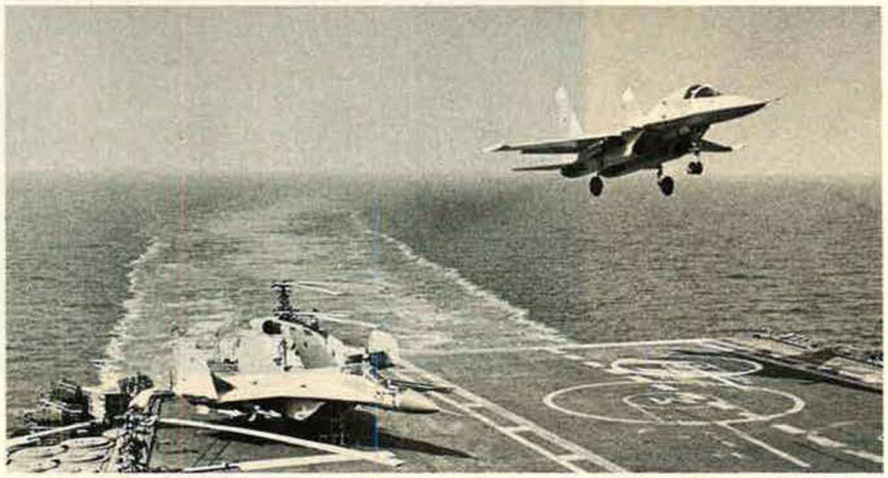
Other new aircraft are in the wings. France appears committed to the Rafale, which should fly in March. Dassault hopes to sell 250 to the French Air Force and eighty-six to its Navy for use in air defense, tactical support, attack, and reconnaissance missions, plus nuclear attack with medium-range missiles. With considerable help from Dassault, Yugoslavia is developing its single-engined multirole Novi Avion. India's Light Combat Aircraft should make its first flight in 1995. Sweden's promising JAS 39 Gripen

—Photo by Lutz Freundt

The MiG-29s of Fighter Wing 3 of the East German Air Force are now equipping the new 5th Luftwaffe Division. Twelve air forces now fly the MiG-29, whose radar capability impressed NATO pilots in simulated air combat last year.

awaits a second production contract for 110 aircraft to add to thirty already on order. Taiwan has launched initial production of 256 of its Ching-Kuo Indigenous Defensive Fighter. Italy and Brazil are coproducing the AMX close air support, battlefield interdiction, and reconnaissance aircraft, which has a secondary counterair role.

—A. Kremko/TASS



The Soviet aircraft carrier Tbilisi, *during an August 1990 test voyage in the Black Sea, received a surprise visit from this side-by-side two-seat trainer version of the Su-27, known to NATO as "Flanker-D" and described by Sukhoi as a deck landing trainer.*

Trends in Cost-Effectiveness

Two major trends are evident in the export market. Faced with ever-rising costs, Jordan and Malaysia abandoned plans to buy Tornados. Instead, Malaysia joined the growing number of smaller nations reequipping with the highly cost-effective two-seat Series 100 and single-seat Series 200 combat versions of the British Aerospace Hawk, which started life as the RAF's standard advanced trainer. At the same time, F/A-18 orders from South Korea and Switzerland, which had seemed firm, came in for reevaluation.

At a time when it is not unusual for the development life of an airplane to last twenty or more years, air forces are trying to make best use of limited funding by upgrading proven designs. An example is Japan's FSX program, which aims to produce a superadvanced offspring of the F-16C. It is to use a Japanese-designed all-composites wing, a more powerful turbofan, ventral canards, and state-of-the-art avionics, plus air-to-air and air-to-surface missiles of domestic manufacture. The FSX is a warning sign that Asian aerospace industries might well threaten those in North America and Europe.

The practice of making the good better is nowhere more evident than in the USSR. While it presses on with research into stealth technology, Moscow is putting greater effort into what it refers to as the "asymmetric reply" of improving air defense systems to cope with the emerging generation of stealth bombers and fighters. At the same time, it is building on the excellence of its current combat aircraft by developing their potential.

At the Moscow air show last fall, Mikoyan's general designer, Rostislav Belyakov, referred to his latest fighter, now under test. It is based on the aerodynamically stable airframe of the MiG-29 but, he said, is "different in every other respect." Like many current NATO aircraft, notably the F-16, it will include features to reduce its radar signature without being a specifically stealth design. Field performance, avionics, and fuel efficiency will all show improvement. New materials will be used. In this respect, it is worth remembering that the MiG-29 made extensive use of carbonfiber composites in secondary structures and aluminum-lithium alloy in production components while the West was still experimenting with these materials.

More is known about Su-27 development for the 1990s. Many predict this year's Paris Air Show will see a new type of "Flanker" with "glass" cockpit and flight-refueling probe. The single-seat naval version known to NATO as "Flanker-D," with folding wings, all-moving canards, and deck hook, was photographed recently on the 67,000-ton Soviet carrier *Tbilisi*. It had what appears to be a reconnaissance pod between its engine intake ducts. An all-new, two-seat model completed deck trials, with side-by-side seating in a front fuselage somewhat reminiscent of that in the SR-71. The radar has gone, and deletion of the usual underwing weapon pylons supported Sukhoi's description of it as a deck landing trainer. A similar configuration could be used in a formidable attack and/or reconnaissance version of the Su-27 with large space in the new cockpit fairing for role equipment, or for extra fuel if the current standard internal fuel capacity for a 2,500-mile range were considered inadequate.

NASP on the Horizon

It is good to be told that the US has settled on the design of the projected X-30 National Aerospace Plane (NASP), as the first step on a long road to the future transatmospheric vehicle (TAV). The currently approved NASP concept is for a lifting body between 150 and 200 feet long, weighing 250,000–300,000 pounds, with a crew of two, and powered by a single small rocket motor and up to five scramjets. The program envisages a start on two flight prototypes in 1993, first flight in 1997, and achievement of single-stage-to-orbit operations by 1999. The flight profile would enable an operational TAV, flying at up to Mach 25, to drop out of orbit to photograph or attack a specific target on the ground or at sea, and then return to orbit afterward. Such a vehicle was under discussion at Air Force Systems Command at least ten years ago. It is beginning to look practicable.

Today there are many examples of growing East-West cooperation. Civilian airline operators within what once was the Eastern Bloc, including Aeroflot, are buying Western airliners. Chiefs of staff and senior officers of NATO and ASEAN air forces have flown in the Su-27 and MiG-29. The Polish Air Force is evaluating the F-16, F/A-18, and JAS 39 Gripen, but without any immediate plans to purchase.

Perhaps to dampen the clamor for payment of peace dividends, defense ministers are making cuts they may later regret. The RAF, for example, is reducing its Tornado interdiction squadrons from twelve to seven, using some of the surplus aircraft to reequip its two Buccaneer maritime strike squadrons. Four RAF Phantom ADF squadrons also will go.

Another four-nation program is the NATO "Helicopter for the '90s," designated NH 90. France, Germany, the Netherlands, and Italy are collaborating to develop this ship-based, antisubmarine warfare helicopter.

France had been expected to reduce deliveries of Atlantique 2 maritime patrol aircraft from five to three a year and delay introduction into service of the French Air Force's Rafale and the Navy's nuclear-powered carrier. That plan is being revised as a result of the Persian Gulf crisis. To pay for the Rafale program, 1991 procurement of Mirage 2000 fighters will now be cut from twenty-eight to twenty-four. In its program to replace Jaguars, Mirage IIIs, and Mirage 5s, France will upgrade forty-one (rather than fifty-five) Mirage F1s this year. Only Japan, an economic superpower, continues to have no difficulty financing the growth and upgrading of its Self-Defense Forces.

Think International

As Europe's Economic Community progresses steadily toward the "single market" after 1992, collaborative and inter-EC programs proliferate. In addition to the four-nation EFA, France and Germany are developing the Tiger antitank helicopter; the same nations, plus the Netherlands and Italy, are collaborating on the NATO "Helicopter for the '90s" program. It calls for a tactical transport, search-and-rescue, surface attack, and ship-based ASW helicopter. Italy and the UK are well-advanced on the much larger EH 101 for naval, military, and commercial multirole missions. Production of the Tornado continues in Germany, Italy, and the UK. Plans call for the five-nation European Future Large Aircraft Group four-turbofan transport to replace the C-130 Hercules and Transall C-160. These plans look purposeful but long-term, with a first flight in 2000. Work is under way on a variety of important civil programs, ranging from the ATR 42/72 short-haul transports to the Eurofar thirty-passenger civil tilt-rotor transport and additions to the Airbus family.

Fewer and fewer aircraft are one-nation products. British Aerospace works with McDonnell Douglas to develop ever-better Harriers, with night attack variants now adding immensely to the unrivaled V/STOL capability of this combat aircraft. MBB of Germany has collaborated with Rockwell to build the X-31A Enhanced Fighter Maneuverability research prototypes that point the way to more agile and formidable fighters of the future. Grob of Germany has fitted E-Systems equipment and a Garrett engine into an airframe of its own design. Result: the D-500, a high-flying, LO, multipurpose aircraft that is likely to perform sigint and surveillance duties for German and other air forces. ■

John W. R. Taylor, a longtime Contributing Editor to AIR FORCE *Magazine, is editor emeritus of* Jane's All the World's Aircraft *and a Fellow of both the Royal Aeronautical Society and the Royal Historical Society. Mr. Taylor compiles or edits for us the galleries of aerospace weapons that appear in various issues throughout the year.*

A Checklist of Major Aeronautical Systems

Aeronautical works in progress at the Air Force's Major Program Offices, Aeronautical Systems Division, and Wright Research and Development Center, Wright-Patterson AFB, Ohio

Advanced Cruise Missile System Program Office

AGM-129A Advanced Cruise Missile
Program to develop a second-generation strategic ALCM with increased range, accuracy, and stealth features. Designed for use by B-52 and B-1B bombers. **Contractors:** General Dynamics (GD), Williams, McDonnell Douglas (MD). **Status:** Production.

Advanced Tactical Fighter System Program Office

Advanced Tactical Fighter
Development of the Air Force's next-generation air-superiority fighter for operational service starting in the mid-1990s. The ATF concept is being studied during demonstration/validation phase, including assessment of ground-based avionics prototypes and flying airframe prototypes designated YF-22A and YF-23A. The ATF is expected to include advanced propulsion, flight controls, and fire controls; significant avionics integration; advanced system survivability features; designed supportability characteristics; low-observable technologies; superior subsonic and supersonic maneuverability; supersonic persistence without use of afterburners; greatly increased combat radius. Demonstration will include use of two advanced technology fighter engines, YF119-PW-100 and YF120-GE-100. **Contractors:** Northrop/MD, Lockheed/Boeing/GD, GE, Pratt & Whitney (P&W). **Status:** Dem/val.

Aeronautical Equipment System Program Office

Air Base Operability
Development and production of equipment to enhance survivability of air bases; camouflage, concealment, deception, decoys, contingency airfield lighting. **Contractors:** Many. **Status:** R&D, production.

Avionics Subsystems
Acquisition of avionics systems common to many aircraft; standard components. **Contractors:** Many. **Status:** R&D, production.

Common Support Equipment
Production of ground-support equipment capable of supporting many types of aircraft, ground power generator system, and advanced X-ray system. **Contractors:** Many. **Status:** R&D, production.

Fasteners, Actuators, Connectors, Tools, Subsystems
Development and production of improved FACTS parts to enhance weapon system and subsystem performance, reliability, and service life. **Contractors:** Many. **Status:** R&D, production.

Modular Automatic Test Equipment System
Management system to govern procedures, architecture, hardware, and software in systems that use automatic test equipment. **Contractors:** Many. **Status:** Continuing.

Productivity, Reliability, Availability, and Maintainability Program
Program to increase combat power and reduce support costs of the Air Force by improving equipment efficiency and exploiting lower lifetime cost alternatives. **Contractors:** Many. **Status:** Continuing.

Reliability and Maintainability Technology Insertion Program
Program to develop and accelerate incorporation of promising new technology into current and future systems. **Contractors:** Many. **Status:** Continuing.

B-1B System Program Office

B-1B Bomber
Production of 100 manned penetrating strategic bombers to replace B-52 bombers and carry out SIOP and possibly conventional bomb missions. Program responsibility began passing to AFLC in 1989. **Contractors:** Rockwell, Boeing, Eaton, GE. **Status:** Program management responsibility transfer.

B-2 System Program Office

B-2A Bomber
Development of a four-engine, low-observable, flying-wing type of strategic penetrating bomber, designed specifically to defeat enemy radar. Supplements, then supplants, B-1 in penetrating role. Plans call for building 75 two-place intercontinental-range B-2s. B-2 design and manufacturing program has made extensive use of computer-aided design and manufacturing. Initial operational capability scheduled for the mid-1990s. **Contractors:** Northrop, Boeing, LTV, GE, Hughes, Link. **Status:** FSD/Low-rate initial production.

C-17 System Program Office

C-17A Aircraft
Development and production of new airlifter to augment C-5, C-141, and C-130. Will be used for rapid intertheater deployment of Army and other units directly to overseas areas and airlift of outsized cargo over both intertheater and intratheater ranges with the ability to take off and land at small, austere airfields. **Contractor:** MD, P&W. **Status:** FSD, initial production.

EC/Reconnaissance System Program Office

Advanced Strategic and Tactical Expendables
Program to develop near-term and longer-term infrared expendables for a variety of USAF aircraft. **Contractor:** None. **Status:** Pre-FSD.

Advanced Tactical Air Reconnaissance System
Development of electro-optical and infrared sensors, digital recorders, and management system for reconnaissance aircraft, UAVs, and fighter aircraft pods. **Contractor:** Control Data. **Status:** FSD.

Air Force Electronic Warfare Evaluation Simulator
Hybrid digital/RF simulator that provides a terminal engagement environment for testing electronic combat systems. **Contractor:** GD. **Status:** FSD.

Airlift Defensive System
Class V installation of threat warning and countermeasures dispenser systems for MAC aircraft. **Contractor:** None. **Status:** FSD.

EF-111A System Improvement Program
This program upgrades the EF-111A Tactical Jamming System (TJS), ALQ-99E, to maintain its capability against the growing number and sophistication of threat radars and to improve its operational availability. **Contractor:** None. **Status:** FSD.

Follow-On Wild Weasel
Investigation of alternatives for replacement of F-4G. **Contractor:** None. **Status:** Concept exploration.

Have Charcoal Interactive Defensive Avionics System
Development of improved infrared countermeasure jammers to protect aircraft from heat-seeking missiles. **Contractor:** None. **Status:** Completed.

Interactive Defensive Avionics System Airlift Defensive System
Development, prototype, and test of an integrated electronic countermeasures suite for Special Operations Forces/Airlift aircraft. **Contractor:** None. **Status:** Pre-FSD.

Real-Time Electromagnetic Digitally Controlled Analyzer and Processor
Program to develop hybrid digital/RF simulator that provides an Integrated Air Defense System (IADS) environment for testing electronic combat systems. **Contractor:** Arvin Calspan Corp. **Status:** FSD.

Seek Spartan
Initiative to examine the application of threat warning capabilities on USAF, Navy, and Army aircraft using Integrated Electronic Warfare System technology. **Contractor:** None. **Status:** Pre-FSD.

Tactical Countermeasures Dispenser Upgrade (AN/ALE-47)
USAF-Navy program to provide dispenser that can operate together with radar warning receivers and missile warning systems. **Contractor:** Tracor. **Status:** FSD.

TR-1 Ground Station
System to receive and process data collected by TR-1 sensors. **Contractor:** Ford Aerospace. **Status:** FSD.

F-15 System Program Office

F-15 Radio Frequency Compatibility Program
An effort to improve interoperability of TEWS with F-15 radar, weapons, and avionics. **Contractor:** MD. **Status:** FSD.

F-15E Dual-Role Fighter
Two-seat version of F-15 to provide long-range, day/night, fair/foul weather delivery of air-to-ground munitions as well as air-to-air capability. Includes advanced cockpit technology, LANTIRN, ring-laser gyro guidance, conformal fuel tanks, reconfigured engine bay, and upgraded tactical electronic warfare system. Weapons integration efforts include SRAM-T and AMRAAM. **Contractors:** MD, P&W. **Status:** Production.

Memory/Radar Module Test Station
New depot test systems to support F-15's new APG-70 radar and F-15E avionics. **Contractor:** MD. **Status:** Production.

Mobile Electronic Test Set
Initiative to enhance supportability and mobility of the F-15E Avionics Intermediate Shop. **Contractor:** MD. **Status:** Production.

Tactical Electronic Warfare System Intermediate Support System
Program to provide test system to support all configurations of F-15 TEWS. **Contractor:** MD. **Status:** Production.

Tactical Electronic Warfare System P^3I
Provides improvements to ALR-56C Radar Warning Receiver, ALQ-135 internal countermeasures set, and ALE-45 countermeasures dispenser on F-15. **Contractors:** Loral, Northrop, Tracor. **Status:** FSD/Production.

F-16 System Program Office

F-16 Multimission Fighter
The F-16 Multimission Fighter is a single-engine, lightweight, high-performance, tactical fighter with an air-to-air and air-to-surface multirole capability that can be deployed from the continental US to any possible trouble spot in the world with minimum en-route support, high reliability, and simplified maintenance procedures to assure successful operation under austere conditions. The F-16 program is part of the continuing modernization of US tactical fighters to reverse the upward trend in total investment and operating and support costs. The program involves 15 foreign nations, more than 50 distinct aircraft configurations, and extensive foreign coproduction, making it the largest, most complex acquisition program in the Department of Defense. **Contractors:** GD, P&W, GE, SABCA (Belgium), Fokker (Netherlands), Fabrique Nationale (Belgium), Norsk Forsvarsteknologi (Norway), Philips (Netherlands), TAI (Turkey). **Status:** Development, production, deployment.

Flight Training System Program Office

Enhanced Flight Screener
Acquisition of 125 aerobatic, piston aircraft to support the Pilot Selection and Classification System. **Contractor:** None. **Status:** RFP preparation.

Joint Primary Aircraft Training System
Program to acquire "missionized," nondevelopmental aircraft and associated ground-based components to replace USAF T-37B and Navy T-34C training system components. **Contractor:** None. **Status:** Acquisition strategy planning.

T-1A Training System
Program to acquire 211 Beech 400T aircraft (T-1A Jayhawk), plus 11 simulators and other training devices, and courseware to support specialized undergraduate pilot training. To be used by ATC to train student pilots in skills essential for flying military tanker and transport aircraft. **Contractors:** MD Training Systems, Beech, Quintron. **Status:** Courseware—development; aircraft & simulator—production.

Joint Tactical Autonomous Weapons System Program Office

Tacit Rainbow Air Launch (AGM-136A)
USAF-Navy program to produce a high-speed, jet-powered emitter attack weapon that is programmable before launch but can loiter and search for targets after launch from bombers or fighters. **Contractors:** Northrop, Raytheon. **Status:** FSD and second-source qualification.

LANTIRN System Program Office

LANTIRN System
Production of two-pod navigation/targeting system for night, under-the-weather ground attack by F-15E and F-16C/D aircraft. Navigation pod with FLIR provides on the HUD a video display of terrain in an aircraft's flight path, and a Terrain Following Radar (TFR) provides the pilot with flight cues as warnings of obstacles. Targeting pod with FLIR provides aircrew with infrared target detection and tracking, and a laser designator/rangefinder is used for precision munition deliveries. LANTIRN Mobility Shelter Set (LMSS) provides intermediate-level maintenance capability. **Contractor:** Martin Marietta. **Status:** Production.

Mark XV Identification, Friend from Foe System Program Office

Mark XV IFF System
Development of secure, antijam, highly reliable replacement for the aging Mark XII IFF system. Interoperable with NATO. Compatible with USAF, Army, and Navy platforms. **Contractor:** Bendix. **Status:** FSD.

National Aerospace Plane Joint Program Office

National Aerospace Plane
DoD-NASA research program aimed at developing and demonstrating single-stage-to-orbit (SSTO) and hypersonic flight technologies for new generation of aerospacecraft capable of flying in the atmosphere and low-Earth orbit. Development and flight test of a technology demonstrator, the X-30, in horizontal takeoff, hypersonic flight, and SSTO flight. **Contractors:** NASP National Team, comprising GD, MD, North American Aircraft, P&W, and Rocketdyne. **Status:** Technology development.

Propulsion System Program Office

Engine Component Improvement Program
Continuing engineering support for all air-breathing engines used in manned USAF aircraft. **Contractors:** All major engine firms. **Status:** Continuing.

F110-GE-100 Engine for F-16
Acquisition of the GE engine for the Alternate Fighter Engine program. Installation in new F-16C/D aircraft. **Contractor:** GE. **Status:** Production.

F100-PW-229 Engine for F-15 and F-16
Increased Performance Engine (IPE) version of the existing F100 being developed for the F-15 and F-16 in the 1990s. Greater thrust and reliability. **Contractor:** P&W. **Status:** Production.

F110-GE-129 Engine for F-15 and F-16
IPE version of the existing F110 also being developed for the F-15 and F-16. Will compete with P&W in engine buys of the 1990s. **Contractor:** GE. **Status:** Production.

F112-WR-100 Engine for Advanced Cruise Missile
Production of a small turbofan engine for the second-generation strategic cruise missile. **Contractor:** Williams. **Status:** Continuing.

F117-PW-100 Engine for C-17
Development and acquisition of a version of the commercial PW-2040 turbofan engine, with 40,000 pounds of thrust, to power the C-17A aircraft. **Contractor:** P&W. **Status:** FSD.

F121-WR-100 Engine for Tacit Rainbow
Production of a small turbofan engine for the air-launched Tacit Rainbow defense suppression weapon. **Contractor:** Williams. **Status:** FSD.

Propulsion Technology Modernization
Insertion of state-of-the-art technologies in engine manufacturing systems to increase productivity and efficiency. **Contractors:** GE, P&W, Garrett, Williams, Teledyne, Allison. **Status:** Continuing.

Special Operations Forces Systems Program Office

AC-130U Gunship
Development of side-firing gunships with highly accurate gun suite and new ECM systems. Replacement for aging AC-130As in inventory. **Contractor:** Rockwell. **Status:** FSD.

C-130H Aircraft
Acquisition of C-130H aircraft for all US military and foreign military sales (FMS) customers. Averages 28 aircraft per year for such customers as Air National Guard, Air Force Reserve, US Navy Reserve, US Marine Corps Reserve, and Japanese Air Self-Defense Force. **Contractor:** Lockheed. **Status:** Production.

Joint Vertical Lift Aircraft (CV-22A)
Development of tilt-rotor V/STOL aircraft combining the versatility of a helicopter with the speed of a high-performance turboprop airplane. Will significantly enhance SOF long-range infiltration/exfiltration capability. **Contractor:** Bell/Boeing Tilt-Rotor Team. **Status:** FSD.

MH-60G Pave Hawk
Acquisition and modification of Army UH-60A helicopters for special operations, rescue, and tactical air control. Contains aerial refueling capability and additional avionics. **Contractor:** Sikorsky. **Status:** Production.

MC-130H Aircraft
Acquisition of 24 aircraft with integrated avionics, improved navigation, terrain-following radar, and ECM. Will augment Combat Talon I SOF aircraft. **Contractors:** Lockheed, IBM. **Status:** Production.

SRAM II System Program Office

Short-Range Attack Missile (SRAM II) (AGM-131A)
Development of a strategic-bomber-borne attack missile of longer range and improved lethality to augment and ultimately replace the AGM-69A SRAM-A. **Contractor:** Boeing. **Status:** FSD.

Short-Range Attack Missile Tactical (SRAM-T) (AGM-131B)
Development of a tactical variant of the SRAM II to meet the requirement for a nuclear, tactical, air-to-surface missile. **Contractor:** Boeing. **Status:** FSD.

Systems Program Office

A-7 Prototype Modification Program (YA-7F)
Structural modifications and reengining of two A-7D aircraft as prototypes. Will be used to determine future uses of existing A-7 inventory. **Contractor:** LTV. **Status:** Flight testing.

A/OA-10 Technology Demonstrator Program
Class II modification to evaluate avionics improvements to the A-10 that could be used to improve A-10 CAS and OA-10 FAC capabilities. **Contractor:** Grumman. **Status:** Flight testing.

Airdrop Development Program
Development, test, and production of improved airdrop systems for C-130 and C-141. **Contractors:** Ver-Val, Douglas. **Status:** Production.

Air Force Advanced Tactical Aircraft
Program to develop a variant of Navy A-12 to replace the F-111 beyond the year 2000. Major modifications include laser target designator capability and associated GBU weapons integration, strike bay fuel tank, rear cockpit flight controls, and Air Force air refueling receptacle. **Contractors:** Team of GD and MD. **Status:** Early risk reduction.

Air Force Infrared Maverick (AGM-65D)
Precision-guided, launch-and-leave, air-to-ground weapon to counter armored vehicles and fortified structures. **Contractors:** Hughes, Raytheon. **Status:** Production.

Air Force Infrared Maverick (AGM-65G)
Incorporates unique tracking algorithms and a pneumatic actuation system into the standard Maverick. **Contractors:** Hughes, Raytheon. **Status:** Production.

Air Force One (VC-25A)
Replacement of two aging VC-137 Presidential aircraft with two new widebody planes, modified 747-200Bs. **Contractor:** Boeing. **Status:** Production, modification.

Attack Radar Set
Upgrading of F/FB-111 attack radar equipment. **Contractor:** GE. **Status:** Production, deployment.

C-21A Aircraft
Modification of 83 Learjet aircraft with Digital Electronic Engine Controls. **Contractor:** Learjet Corp. **Status:** Modification.

C-26A Aircraft
Acquisition and support of 13 Fairchild aircraft to replace the ANG C-131 fleet. **Contractor:** Fairchild Aircraft. **Status:** Deliveries completed; all aircraft operational.

C-27A Aircraft
Acquisition of five commercially available STOL aircraft with options for 13 others. These aircraft will provide rapid response intratheater airlift of personnel and cargo to remote locations accessible primarily through unimproved airfields with short, unpaved landing surfaces for US Southern Command. **Contractor:** Chrysler Technologies Airborne Systems, Inc. **Status:** Production.

C-29A Aircraft
Acquisition of six commercial, FAA-certified, business jet aircraft with state-of-the-art flight-inspection systems, to provide worldwide, all-weather, certified instrument approaches; traffic control and landing systems equipment; air-ground communications in wartime operations. **Contractor:** LTV Aerospace. **Status:** Production.

F/FB/EF-111 Digital Flight-Control System Program
Class IVA safety modification to develop, test, and produce a digital flight-control computer to replace the current analog flight-control computers. Also replaces the angle-of-attack transmitters and normal accelerometers for improved reliability. **Contractor:** GD. **Status:** Flight testing.

F/RF-111C Digital Flight-Control System
Foreign military sales case to provide the F-111 Digital Flight-Control System to the Royal Australian Air Force. **Contractor:** None. **Status:** Pricing and availability for letter of offer and agreement.

KC-10 Wing Pods
Modification of KC-10A aircraft with two wingtip aerial refueling hose reel pods to provide simultaneous air refueling to Navy/NATO aircraft. **Contractor:** MD. **Status:** Modification.

KC-135 Improved Aerial Refueling System
Development and test of new aerial refueling systems and subsystems. **Contractor:** None. **Status:** Development.

Navy Infrared Maverick (AGM-65F)
Incorporation of a ship-track algorithm and heavyweight penetration/blast warhead into the design, resulting in a Maverick that the Navy can employ against its sea/land target spectrum. **Contractors:** Hughes, Raytheon. **Status:** Limited production.

Navy Laser Maverick (AGM-65E)
Precision-guided, close air support weapon with heavyweight penetration/blast warhead homes in on reflected laser radiation generated by either ground or airborne laser designators. **Contractor:** Hughes. **Status:** Limited production.

Tacit Rainbow Rotary Launcher
Development of launcher for internal carriage of Tacit Rainbow defense-suppression missiles by B-52G bombers. **Contractor:** Boeing. **Status:** Development.

Terrain-Following Radar
Upgrading of the reliability and supportability of F/FB-111 TFR. **Contractor:** Texas Instruments (TI). **Status:** Production, deployment.

Training Systems Program Office

Air Defense Fighter Training System
Procurement of system for training of air defense crews. **Contractor:** GD. **Status:** Development/acquisition.

ATF Trainer
Comprehensive analysis to develop training system concept to meet requirements for ATF. **Contractors:** Northrop/MD, Lockheed/GD/Boeing. **Status:** Planning.

B-1B Simulator System
Development and production of system to train all B-1B crews. Includes five weapon system trainers that simulate all four crew positions, two mission trainers that simulate only the offensive/defensive positions, and cockpit procedures trainers. **Contractor:** Boeing. **Status:** Production.

C-5/C-141 Aerial Refueling Part-Task Trainer
Development of one prototype and production of six units to provide visual, audio, and flight-control cues for realistic air-refueling training. **Contractor:** Reflectone. **Status:** Production.

C-17 Aircrew Training System
Development and production of a total aircrew training system for C-17A aircrews. **Contractor:** MD Training Systems. **Status:** Development, acquisition.

C-17 Maintenance Training Devices
Development and acquisition of five suites of devices to certify C-17A maintenance personnel without using the aircraft. **Contractor:** ECC. **Status:** Development, acquisition.

C-130 Aircrew Training System
Development and acquisition of totally integrated aircrew training system that encompasses the continuum of training from initial entry through refresher and continuation training. **Contractor:** CAE-Link. **Status:** Development, acquisition.

C-141 Aircrew Training System
Development and acquisition of a total aircrew training system for C-141 crew members from initial entry through ongoing continuation training. **Contractor:** Hughes. **Status:** Development, acquisition.

F-15E Weapon System Trainer
Production of four F-15E WSTs for initial entry level through advanced aircrew training. Contains high-resolution sensor displays, electro-optical/infrared weapons delivery, and LANTIRN capability for air-to-ground and low-level training. **Contractor:** Loral. **Status:** Production.

F-16 Weapon System Trainer
Procurement of operational flight trainers, improved digital radar landmass simulators, improved electronic warfare training devices, visual systems, and various LANTIRN simulators. **Contractors:** CAE-Link, GE, AAI, E&S. **Status:** Acquisition.

Joint Primary Aircraft Training System (JPATS) Ground-Based Training System
Development and production of a total aircrew training system for JPATS aircrews. **Contractor:** None. **Status:** Preconcept analysis.

Joint Surveillance Target Attack Radar System
Training system requirements analysis to establish preliminary training system requirements for aircrew, mission, and maintenance personnel. **Contractor:** JWK Int'l. **Status:** Planning.

LANTIRN Part-Task Trainer
Production of PTTs in F-16 configuration to train aircrews in LANTIRN techniques and operations. **Contractor:** ECC. **Status:** Production.

Light Combat Aircraft
Foreign military sales case with government of India for supplying aircraft components for Indian production of the Light Combat Aircraft. **Contractor:** None. **Status:** Concept definition.

Modular Simulator Design Program
Program to explore ways to use microcomputers and high-speed data communications in modular flight simulators. **Contractor:** Boeing. **Status:** Development.

Simulator for Electronic Combat Training (SECT)
Program to generate documentation that accurately defines the Electronic Warfare Officer Training (EWOT) requirements needed for today's advanced technology. **Contractor:** JWK Int'l. **Status:** Requirements analysis.

Special Operations Forces Aircrew Training System
Development and production of a total aircrew training and mission-rehearsal system for MC-130H/E, AC-130H/U, MH-53J, HC-130H/P/N, MH-60G, and V-22 crew members. **Contractor:** Loral. **Status:** Development, acquisition.

Standard DoD Simulator Digital Database (Project 2851)
Triservice-sponsored and -approved program to develop database standards, production capability, and central library to support training and mission-rehearsal systems for all services. **Contractor:** Planning Research Corp. **Status:** Development.

USAFE Low-Altitude Training System (LATS) Requirements Analysis
Program to examine and analyze current USAFE LATS program. **Contractor:** JWK Int'l. **Status:** Requirements analysis.

WRDC Aeropropulsion Laboratory

Advanced Turbine Engine Gas Generator
Program to assess new core engine components, advanced structures, and material technologies in a true, large-thrust-class engine environment. **Contractors:** Allison, GE, P&W. **Status:** Advanced development.

Air-Breathing Missile Propulsion
Program to develop and demonstrate "wooden round" propulsion concepts for air-to-air and air-to-ground missile applications. **Contractors:** Atlantic Research, Hercules, UTC's Chemical Systems Division. **Status:** In-house research, exploratory and advanced development.

Aircraft Power
Program to develop noncombustible hydraulic system, power electronics, advanced battery, and highly reliable electrical power systems for current and future airplanes. **Contractors:** Many. **Status:** In-house research, exploratory and advanced development.

Aviation Fuel Technology
Program to develop advanced fuels and fuel systems for subsonic, supersonic, and hypersonic aircraft and missiles powered by air-breathing engines. Emphasis is on endothermic and other high-heat-sink fuels. **Contractors:** Many. **Status:** In-house research, exploratory and advanced development.

Combustion
Program to provide experimental data and advanced design codes for turbine engine and ramjet combustors. Extensive application of optical diagnostic techniques and computer modeling. **Contractors:** SRI, U. of Dayton Research Institute. **Status:** Research, exploratory development.

High-Speed Propulsion
Technology program to develop an Air Force capability for manned and unmanned flight at very high speeds using air-breathing propulsion and logistically attractive fuels. **Contractors:** Many. **Status:** Exploratory development.

Hypersonics
Program to develop the technology of air-breathing propulsion, using hydrocarbon-based storable fuels, to the highest achievable flight speed. This includes turboramjet, air turbo rocket, scramjet, and new concepts. **Contractors:** UTRC, CSD, and others. **Status:** Research, exploratory development.

Integrated High-Performance Turbine Engine Technology Initiative
National program to develop and demonstrate revolutionary advances in turbine engine technology that will double current propulsion capability. **Contractors:** Many. **Status:** In-house research, exploratory and advanced development.

Joint Expendable Turbine Engine Concepts
Interservice program to develop demonstrator engines to help define future technology requirements for small, unmanned, limited-life vehicles. **Contractors:** Allison, Garrett, Teledyne, Williams. **Status:** Advanced development.

Joint Technology Demonstrator Engine
Interservice program to develop large-thrust-class demonstrator engines combining advanced high-pressure cores from ATEGG with advanced low-pressure and adaptive components. **Contractors:** Garrett, GE, P&W. **Status:** Advanced development.

Joint Turbine Advanced Gas Generator
Interservice program to assess new core engine components, advanced structures, and material technologies in a true, small- to medium-thrust-class engine environment. **Contractor:** None. **Status:** Advanced development.

Plasma Physics
Program to investigate the fundamental properties of plasmas for application to thin film deposition, high-power switches, and advanced lasers. **Contractors:** SRI Int'l, U. of Chicago, Wright State U. **Status:** Research, exploratory development.

Spacecraft Power Technology
Program to provide evolutionary and revolutionary improvements in spacecraft power systems and thermal management technologies while reducing weight and volume and improving survivability. **Contractors:** Many. **Status:** In-house research, exploratory and advanced development.

Special-Purpose Power
Initiative to provide pulsed power and energy storage technology for special-purpose loads such as high-power microwaves, electromagnetic launchers, and accelerator systems. **Contractors:** Many. **Status:** In-house research, exploratory and advanced development.

Survivable Solar Power System
Initiative to design, fabricate, and test a survivable solar power and energy storage system for use in space. **Contractors:** TRW, Boeing, Martin Marietta, Lockheed. **Status:** Advanced development.

WRDC Avionics Laboratory

Advanced Avionics Reconfiguration Technology
Development and application of neural computing methods for RF threat alert. Addresses parametric and intrapulse information domains as well as information correction. **Contractors:** Booz-Allen Hamilton, Georgia Tech Research Institute. **Status:** Development.

Airborne Imagery Transmission
Development of a modular, wideband, multiple-sensor, jam-resistant, air-to-air data link for transmission of reconnaissance imagery or digital data. **Contractor:** Unisys. **Status:** Development.

Airborne Integrated Antenna System
Program to define requirements and to conduct trade-off studies regarding optimized AIAS architectures. **Contractor:** TRW. **Status:** Concept definition, design.

Air-to-Air Attack Management
Program to develop an integrated set of advanced fire-control algorithms and innovative control and display concepts for a single-seat fighter aircraft in multitarget combat. **Contractor:** Northrop. **Status:** Development.

Air-to-Air Covert Sensor Technology
Definition and design of a future covert electro-optical sensor subsystem to enhance situational awareness by providing missile warning, acquisition, tracking, and identification functions. **Contractor:** Honeywell. **Status:** Development.

Automatic Radar Air-to-Ground Target Identification Program
Two-phased effort to design, build, and demonstrate an all-weather target identification of ground-mobile targets using synthetic aperture radar imagery, model-based vision techniques, and massively parallel computing engines. **Contractor:** Martin Marietta. **Status:** Development.

Automatic Radar Target Identification
Three-phased effort to produce and demonstrate an air-to-air identification system using one-dimensional radar signatures. **Contractor:** GD. **Status:** Development.

Common Signal Processor
Program to develop a modular, high-performance, reliable, VHSIC-based, digital signal processor for next-generation avionics. **Contractor:** IBM. **Status:** Development.

Concealed Target Detection Technology Program
Two-phased program to develop and demonstrate airborne radar technology required to detect strategic and tactical targets concealed by foliage and/or camouflage. **Contractor:** None. **Status:** Concept definition.

Coronet Prince Prototype
Packaging of existing countermeasure technology into an aircraft pod to demonstrate effectiveness against ground-based optical and electro-optical tracking systems. **Contractor:** Westinghouse. **Status:** Flight testing.

Digital EW Receiver
Development of a wideband EW receiver in which the baseboard frequency is digitized, thus allowing all subsequent receiver functions to be performed in the digital domain. **Contractor:** *TBD*. **Status:** Development.

Electronic Combat Multifunction Radar Technology
Program to develop ECCM technology for robust airborne radar performance in post-1995 threat environments. Uses wide, tunable bandwidth and adaptive waveforms. **Contractors:** Hughes, Raytheon. **Status:** Development.

Embedded Computer Resources Support Improvement Program
Development of software support technologies to reduce costs, improve turnaround capability, and provide software supportability. New technology insertion for support of current, new, and retrofit weapons platforms. **Contractors:** In-house, TRW, Westinghouse, JFTaylor, Hughes, Analytic Sciences Corp. **Status:** Development.

High-Power Countermeasures
Definition, development, and flight testing of a long-range standoff jamming capability. Elements include very high effective radiated power and fast-switching, narrow-beamwidth, multiple-beam jamming. **Contractor:** Raytheon. **Status:** Completed preliminary flight testing.

Integrated Communication Navigation Identification Avionics System (ICNIA)
Triservice avionics program to demonstrate that multiple existing and planned communication, navigation, and identification functions can be integrated into one airborne system. **Contractor:** TRW. **Status:** Development.

Integrated Electromagnetic System Simulator
Development of a system to provide a realistic simulation of operational environments that can be used to evaluate integrated Communication, Navigation, and Identification (CNI) functions. **Contractor:** TRW. **Status:** Development.

Integrated Electronic Warfare Analysis and Modeling
Program to analyze, evaluate, and model RF/EO/IR countermeasures concepts and EW advanced development prototype hardware. **Contractor:** SAIC. **Status:** Development.

Intra-Flight Data Link
Develop and demonstrate a covert, jam-resistant, secure LPI wideband common avionics situational awareness data link for intra- and inter-flight sharing of multisensor information. **Contractors:** Northrop, Hazeltine, Unisys/TRW. **Status:** Studies, development.

Laser Warning
Program to analyze, develop, and test technology for threat warning of hostile laser systems. Emphasis on robust, low-cost, reliable techniques and designs. **Contractor:** None. **Status:** Ongoing in-house project.

Low Probability of Intercept Radio Brassboard
Development and demonstration of the feasibility of a cost-effective, multimode, LPI/antijam, secure airborne radio system. **Contractor:** QualComm. **Status:** Development.

Modular Avionics Maintenance Technology
Development and demonstration of an integrated diagnostics concept to address maintenance issues in JIAWG-type avionics. **Contractor:** None. **Status:** Development.

Multifunction CNI/EW Antenna System
Joint USAF-Navy development of broadband (2MHz-6GHz) antenna system to service CNI/EW functions. **Contractor:** TRW. **Status:** Development.

Multiple Target Attack Program
Program to develop and demonstrate fire-control techniques for maneuvering attack of multiple targets in a single pass using advanced avionics and weapons. **Contractors:** MD, Hughes, Martin Marietta. **Status:** Man-in-the-loop simulation.

Passive Expendables Analysis Measurements
Design, develop, and test passive or partially passive expendable/decoy ECM techniques for tactical and strategic applications. **Contractor:** None. **Status:** Ongoing in-house project.

Pave Pace
Design and demonstration of key elements to enhance avionics architecture for the twenty-first century. Exploits potential of emerging technologies in parallel processing, opto-electronics, and artificial intelligence. **Contractors:** Boeing, Lockheed, McDonnell Aircraft. **Status:** Design.

Real-Time Artificial Intelligence System
Joint USAF-Army-NASA program to develop and demonstrate a modular computing system for real-time processing of artificial intelligence/expert systems applications for aiding aircrews. **Contractor:** IBM. **Status:** Development.

Resonant Fiber-Optic Gyro
Program to develop and demonstrate feasibility of an inertial grade resonant fiber-optic gyro. **Contractor:** Charles Stark Draper Laboratory. **Status:** Development.

Silent Attack Warning System
Development of hardware to demonstrate a state-of-the-art infrared detection system for missile and aircraft warning. **Contractors:** GE, Loral, TI. **Status:** Development.

Strategic Targeting Laser Radar (LADAR) Technology
Development and demonstration of critical technologies and components needed to produce a CO_2 laser radar (LADAR) sensor that can permit manned bombers to recognize and attack relocatable targets. **Contractors:** Hughes, Rockwell. **Status:** Development.

Superconductivity Application for EW
Evaluation of superconductivity application concepts and resulting payoffs in electronic combat/electronic warfare systems. **Contractors:** TRW, SRI Int'l. **Status:** Studies.

Tactical Situation Assessment and Response Strategy
Partial demonstration of benefits and risks associated with application of artificial intelligence technologies to integrated defensive processing in the post-2000 fighter. **Contractors:** Loral, Hughes. **Status:** Development.

WRDC Electronics Technology Laboratory

Device Research
In-house program of III-V semiconductor technology research. Includes material growth and characterization integrated with device design, fabrication, evaluation, and modeling. **Contractor:** None. **Status:** Ongoing.

Microwave/Millimeter Wave Monolithic Integrated Circuits
DARPA/triservice program to develop affordable gallium arsenide MIMICs for advanced DoD systems. Emphasizes MIMIC development areas such as computer-aided design, chip fabrication, testing procedures, packaging, and manufacturing. **Contractors:** Phase I: Hughes/GE. Phase III: AT&T, Varian, Gateway Modeling, M/A-COM. **Status:** Continuing.

Strategic Defense Initiative
Multitechnology program involving the development of advanced microwave and electro-optical devices for spaceborne imaging radar and surveillance applications. **Contractors:** Many. **Status:** Development.

WRDC Flight Dynamics Laboratory

Advanced Fighter Technology Integration F-16
Program to develop, integrate, and flight-demonstrate technologies that will improve lethality and survivability of future advanced military fighters. Technologies include digital flight-control system, automated maneuvering attack system, digital terrain management and display system, head-steerable FLIR, integrated night vision helmet, automatic target hand-off system, and Pave Penny. **Contractor:** GD. **Status:** Aircraft modification, flight tests February 1991, final reports December 1991.

Aircraft Windshield System Development
Integration of emerging technologies into operationally acceptable transparency systems compatible with evolving military missions. **Contractor:** In-house. **Status:** Continuing.

Airframe Propulsion Integration
Technology development program for advanced fighters and high-speed flight vehicles. Advanced multifunction exhaust nozzles and highly survivable inlets. **Contractors:** MD, Lockheed, GD. **Status:** Continuing in-house exploratory and advanced development.

Carbon-Carbon 2-D Exhaust Nozzle Structures
Program to develop the technologies required to design and manufacture

"Airspeed,

500 knots.

Altitude,

below

400 feet.

Pitch black.

You know,

if I

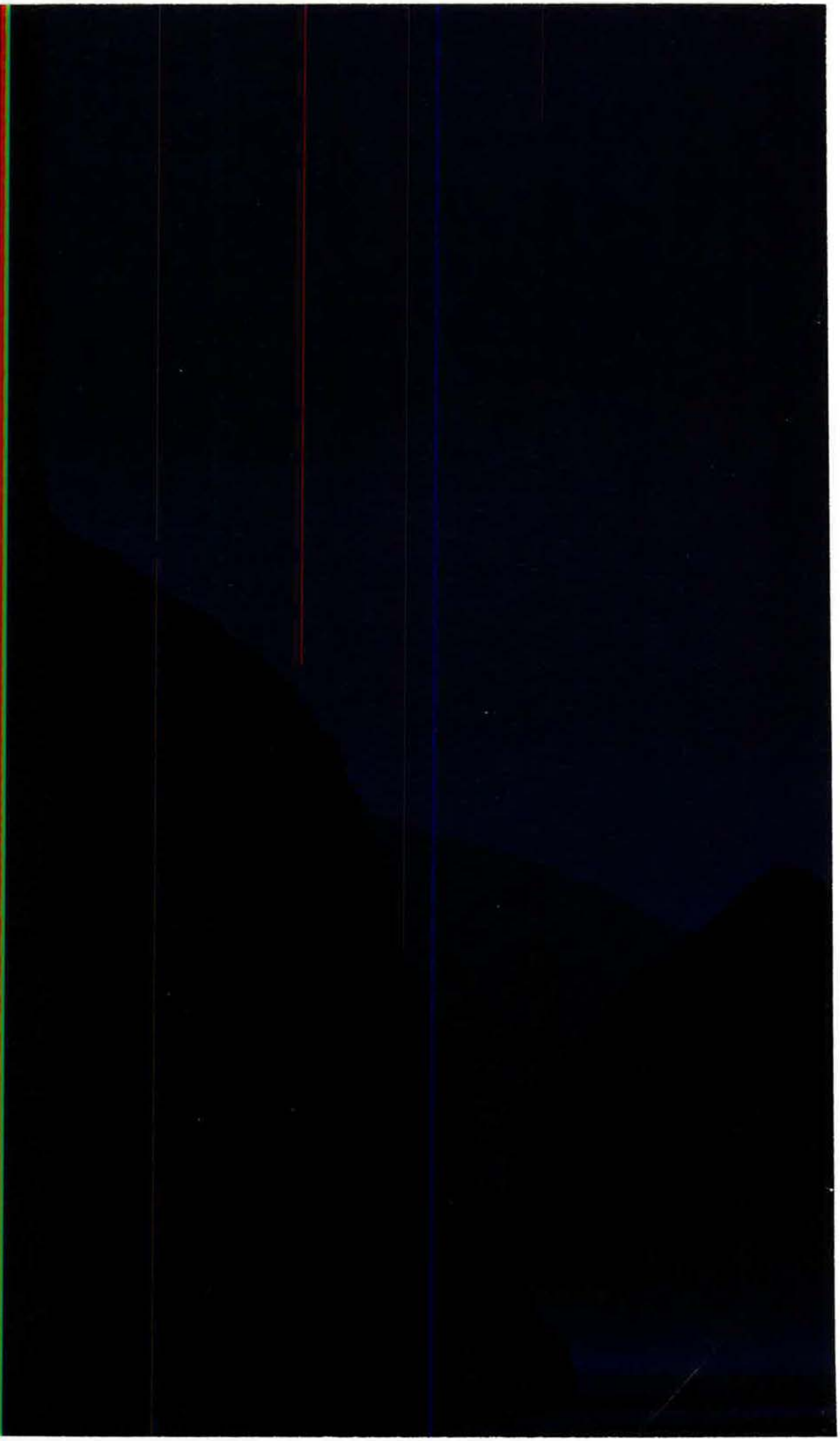
couldn't

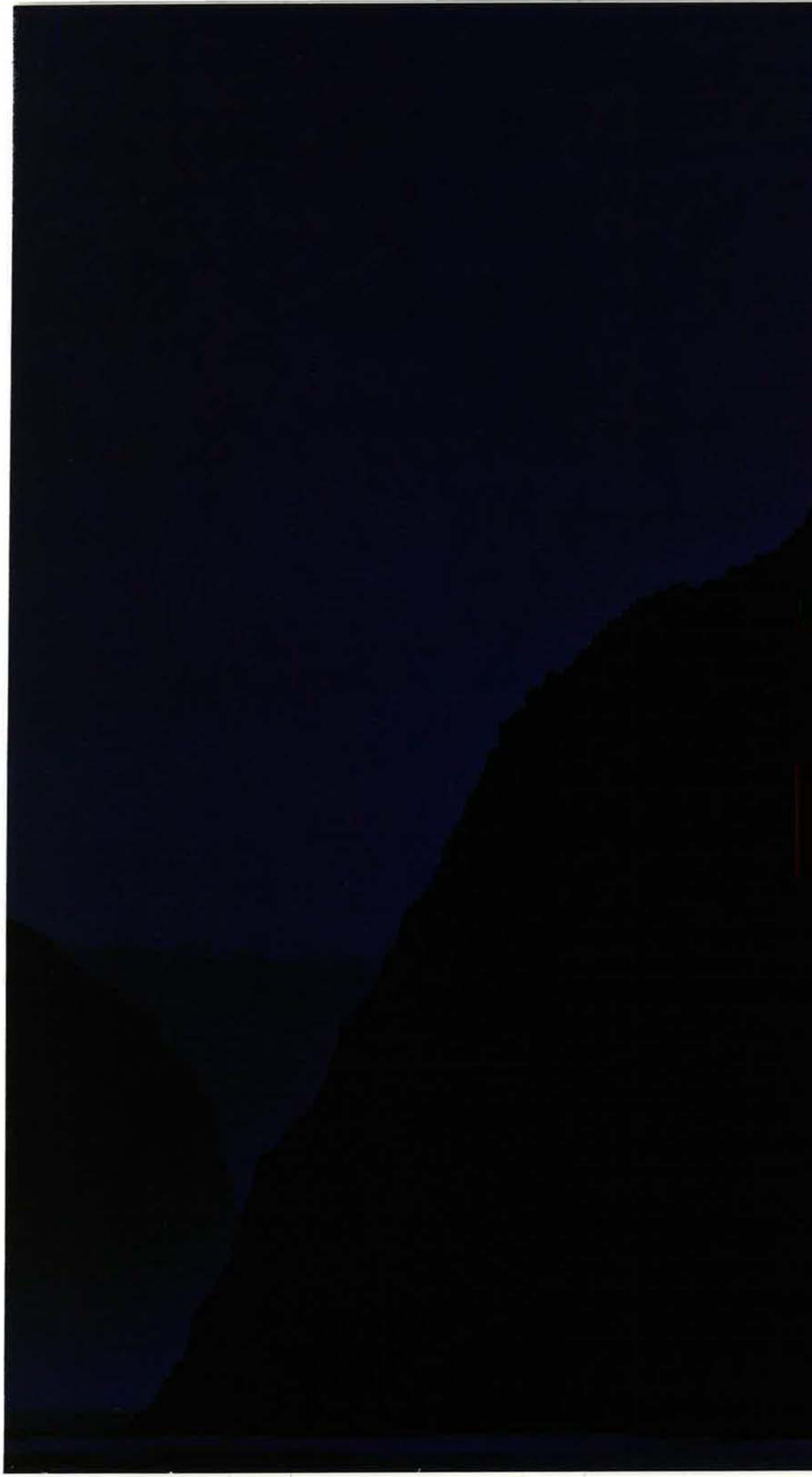
see, I

might be

a little

nervous."





advanced engine thrust-vectoring/thrust-reversing nozzle components of carbon-carbon composites. **Contractor:** GE. **Status:** Materials testing on F110 engine. Fabricating components for ATF engine tests.

Computational Fluid Dynamics
Program to develop, validate, and apply CFD methods for design and analysis of advanced vehicles, aeromechanics technologies development, and vehicle system support. **Contractors:** Many. **Status:** Exploratory development.

Configuration Research
Investigation of ways to shape, arrange, and integrate configuration components for maximum aerodynamic performance. **Contractors:** Many. **Status:** Exploratory development.

Hybrid Laminar Flow Control
Joint program (with Flight Dynamics Laboratory, NASA Langley Research Center) to develop and flight-test hybrid laminar flow-control system on Boeing 757. **Contractor:** Boeing. **Status:** Data analysis.

Hypersonics
Program to provide the aerodynamic and thermodynamic technology base for the analysis, design, and development of advanced hypersonic aircraft, aeroconfigured missiles, and reusable launch vehicles. **Contractors:** Many. **Status:** Research.

Integrated Control and Avionics for Air Superiority
Development of key control and avionics technologies that will enable cooperating fighter aircraft to engage and defeat multiple airborne threats. **Contractor:** MD. **Status:** Development.

Mission Integrated Transparency System
Development of a transparency system for advanced tactical aircraft operating in 1995. **Contractor:** GD. **Status:** Demonstration.

Prototype Flight Cryogenic Cooler
Program to develop, integrate, and test advanced cryogenic cooler technologies capable of producing cooling capacities and temperatures that meet SDI requirements. **Contractors:** Arthur D. Little, Allied-Signal. **Status:** Testing.

Self-Repairing Flight-Control System
Development of reconfiguration and on-board maintenance diagnostic technologies capable of improving reliability and maintainability of a flight-control system. **Contractor:** MD. **Status:** Final report in progress.

STOL and Maneuvering Technology Demonstrator (SMTD)
Program to develop and flight-test advanced technologies on an F-15 testbed to provide future fighters with STOL capabilities from bomb-damaged runways while enhancing maneuverability and cruise performance. Technologies include two-dimensional (rectangular) thrust-vectoring/thrust-reversing engine nozzles, integrated flight and propulsion control system, rough-field landing gear, and advanced pilot-vehicle interface. **Contractor:** MD. **Status:** Flight testing, military utility assessment.

Structural Assessment and Vulnerability Evaluation
Program to define the structural engagement conditions of key USAF aircraft, to demonstrate the problem through component level testing, and to validate analytical tools for use in future hardening programs. **Contractor:** SAIC. **Status:** Vulnerability assessment, materials assessment.

Subsonic Aerodynamic Research Laboratory
In-house design and development of a large, open-circuit, low-turbulence, subsonic wind tunnel for flow visualization, computational fluid dynamics code calibration, and high-angle-of-attack research. **Contractor:** Fluidyne. **Status:** Facility calibration.

Supportable Hybrid Fighter Structures
Demonstration of the supportability, durability, weight, and life-cycle cost advantages of an advanced hybrid structure compared to conventional hardware used in major airframe structures. **Contractor:** GD. **Status:** Fabrication.

Variable Stability In-Flight Simulator Test Aircraft (VISTA/F-16)
Design and production of a high-performance in-flight simulator to replace the NT-33. **Contractors:** GD, Calspan. **Status:** Fabrication.

X-29A Advanced Technology Demonstrator
Development and validation of advanced aerodynamic, structural, and flight-control technologies of a forward-swept-wing aircraft. **Contractor:** Grumman. **Status:** Flight testing.

WRDC Materials Laboratory

Advanced Structural Metallic Materials
Comprehensive two-part program to research and conduct exploratory development of aluminum, titanium, and magnesium structural alloys and metal matrix composites. Aims to put into production superior alloys of higher strength, improved resistance to corrosion, and greater resistance to heat. **Contractors:** Lockheed, GE, U. of Va., Metcut, SRL, P&W, Boeing, Lockheed-Calac. **Status:** Research and exploratory development.

Composite Materials Research and Development
Investigation and development of a wide variety of new composite materials for USAF aircraft, spacecraft, missiles, and ICBMs. **Contractors:** Boeing, GD, U. of Dayton Research Institute, others. **Status:** Research, exploratory and advanced development.

Electronic and Optical Materials Research and Development
Programs to develop new and improved materials and processing techniques for II-VI and III-V compound semiconductors, high-temperature superconducting thin films, nonlinear optical materials, and high-performance infrared transparencies for applications in infrared detectors; microwave, microelectronic, and opto-electronic devices; and high-speed missiles and aircraft. **Contractors:** AT&T, GE, Hughes, Rockwell, U. of Dayton Research Institute, Westinghouse, others. **Status:** Research, exploratory development.

Hardened Materials/Airborne and Space Subsystems
Program to develop technology base to be used by systems designers for protecting tactical and space systems from effects of directed energy, kinetic energy weapons, and laser radiation. **Contractors:** TI, MD, Hughes, Rockwell, Acurex, GE, TRW, Barnes, Lockheed, Arthur D. Little, Perkin Elmer, LTV, GA Technologies, SAIC, Martin Marietta, AVCO. **Status:** Advanced development.

High-Temperature Materials
Development of revolutionary high-temperature materials—primarily ceramic matrix composites, carbon-carbon composites, and intermetallics—for application in future gas-turbine engines and in hypersonic vehicle structures. **Contractors:** Many. **Status:** Research and exploratory development.

Manufacturing Research
Provides the technology base for early introduction of advanced materials and processes into manufacturing; for significantly reducing new product cycle time; for significantly reducing acquisition and life-cycle cost; and for flexible, low-volume, quality manufacturing. The research will address the advancement of computer technology as applied to manufacturing. **Contractors:** Many. **Status:** Research.

Materials Processing Modeling
Development of computer analytical models and physical modeling to allow prediction of materials' response to processing and to enable the attainment of preferred microstructure and properties the first time, avoiding costly, traditional trial-and-error approach. **Contractors:** UES, Battelle, Shulz Steel. **Status:** Research and exploratory development.

Mechanical Behavior of Advanced Materials
Program to develop understanding of the engineering behavior and life-prediction methodologies necessary to use revolutionary, high-temperature materials in both propulsion and airframe applications. Materials include titanium aluminides, intermetallic matrix composites, carbon-carbon composites, and ceramic matrix composites. **Contractors:** Many. **Status:** Exploratory development.

Nondestructive Inspection/Evaluation R&D
Exploratory and advanced development of new, more accurate, more reliable, nondestructive/inspection (NDE/I) capabilities to support weapon systems quality assurance and reliability and maintainability programs within the Air Force. **Contractors:** Many. **Status:** Exploratory and advanced development.

Nonstructural Materials
Development of a variety of lubricants, seals, coatings, foams, and other critical materials. **Contractors:** Hughes, U. of Dayton, GE, TRW, Ultrasystems, others. **Status:** Exploratory development.

Ultralightweight Structural Materials
Development of advanced carbon-fiber matrix composites, ordered polymers, molecular composites, and other types of substances for future USAF aircraft, spacecraft, and missiles. **Contractors:** MD, Northrop, Dow Chemical, Foster Miller, others. **Status:** Research, exploratory and advanced development.

Weapon Systems Material Support
Development of advanced composite repair techniques, new NDE/I procedures, and corrosion control coatings and methods. Provides structural and electronic failure analysis and materials-engineering support to acquisition, operational, and logistics commands. **Contractors:** U. of Dayton Research Institute, Universal Technology Corp., Rockwell, Boeing, McAir, others. **Status:** Continuing.

WRDC Cockpit Integration Directorate

Assault Transport Crew Systems Development
Effort to define and develop crew system concepts for an advanced assault transport. **Contractor:** Douglas Aircraft. **Status:** Development.

Color Head-Down Display
Development of a large-area, direct-view, flat-panel display that will have high contrast even in bright sunlight. **Contractor:** David Surnoff Research Labs. **Status:** Completed.

3-D Flat Panel Display
Development of a flat-panel color display for cockpit use with the capability to display 3-D stereoscopic information. **Contractor:** Dimension Technologies, Inc. **Status:** Development.

Graphics Processor Definition
Program to define the requirements, design a detailed architecture, and create a system/segment design document for a graphics processor system for application in an Air Force avionics environment. **Contractors:** Honeywell, Inc., MD. **Status:** Development.

Panoramic Cockpit Control and Display System
Demonstration of advanced control and display techniques in a full-cockpit simulation. Validate concept for application in F-15 in the mid-1990s. **Contractor:** MD. **Status:** Development.

Pilot's Associate
Program to apply artificial intelligence technology to cockpit to assist pilots of advanced aircraft by managing information and helping to improve situational awareness. **Contractors:** Lockheed, MD. **Status:** Development, demonstration.

Threat Expert Analysis System
Development of system to provide a fighter pilot with an integrated defensive response to a threat by providing available options and recommendations. **Contractor:** FAAC Perceptronics. **Status:** Completed.

WRDC Manufacturing Technology Directorate

Advanced Data/Signal Processing
Program to increase real-time data collection during VLSI processing, to improve manufacturing of printed wiring boards for 25 MHz operation, to establish manufacturing process for solder assembly of said boards, and to conduct functional tests of candidate assemblies. **Contractor:** Martin Marietta. **Status:** Manufacturing technology.

Aircraft Composite Structure Manufacturing
Initiative to provide more efficient ways of producing primary advanced composite components for aircraft. **Contractors:** Boeing, MD. **Status:** Manufacturing technology.

Automated Airframe Assembly Program
Development and integration of advanced design, planning, scheduling, control, and information-management technologies. Major concentration on the development of commercially supported products that allow the migration from existing factory systems to advanced-technology solutions. **Contractors:** Northrop and its subcontractors. **Status:** Manufacturing technology.

Engineering Information System
Program to define and demonstrate a set of candidate standards that will enable electronic CAD tools from different vendors to work in concert. **Contractor:** Honeywell. **Status:** Development.

Enterprise Integration Program
Initiative to advance the state of the art in certain key technology areas that have been determined critical to enterprise integration. **Contractor:** None. **Status:** Source selection.

Integrated Product Support Initiative
Initiative to apply CALS technology to Air Force programs and to shape national and international standards and specifications. **Contractors:** Northrop, P&W, MD, ICAD, Lockheed, Boeing, D. Appleton & Co., others. **Status:** Continuing.

Manufacturing Technology for Advanced Propulsion Materials
Initiative to provide production capabilities for engine components, incorporating advanced materials systems. **Contractors:** GE, P&W. **Status:** Continuing.

Manufacturing Technology for Radar Transmit/Receive Modules
Program to establish and demonstrate a low-cost manufacturing capability for large quantities of complex microwave T/R modules for inclusion in active element phased-array radar systems. **Contractors:** Hughes, TI/Westinghouse joint venture. **Status:** Continuing.

Manufacturing Technology for Silicon on Insulator Wafer
Program to optimize the "separation by implantation of oxygen" (SIMOX) process for silicon wafers up to six inches in diameter and establish a US source for same. **Contractor:** TI. **Status:** Continuing.

Microelectronics Manufacturing Science and Technology (MMST)
Joint WRDC/EL/MT-DARPA program to demonstrate new, low-cost, semiconductor manufacturing techniques using modular, vacuum processing chambers in clusters with reactive ion etching (RIE), plasma-enhanced chemical vapor depositions (PECVD), and in-situ sensors with expert system process control for low-volume, military semiconductor products. **Contractor:** TI. **Status:** Continuing.

WRDC Technology Exploitation Directorate

Advanced Technology Cost Assessment
Development of methods and a procedure to assess quantitatively the cost-effectiveness of emerging advanced technologies and systems to the component level during the late concept definition and early predesign stages of development. **Contractor:** None. **Status:** Continuing.

Advanced Theater Transport (ATT) Program
Joint program to address design and technology issues posed by perceived mission requirements for a twenty-first-century theater transport. **Contractors:** Many. **Status:** Research, exploratory and advanced development.

Fighter Airframe/Propulsion Integration Predesign Studies
Program to study and assess benefits and penalties of individual technologies and integration concepts for future multimission fighter aircraft. Areas include advanced aerodynamic controls; thrust-vectoring nozzles; signature reduction; component cost reduction; reliability, maintainability, and supportability; and vehicle management systems. **Contractor:** None. **Status:** Planning for contract awards in 1991.

Fighter Avionics/Cockpit Predesign Studies
Program to search for high-payoff ways to optimize pilot–weapon system interface technology for future multimission fighter aircraft and define avionics/cockpit technology needs and demonstration levels. **Contractor:** None. **Status:** Planning for contract awards in 1991.

Life Cycle Cost Methodology Development
Program to create Modular Life Cycle Cost Model as a cost estimation method for use during vehicle conceptual design. **Contractor:** None. **Status:** Planning.

Simulation of Future Air Combat
Enhancements to the in-house manned air-combat simulation Air-to-Air System Performance Evaluation Model. Includes use of electronic countermeasures, inter- and intraflight data fusion, close-in and beyond-visual-range combat, air-to-air and air-to-ground missions, and post-stall/agility representation. **Contractor:** None. **Status:** Continuing.

Future Tactical Air Engagement Effectiveness
Investigation and assessment of the impact of advanced technologies applicable to existing and future fighter aircraft to achieve significant increases in Air Force mission effectiveness. **Contractors:** Lockheed, Boeing. **Status:** Development.

Enhanced Surface-to-Air Missile Simulation
Simulation model of interaction between a single airborne target and a specified surface-to-air missile fired from a designated location. **Contractors:** Many. **Status:** Development.

Future Fighter Concepts
Explores multirole fighter technologies that are affordable and combat-effective against a post-2005 threat. **Contractor:** None. **Status:** Continuing.

Man-in-Loop Air-to-Air System Performance Model
Manned air combat computer simulator used to assess and evaluate the military worth of emerging technologies relating to current and future air combat. **Contractors:** Many. **Status:** Development.

Special Operations Aircraft Technology Effectiveness Sensitivity Study
Assessment of a field of SOA concepts for their mission effectiveness to identify and quantify technology contributions and determine critical technology developments needed to support a technology demonstrator. **Contractor:** None. **Status:** Continuing.

ASD Deputate/Avionics Control

Air Force Avionics Roadmap
Annual publication for government and industry planning, providing program details including descriptions, status, objectives, and interrelationships. **Contractor:** ARINC. **Status:** Continuing.

Avionics Decision Support System
Analysis tool for performing technical, cost, effectiveness, and support trade-offs and providing a common database for Air Force avionics programs. Produces annual Avionics Planning Baseline document. **Contractor:** *TBD.* **Status:** Source selection.

Avionics Modernization Decision Process
Structured technical and management review to recommend lead acquisition organization for Class IV–V modifications to initiate major weapon system improvements more effectively. **Contractor:** In-house. **Status:** Continuing.

Avionics Subsystem Users Group
Annual avionics users' conference to evaluate effectiveness of avionics standards and identify standardization opportunities. **Contractor:** In-house. **Status:** Continuing.

Embedded Computer Standardization Program
Program to develop and acquire software support tools (compilers, linkers, debuggers, etc.) for weapon system acquisitions that use MIL-STD-1815A Ada language and MIL-STD-1750 computer instruction set architecture. **Contractor:** Boeing Military Airplane Co. **Status:** Development.

Modular Avionics System Architecture
Program to define modular avionics architecture design, evaluate standardization of modules, and provide design handbooks for development of modular avionics. **Contractors:** ARINC, Battelle, Draper Lab. **Status:** Development.

Standardization Evaluation Program
Avionics life cycle cost model for Air Force and industry to compute the cost of applying common avionics across multiple aircraft. **Contractors:** Analytic Sciences Corp., Information Spectrum Inc. **Status:** Continuing.

ASD Deputate/Development Planning

Advanced Attack Weapon
Development of performance, trade, sensitivity analyses, and system concepts for a short-range, close air support/battlefield interdiction weapon to enhance effectiveness of F-16 and advanced aircraft. **Contractors:** In-house, MD, Martin Marietta, Rockwell. **Status:** Pre–Milestone 0.

Advanced Capability Antiradiation Missile
Analyses of alternative advanced systems to provide lethal suppression of enemy air defenses. Development of preliminary performance goals for next-generation missile. **Contractor:** KMAC. **Status:** Pre–Milestone 0.

Air Force Weapons Roadmaps
Annual publication of air-to-air, air-to-surface, and special operations twenty-year master plans that are cooperative efforts among users, planners, and technologists. **Contractor:** In-house. **Status:** Continuing.

Advanced Multirole Combat Aircraft Design Analysis
Development of configuration alternatives for a future lightweight, multirole aircraft with emphasis on the integration of advanced weapons and reduced signatures. **Contractor:** In-house. **Status:** Continuing.

Advanced Theater Transport
Development of comprehensive database, performance trades, and sensitivity analyses to support MAC definition of next-generation theater airlifter. **Contractors:** In-house, General Research Corp., major airframers. **Status:** Continuing.

Aerial Refueling Systems Plan
Program to assess current aerial refueling capabilities and future requirements; to develop a comprehensive plan to meet future needs through current force modification and new acquisitions options. **Contractor:** Frontier Technology, Inc. **Status:** Preconcept study.

Air Interdiction Design Analysis
Analyzes operational capabilities and design impact in cross-service use of future USAF and Navy aircraft. **Contractor:** In-house. **Status:** Continuing.

Avionics Integration in Design
Program to develop concepts that consider the interaction of avionics with the airframe and armament to ensure a balanced, effective design. **Contractor:** In-house. **Status:** Continuing.

Bomber Aircraft Lethal Penetration Aids
Development of system options to assist SAC in refining its statement of need for a system that will provide penetrating bombers with a lethal self-protection capability. **Contractor:** In-house. **Status:** Pre–Milestone 0.

Extended Coverage Antimateriel Submunition
Development of preliminary concepts and effectiveness analysis for an improved antimateriel submunition that can be used as a payload for either guided standoff weapons or unguided weapons. **Contractor:** In-house. **Status:** Continuing.

Hypersonic Vehicle Technology Mission/Concept Assessment
Analyses of potential future applications of hypersonic weapon systems across a broad spectrum of Air Force missions. **Contractor:** Frontier Technology, Inc. **Status:** Continuing.

Hypervelocity Missile Design Integration
Studies identifying design and integration methods for both air-to-ground and air-to-air applications to maximize combat utility. **Contractor:** In-house. **Status:** Continuing.

Infrared/Electro-Optical Sensor Trends and Requirements
Investigation to provide an assessment of performance capability and availability of specific IR and EO technology. **Contractor:** MacAulay-Brown, Inc. **Status:** Continuing.

Joint Primary Aircraft Training System Study
Development of concepts for a primary-level pilot training system that will train students for entry into the advanced tracks of USAF and USN training. Study will help define requirements for a replacement of the T-37. **Contractor:** Illinois Institute of Technology Research. **Status:** Preconcept definition.

Low-Cost Millimeter Wave Seeker
Concept design and component development for a very-low-cost, millimeter wave seeker. Focus is on the antenna, transceiver, and algorithms. Components will be supplied to the Air Force Development Test Center for insertion in the low-cost, dual-mode seeker program. **Contractor:** Glynn Scientific. **Status:** Continuing.

MAJCOM Supportability Factors for Single-Stage-to-Orbit Vehicles
Investigation to examine supportability requirements of hypersonic vehicles from an operational Air Force perspective. Includes basing, maintenance, and logistics issues. **Contractor:** Science and Engineering Associates, Inc. **Status:** Continuing.

Mission/Flight Systems Integration
Development of functional capability requirements for future aircraft electronic/avionics systems in a variety of vehicles and missions. **Contractors:** Illinois Institute of Technology Research, Frontier Technology, Inc., McAir. **Status:** Continuing.

Operational Utility of STOVL
Evaluation of the operational utility of short takeoff and vertical landing air vehicles. **Contractors:** SAIC, Ball Aerospace. **Status:** Continuing.

Post-2000 Air-to-Air and Air-to-Surface Concept Studies
Program to develop generic, next-century weapon concept that is compatible with advanced aircraft and applies emerging technologies to enhance effectiveness and/or reduce cost. **Contractors:** Boeing, MD. **Status:** Continuing.

SOF Gunship Ammunition Improvements
Devising a program plan and refining the performance requirements for developing and acquiring improved 25-mm, 40-mm, and 105-mm projectiles for the Special Operations Forces AC-130 gunship. **Contractor:** In-house. **Status:** Pre–Milestone 1.

Special Operations Aircraft
Definition of long-range survivable system concepts and needed capabilities for a new special-operations airlift vehicle. **Contractors:** In-house, Boeing, Douglas Aircraft, Lockheed. **Status:** Preconcept definition.

Specialized Undergraduate Pilot Training System Concept
Analysis and development of training system concepts for Specialized Undergraduate Pilot Training. Integrates Bomber-Fighter Training System and Primary Aircraft Training System. **Contractor:** In-house. **Status:** Preconcept definition.

Strategic Relocatable Targets Program Office
Program to demonstrate technologies that will detect, identify, and strike Strategic Relocatable Targets (SRTs). Employs a non-platform-specific, building-block approach to combine mature and emerging technologies. Emphasis on manned bombers, off-board scouts, overhead systems, sensors, automatic target cuing, and automatic target recognition algorithms as well as high-speed processors. **Contractors:** Many. **Status:** Continuing.

Study of Unmanned Air Vehicles
Project to identify promising applications of unmanned air vehicles, define UAV concepts, and provide recommendations for use of UAVs to eliminate force deficiencies. **Contractor:** None. **Status:** Preconcept definition.

Transatmospheric Aeronautical Systems
Preliminary design analysis to identify requirements and capabilities of transatmospheric systems. **Contractor:** In-house. **Status:** Preconcept definition.

Weapons for Multirole Fighter
Concept design for air-to-air and air-to-surface weapons that are tailored to the multirole fighter concept. **Contractor:** In-house. **Status:** Continuing.

ASD Deputate/Engineering

Aircraft Structural Integrity Program
Program to link all aspects of structural design, analysis, test, and operational use of aircraft to establish service life and track it constantly. **Contractor:** None. **Status:** Continuing.

Avionics Integrity Program
Provides a disciplined engineering process for the development of avionics to enhance system reliability and safety. **Contractor:** In-house. **Status:** Continuing.

Engine Structural Integrity Program
Provides organized approach to structural design, analysis, test, and life-cycle management of gas turbine engines. **Contractor:** None. **Status:** Continuing.

Generic Integrated Maintenance Diagnostic System
Program to integrate all aspects of an air vehicle's diagnostics capability. **Contractors:** GD, Bell Helicopter, GE, Giordano, Hughes, Marconi, Rockwell, TRW. **Status:** Continuing.

Industrial Modernization Incentive Program
Program to provide incentives for contractors to bring together advanced productivity-enhancing technologies and the investments necessary to modernize their organizations and facilities. **Contractors:** Many. **Status:** Ongoing.

Integrated Product Development
Initiative in support of "concurrent engineering," a method to combine development and qualification of all system elements. Integrates design, manufacturing, support, and training. **Contractors:** Many. **Status:** Ongoing.

Mechanical Subsystems and Equipment Structural Integrity Program
Program to adapt integrity-assurance process to air and ground mechanical systems and such equipment as hydraulic, pneumatic, and secondary power systems. **Contractor:** None. **Status:** Continuing.

MIL-PRIME Program
Initiative to streamline acquisition by improving quality of specifications and standards placed on contract and to eliminate overspecification of programs. **Contractor:** None. **Status:** Continuing.

R&M 2000
Enhanced systems-engineering process to help meet USAF's R&M 2000 goals. **Contractor:** None. **Status:** Continuing.

Senior Engineering Technology Assessment Review
Program for review and assessment of objectives, approach, and possible payoffs of advanced technology development programs. **Contractor:** None. **Status:** Continuing.

Software Development Integrity Program
Initiative to improve operational capability and supportability of aeronautical weapon system software. **Contractor:** None. **Status:** Continuing.

Value Engineering
Program to reduce acquisition and support costs while maintaining or improving performance by implementing high-payoff changes to such system features as design and production processes. **Contractor:** None. **Status:** Continuing.

4950th Test Wing

Advanced Range Instrumentation Aircraft Scoring Systems
Program to provide state-of-the-art, broad-ocean-area coverage of reentry vehicles for weapon system testing. Functions previously requiring both EC-135 and P-3 aircraft will be combined in the EC-18 ARIA aircraft. The Sonobuoy Missile Impact Location System will acquire and process missile impact data. Impact locations of multiple reentry bodies will be determined using deep-ocean transponders as geodetic references. Associated programs will collect optical data on reentry vehicles during the terminal phases of flight and will sample meteorological parameters from the surface to 80,000 feet. **Contractors:** Applied Physics Laboratory (Johns Hopkins U.), E-Systems. **Status:** Advanced development and aircraft modification.

Cruise Missile Mission Control Aircraft
The CMMCA (designated EC-18D) will provide a stand-alone asset for OT&E (off-range) and a range support asset for DT&E (on-range) cruise missile testing. By combining the aspects of telemetry reception and real-time display, remote command and control, and radar surveillance into one airframe, cruise missile testing will not require the large airborne support group currently used. Initial operational capability is planned for FY 1991. **Contractors:** Chrysler Technological Airborne Systems, Hughes. **Status:** First aircraft in modification.

ECCM/Advanced Radar Test-Bed
In support of the ECCM master plan, the ECCM/ARTB is an airborne platform for development, test, and evaluation of advanced radar systems and ECCM techniques, to include multisensor integration. This unique Air Force resource will support development of the B-1, F-15, F-16, and ATF radar systems and advanced technology programs into the 1990s. The test-bed, currently under design development, is scheduled for employment in FY 1991. **Contractor:** Lockheed Aeronautical Systems Co. **Status:** Fabrication, integration, ground and flight testing.

Integrated Data Facility
The integrated data facility will standardize, modernize, and enhance the capability for processing flight-test data. The IDF will consist of a ground-based laboratories (GBL) module, a real-time test data monitoring module, and a module for improved data computation and analysis. The GBL module will provide for ground integration and checkout of test item hardware prior to aircraft installation. Local and wide area networks will provide for efficient sharing of data and computational resources. Full operational capability is scheduled for FY 1994. **Contractors:** Many. **Status:** Several components are operational.

Mark XV IFF Test Program
This program is intended to test the next generation of IFF equipment for the Air Force, Navy, Army, and NATO. It is designed to be a secure, antijam, high-reliability system that can operate in an ECM environment. **Contractors:** Bendix, TI. **Status:** FSD.

Testing Off-the-Shelf Aircraft
Commercial aircraft purchased for military applications are evaluated against applicable military requirements both during source selection and after contract award. Areas of evaluation include ground handling, maintenance, flying qualities, performance, human factors, and technical orders. Several programs are ongoing: T-1A, C-27, VC-25A Air Force One replacement aircraft, and the Enhanced Flight Screener. Recent evaluations include the C-12, C-18, C-20, C-21, C-22, C-23, and C-29. **Contractors:** Many. **Status:** Continuing.

Photo Safety Chase
The 4950th Test Wing has developed a full complement of photo safety chase aircraft especially suited for medium- and low-speed aircraft. **Contractors:** Many. **Status:** Ongoing. Photographic platform aircraft capabilities are being upgraded. Available to all civilian and DoD contractors. ■

Thrust-vectoring with the engine blast can give airplanes a new edge in maneuvering.

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A Nudge in a Better Direction

By F. Clifton Berry, Jr.

The heart of the F-15 STOL Maneuvering Technology Demonstrator is the two-dimensional thrust-vectoring nozzles built by Pratt & Whitney. Through these nozzles and associated equipment, the NF-15B can perform maneuvers many thought were impossible. Vectored thrust technologies will be vitally important on future combat aircraft.

SAY you are a US combat commander with special airpower needs. You want to be able to operate heavy and fast fixed-wing combat aircraft from a narrow runway that is only 1,500 feet long, or perhaps even from a small clearing in the woods.

At the same time, you want to make sure that these fighter aircraft are more maneuverable at high and low speeds than the fighters of the enemy. Where do you find such aircraft?

For taking off from and landing on the short runway, you will need something similar to the Air Force's NF-15B, an exotic aircraft whose official name is the F-15 Short Takeoff and Landing and Maneuvering Technology Demonstrator (SMTD).

For operations from the woodland clearing, on the other hand, your choice is the USMC AV-8B Harrier II, built by McDonnell Douglas and British Aerospace. Both fighters have enhanced maneuverability.

At first glance, these two aircraft would seem to have little in common. The AV-8B is the latest in the Harrier line, which began service in the RAF in 1969. The NF-15B is a one-of-a-kind, advanced-technology demonstrator version of the venerable F-15 Eagle first delivered to the Air Force in November 1974. Between the two fighters, differences are many and significant.

They do, however, share one critical characteristic: Both use the power of vectored engine thrust to achieve extraordinary aeronautical performances. "Vectored thrust" is a term that the aerospace world is sure to hear more and more in years ahead. A growing number of aircraft types are using vectored thrust, and the feature soon will no longer be exceptional.

Vectoring entails the use of mechanical means to change the direction of the power that spews from an engine—its thrust—in order to achieve special aeronautical effects. As explained by Lt. Col. Felix Sanchez, the Air Force's SMTD program manager at Flight Dynamics Laboratory, Wright-Patterson AFB, Ohio, thrust-vectoring is a way to create "moments" about the center of gravity (CG) of an aircraft in order to move the nose where the pilot wishes.

Pressure of the Moment

"Moments" are defined as the product of a force and a distance in relation to a point—in this case, the CG. A force of one pound exerted on the CG via a twelve-inch crowbar creates a moment of twelve "inch-


AF71290

pounds." The same pound of force exerted on a twenty-four-inch bar creates a moment of twenty-four inch-pounds.

The force exerted by this hypothetical crowbar is analogous to moments created by various airplane flight controls. They act on the three axes of an aircraft, corresponding to its three spatial dimensions, and on the relative speed of the plane, which corresponds to a fourth dimension—time.

The horizontal tail or the canard on the forward fuselage exerts pitching moments about the CG; these forces raise or lower the aircraft's nose or keep it level. The ailerons on the wings create moments that roll the aircraft about its CG. Rudders create yawing moments that move the nose from side to side. Maneuvering involves acceleration and deceleration, either with engine thrust or mechanical devices such as speed brakes.

Thrust-vectoring creates an additional type of flight control, one based on the forces created by the engine itself. A simple demonstration can be done with a garden hose. Turn it on full blast with the nozzle adjusted for the narrowest, strongest spray. Turn the nozzle left and right, up and down, and the palm of your hand feels the thrust being vectored.

The idea is simple enough, but for a long time engineers found it difficult to employ it. In the late 1960s, the Harrier became the first vertical/short takeoff and landing (V/STOL) aircraft to enter operational squadron service. Long before that, in the 1950s and early 1960s, plenty of aerospace companies tried their hands at building experimental vectored-thrust aircraft.

Dr. John W. Fozard was chief designer of Hawker (and British Aerospace) V/STOL jet fighters, including the Harrier. As he tells it, Harrier development began with a 1956 concept created by Michel Wibault, a leading French aeronautical engineer. Dr. Fozard recalls that USAF Col. Willis F. Chapman was serving in Paris as the air member of the Mutual Weapons Development Program (MWDP) at the time. Colonel (later Brigadier General) Chapman evaluated Wibault's design, finding its vectored thrust impractical.

However, Colonel Chapman interested the Bristol Aero Engine Co. Ltd. in taking on a similar project, and the company linked up with Hawker to design a workable V/STOL, vectored-thrust fighter. In due course, the Bristol Pegasus engine was developed under the MWDP. The US provided seventy-five percent of the financing and Bristol the other twenty-five percent. (Bristol later became part of Rolls-Royce.)

The first vertical takeoff aircraft to enter squadron service was the Harrier. Its remarkable capabilities come from a Rolls-Royce Pegasus engine using vectored thrust directed though four nozzles mounted on the fuselage. Above, a Marine AV-8B Harrier II returns to Indian Springs, Nev., during an exercise.

Fine-Tuned Control

With the Royal Air Force providing development funding, the Harrier flew in 1966. Dr. Fozard notes that the US Marine Corps evaluated the Harrier in 1968 and, from 1971 to 1976, bought 110 AV-8A jets. The latest version in USMC service is the AV-8B, powered by a more powerful Rolls-Royce Pegasus turbofan engine, generating 22,000 pounds of thrust.

Thrust from the Pegasus is vectored by a simple system of swiveling nozzles, controlled by a single lever in the cockpit. The center of thrust is at the aircraft's center of gravity. The fore and aft nozzles point downward for vertical or short takeoff and landing. The pilot moves them to vector the thrust through transition between vertical and forward flight.

In the Harrier, full Pegasus engine power is available in both the horizontal and vertical modes. The plane receives additional, fine-tuned control in flight via use of a reaction-control system that augments the Harrier control surfaces. It bleeds high-pressure air from the combustor to valves in the wingtips, nose, and tail.

With the airplane in service for nearly a quarter of a century, the obvious question is "How have Harriers performed in combat?" Has the enhanced maneuverability available with thrust-vectoring paid off?

The 1982 Falkland Islands clash of British and Argentine forces provides the best evidence to date. In that war, Royal Navy Sea Harrier V/STOL aircraft flew more than 1,100 combat air patrol sorties. In air-to-air fighting, they destroyed twenty-three Argentine aircraft. British forces did not lose a single Harrier in aerial combat, though Argentine ground defenses shot down two Sea Harriers and three RAF GR. Mk. 3 variants.

Radically Different

The Air Force's NF-15B is radically different from the Harrier. The Air Force launched the SMTD program in 1984 to demonstrate, in flight, the technologies required to give future fighters enhanced maneuverability and to permit them to carry out nighttime, all-weather operations from segments of bomb-damaged runways measuring only fifty feet wide and 1,500 feet long.

Thrust-vectoring and thrust-reversing via rectangular (2-D) nozzles is only one technology that was being proven in flight. Other technologies on the F-15 SMTD include an integrated flight/propulsion system, advanced interface between the pilot and aircraft, antiskid autobraking, and rough/soft-field landing gear. McDonnell Douglas is the prime contractor. Power for the aircraft is provided by two Pratt & Whitney F100-PW-220 engines fitted with rectangular 2-D nozzles and P&W engine controls. General Electric provides the flight-control computers; National Water Lift, the flight-control actuators; Cleveland Pneumatic, the rough-field landing gear; and Crane Hydro-Aire, the digital skid-control system.

Thrust-vectoring and thrust-reversing are actuated by the integrated control system. Roger Bursey, SMTD manager at the P&W engine house, says that the system automatically determines what the pilot wants the aircraft to do through his inputs to the control stick, throttles, and rudder pedals. The flight-control system then directs the aircraft nozzles, canards, and standard flight-control surfaces to accomplish the maneuver commanded by the pilot.

Since its first flight in September 1988, the SMTD has flown through a series of increasingly rigorous phases to test the thrust-vectoring/reversing technologies and other new techniques. By November 1990, fifty-three flights had been made using the 2-D nozzles, during which the aircraft racked up an impressive list of "firsts."

Sudden Slowdowns

One of the firsts was achievement of thrust-reversal at supersonic speeds (first at Mach 1.4, then at Mach 1.6). The maneuver, if perfected, would provide the kind of sudden deceleration that would be useful in air combat. The SMTD's ability to do it permits investigation of formerly unknown aerodynamic effects on airframe structures.

Another first was improving the aircraft's roll performance by vectoring the right and left engine nozzles in opposite directions.

Thrust-vectoring is especially valuable in the low-speed portion of the flight envelope. At low speeds, when the aerodynamic controls are less effective, the thrust-vectoring method of control continues to be fully functional. In fact, the SMTD program has proved thrust-vectoring effectiveness throughout the full flight envelope, from lowest to highest speeds. That includes a sixty-five percent increase in the pitch rate at high angles of attack, increasing agility for air-to-air combat.

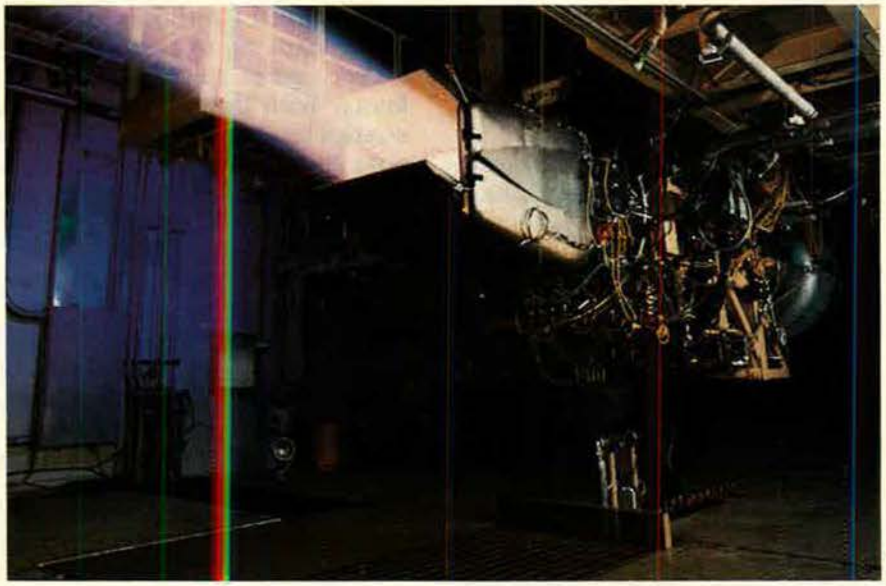
The F-15 SMTD also has demonstrated extraordinary capabilities in taxiing, takeoff, and landing. A fighter's nose gear is vulnerable to damage on rough fields. The SMTD's rough-field landing gear has absorbed the shocks of taxiing over bumps up to four and a half inches high at speeds up to ninety knots. With thrust-vectoring, the nozzles can be directed to raise the nose to reduce load on the nose gear, further enhancing the aircraft's ability to operate on rough fields.

On takeoff, the NF-15B's nose can be raised at thirty knots by vectoring the thrust, and takeoff speed and angle of attack can quickly be achieved. That cuts required runway length by more than twenty-five percent. Short landings using thrust-reversing reduce runway required by two-thirds, from more than 4,500 feet to 1,500 feet or less.

In fact, the SMTD's autonomous landing guidance system and thrust-reversing and control technologies have achieved truly remarkable results. When all the technologies are used together, the SMTD will demonstrate the ability to take off and land at night on a wet, bomb-damaged segment of runway only fifty feet wide by 1,500 feet long, in a thirty-knot crosswind, under a 200-foot ceiling, with only one-half-mile visibility, and with no active navigational assistance from the ground.

Because its array of technologies has been successfully demonstrated, the SMTD program is well into its military utility demonstration phase. Air combat experts from Tactical Air Command and its Fight-

During the F-15 SMTD's fifty-three carefully monitored flights using thrust-vectoring nozzles, the aircraft has racked up an impressive list of "firsts." The STOL demonstrator, above left, is based and maintained at the Air Force Flight Test Center at Edwards AFB, Calif.



Above, the Pratt & Whitney YF119-PW-100 demonstrator engine, used to power the second YF-22 Advanced Tactical Fighter prototype, on the test stand at the company's facility at West Palm Beach, Fla. The YF-22 uses thrust-vectoring nozzles.

er Weapons School are working with Colonel Sanchez and the SMTD team to evaluate the results and devise practical ways to use the technologies. This makes it more likely that the technology investment will yield an early payoff for flying units.

The F-Pole Maneuver

One possible technique is the "F-Pole Maneuver." When a fighter pilot launches a missile at an enemy aircraft beyond visual range, he wants to turn away just as soon as his missile has locked on to the enemy in order to reduce his chances of being hit by an enemy missile.

At supersonic speeds, that turn can extend over a very long distance, leaving the fighter in a potentially vulnerable position. With supersonic thrust-vectoring and thrust-reversing capabilities, the fighter can turn and build distance more rapidly.

Thrust-vectoring is being used on at least two other US technology demonstrator aircraft: the Rockwell-MBB X-31 enhanced fighter maneuverability project and the NASA High Angle of Attack Research Vehicle (HARV), a specially modified F/A-18 on loan from the US Navy. Both use thrust-vectoring, and both are in flight testing. *[See "High Alpha," October 1990 issue, p. 54.]*

The Advanced Tactical Fighter (ATF) may be the first Air Force production aircraft to use thrust-vectoring technologies. The Lockheed YF-22 ATF candidate uses thrust-vectoring, 2-D nozzles. Northrop's YF-23 ATF candidate strives to achieve the same level of performance by using more conventional flight controls. Lessons learned and data collected on the SMTD project have reduced the overall risk in ATF design.

Both Pratt & Whitney and General Electric are working on round thrust-vectoring nozzles, known as "axisymmetric thrust-vectoring nozzles." Information on the test versions is proprietary, and the companies are not ready to disclose details. Pratt & Whitney reports that it has achieved controlled vectoring of between fifteen and twenty degrees around the entire 360-degree circle. Its nozzle fits on the standard F100 engine that powers the F-16 and F-15.

The United States is not the only venue for development of the technology. In the Soviet Union, the Sukhoi design bureau has fitted an Su-27 "Flanker" demonstrator aircraft with 2-D thrust-vectoring nozzles, and the rig is being flight-tested. Engineers surmise that the already agile Su-27 will be made even more maneuverable with thrust-vectoring capability.

Under a US-UK Memorandum of Understanding of 1986, Rolls-Royce is working in the US and the UK with engine and airframe companies on advanced concepts. These include supersonic, advanced short takeoff, vertical landing (ASTOVL) aircraft for the twenty-first century. Four main concepts are being evaluated. All use some form of thrust-vectoring: vectored thrust with plenum chamber burning, tandem/hybrid fan, remote augmented lift system, or injector lift.

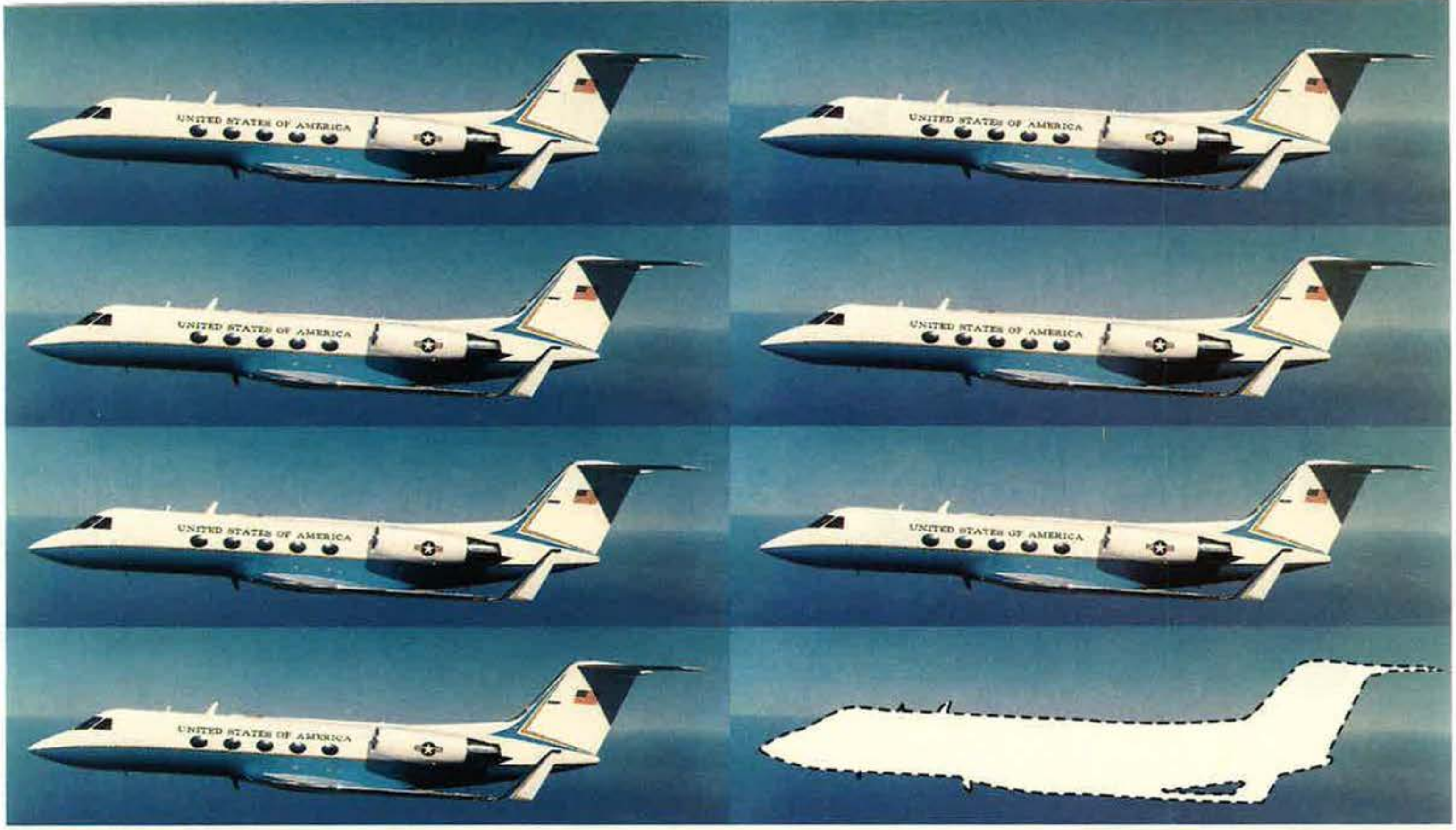
Rolls-Royce and Pratt & Whitney are working together on exploration of a next-generation engine for advanced V/STOL aircraft. Among the known aircraft projects are the McDonnell Douglas MD 279-3, the Vought TF120, the Lockheed hybrid fan concept, a Grumman supersonic V/STOL aircraft, the British Aerospace P103, and General Dynamics E7 and 218V. Lockheed is evaluating vectored-thrust payoffs in future combat aircraft.

Congress, moreover, is pressing the Defense Advanced Research Projects Agency to get moving on development of technologies for a vectored-thrust, combat transport aircraft. Whether any or all of these aircraft will take to the skies is uncertain, but certainly vectored thrust is viewed as a fruitful technology field.

As Air Force officials see it, developing usable vectored-thrust capabilities is a form of insurance. Technologies proven in today's demonstrators are ready for use on tomorrow's production aircraft. For the USAF fighter force, that is expected to be the Advanced Tactical Fighter. However, should the ATF be the victim of delays or termination, its technologies can be used to continue improving existing US fighter and attack aircraft.

As such, vectored thrust may well be the most important piece of technological insurance now being purchased. ■

F. Clifton Berry, Jr., is a former editor in chief of Air Force *Magazine. He served with the Air Force in the Berlin Airlift (1948–49), as a paratrooper and an officer in the 82d Airborne Division, as commander of airborne and infantry units in the US and Korea, and as operations officer of a light infantry brigade in Vietnam. His most recent article for this magazine, "High Alpha," appeared in the October 1990 issue.*



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A risky, "100 percent" solution to TACC modernization failed in the 1970s. Now the Air Force is trying a different approach.

The Eighty Percent Solution

By Gen. Robert D. Russ, USAF

THE Air Force's current Tactical Air Control System (TACS) evolved from the command and control systems used in the Korean War. The TACS performs two important functions for the air commander. It provides positive command and control over air assets, and it provides the necessary operational interface with ground forces.

The heart of the TACS is the Tactical Air Control Center (TACC), which serves as the air commander's central command and control facility. Attempts to modernize this command and control center have been going on for many years. In the end, it was an evolutionary acquisition approach that finally brought about a modernized TACC.

Twenty-three years ago, at the height of the Vietnam War, the Air Force first defined a requirement to automate the manual TACC in operation at the time. During the 1970s, the Air Force's development effort to meet this need was called "TACC Auto."

TACC Auto was the service's first attempt to develop a software-based, totally integrated command and control system. Though the service committed nearly nine years and $80 million to the development of TACC Auto, the program did not produce an operationally useful product and was canceled in 1979.

Tactical Air Command, by automating the generation of air tasking orders, will transform the labor-intensive work of the old TACC by using a computer-based system (above: inside a TACC shelter segment).

There were four primary reasons for this failure. First, operational requirements were poorly defined. Second, program managers exhibited little requirements discipline, constantly increasing requirements as new technology and concepts developed. Third, the program suffered from insufficient user involvement. Finally, rapidly changing software and hardware technology outpaced the development and procurement process.

With the demise of TACC Auto, the tactical air forces were forced to look to a new program aimed at automating the TACC. Tactical Air Command began an in-house effort to automate the generation of air tasking orders. This program was called the Computer Assisted Force Management System (CAFMS). It became the first step toward transforming the labor-intensive manual operations of the TACC to a modern, computer-based system. The CAFMS was an important first step, becoming the

—USAF photos by Lt. Col. Richard Casati

primary focus of the modernization effort in the early 1980s.

Top-Down Modernization

In the mid-1980s, several events converged to revive interest in modernizing the entire TACC.

First, Air Force Logistics Command determined that existing TACC facilities were becoming logistically unsupportable. Sacramento Air Logistics Center procured a replacement shelter for the TACC. Though the shelter permitted use of a smaller, dispersed TACC, it was only half a solution; new communications and computer equipment was required for dispersed operations. These realities drew attention to the immediate need for a new TACC.

Then, in 1986, the commander of Air Force Systems Command commissioned the Air Force Studies Board to study tactical command and control systems. This study recommended for the TACS a modernization program centered on three important tenets: use of existing technology, heavy user involvement during development, and rapid prototyping.

After a series of meetings and briefings, the commanders of Air Force Systems Command and Tactical Air Command agreed on a course of action. Tactical Air Command would assume the lead in the new campaign to automate the TACS.

The first steps were to design a program to improve the TACS as a system and to place the modernization efforts under a broad umbrella program called the Contingency TACS Automated Planning System (CTAPS). From the system's conception, the goal was to automate and modernize the major elements of the TACS from the top down. Included would be the TACC, the Air Support Operations Centers, and the wing and squadron operations centers.

Modernization began with the TACC not only because it was the centerpiece of the TACS but also because it was becoming difficult to support and lacked survivability. It was housed in large, inflatable shelters—assembly of each required twenty-four hours and about forty workers—and operated on a labor-intensive manual system of 1960s vintage.

The entire Modular Tactical Air Control Center (MTACC) is based on a compact, expandable shelter unit. Rugged shelters can be transported worldwide, expanded, and configured appropriately.

The effort to develop the new TACC included an innovative acquisition strategy based on the recommendations of the 1986 Air Force Studies Board. The new TACC, to be developed in modular form, was named the Modular TACC, or MTACC. Program managers considered several alternative organizations for developing an MTACC and settled on the Idaho National Engineering Laboratory, a Department of Energy lab with previous experience in Air Force projects. This unique relationship with a national laboratory allowed rapid development of a prototype MTACC. At the same time, operational TAC units and the Sacramento ALC maintained a strong influence over the developmental process.

This relationship also kept design, support, and training experts involved in every step of the development process. It gave them the opportunity to recommend changes while the program was still in the prototype phase and thus avoided the costs associated with changes made during the full-scale development phase. Moreover, the setup permitted the user to make incremental evaluations, rather than waiting for the usual "pass/fail" testing at the end of development.

Avoiding the Exotic

The design concept aimed for an "eighty percent solution." Simply put, its purpose was to provide sufficient capability with advanced technology systems and avoid the use of risky, exotic technologies associated with the "100 percent solution," which often produces only marginal improvement at exorbitant cost.

Further, managers enforced strict requirements discipline, used off-the-shelf components when possible, and made sure these hardware and software components were adaptable to future growth.

The MTACC that emerged was based on a compact, expandable shelter unit. These rugged shelters can be transported worldwide in Air Force aircraft and taken by truck to a designated site. They can be expanded to three times their original volume and arranged in a variety of configurations and sizes to establish the appropriate type of TACC. Four workers can set up the shelter in approximately fifteen minutes. TACS operators can assemble an entire TACC with its associated equipment in approximately six hours.

Compared to the current system, these modular TACCs provide more flexibility. For example, deployment of the present TACC in response to a contingency requires some twenty C-141 aircraft. This is so because the deploying Air Force units must take along an entire TACC with associated equipment, rather than a smaller unit matched to the size of the contingency.

The MTACC will allow deployment of packages as small as three shelters that require only seven C-141s. This flexibility greatly reduces the demand on the already overburdened strategic airlift assets and allows the package to be tailored to fit the contingency operation being supported.

The Idaho National Engineering Laboratory developed nine prototype MTACCs and transferred the technology to industry for production. As a result, a prototype MTACC was produced in little more than two years, and the first units were fielded less than three years after the original approval of the CTAPS concept.

Four persons can set up a shelter unit in fifteen minutes. It used to take forty workers and twenty-four hours. TACS operators can assemble an entire TACC and its equipment in six hours.

The modular design of this new TACC lays the foundation for future improvements and system growth. Future upgrades will be based on feedback from the operational user and the application of new technology, when available.

Two Major Goals

Future improvements will focus on two major goals.

In the near term, the Air Force will give the MTACC additional capability by incorporating the results of other TACS improvement programs. Two of these—the Modular Control Equipment and Triservice Tactical Communications (TRI-TAC) programs—are fully compatible with the new MTACC and will enhance its already impressive capabilities. Another existing program is the Advanced Planning System, which is designed to automate mission planning activities in the MTACC. This system will interface with existing MTACC software to provide an automated Air Tasking Order, increasing the speed and accuracy of tasking that the TACC sends to combat units.

The other, longer-term goal is completion of the CTAPS by modernizing the Air Support Operations Centers and unit-level operations centers. This will result in a flexible, compatible, and modern system whose capabilities will last well into the next century.

The rapid, successful development of the MTACC is an excellent example of the creative thinking required in an environment of shrinking force structure and reduced defense budgets. Though Tactical Air Command took the lead in developing the CTAPS, the lesson for the future is not that operational commands should take on acquisition responsibilities. Rather, the important lesson is in realizing the value of using the incremental requirements approach and in requiring the full involvement of the users in all operational aspects of the acquisition system.

By using this evolutionary approach—one that concentrated on off-the-shelf technology, rapid prototyping, and heavy user involvement—a significant military capability was fielded earlier and at lower cost than would have been possible using the traditional approach. Air Force Systems Command is incorporating these lessons into the Air Force acquisition system so that they can be applied on a broad scale.

If we are to continue improving our forces and solving the tactical problems of the twenty-first century, innovative approaches like the development and acquisition of the CTAPS program must not be forgotten. ■

Gen. Robert D. Russ is commander of Tactical Air Command, Langley AFB, Va. A command pilot with more than 5,700 flying hours, he is a distinguished graduate of the Air Command and Staff College. General Russ previously served as deputy chief of staff for research, development, and acquisition. His most recent article for AIR FORCE *Magazine was "No Sitting Ducks" in the July 1988 issue.*

The year began in Panama and ended in the Arabian desert. In between, there was Congress.

Scorecard From the Budget Wars

By **Robert S. Dudney,** Executive Editor

A YEAR that began with 25,000 US troops fighting against Gen. Manuel Noriega in Panama ended with Washington marshaling a 430,000-strong force in Saudi Arabia to defeat and perhaps disarm Iraq's Saddam Hussein.

In between, 1990 produced other noteworthy events. The Warsaw Pact ceased to exist as a credible fighting force. The two Germanys came together as one nation. Washington started to withdraw fighter aircraft from the Philippines.

Taking note of these and many other factors, Congress and President Bush came to terms late last fall on a national defense budget for Fiscal 1991, which began October 1. It totals $288.3 billion in budget authority, and it is complex. Merely reporting the text required 112 pages of fine print in the *Congressional Record*. The official explanation consumed another 228 pages.

For the Air Force no less than other services, the budget that was worked out during 1990 carries major implications for the future. Even now, however, its meaning in key areas remains murky. The Air Force still doesn't know whether it can procure more B-2 bombers, when it can move the Advanced Tactical Fighter (ATF) into full-scale development, or how much it can spend on the Milstar satellite.

With the unveiling, last January, of a new $307 billion national defense budget request, Secretary of Defense Dick Cheney proposed an austere program that would bring sizable but gradual cuts in the numbers of troops, tanks, ships, and aircraft. The final defense budget, however, came in $19 billion *below* Secretary Cheney's minimal figure.

In its final form, the 1991 budget will bring a real, one-year drop in spending of six percent. That decline, reports Sen. Daniel Inouye (D-Hawaii), head of the Senate's Defense Appropriations Subcommittee, "may well be the largest [single-year] reduction in military spending in our history."

Compared to 1990 levels, procurement spending in 1991 will fall 21.2 percent, to $67 billion; operations and maintenance spending will fall 5.4 percent, to $85 billion; research and development spending will fall 4.8 percent, to $36 billion; and manpower spending will fall 4.1 percent, to $78 billion.

Spending on Department of Energy defense programs rises 8.5 percent, to $11 billion. None of the increase, however, goes to weapons; it is devoted to cleaning up problems at US nuclear-weapons facilities.

A Second Look at Cuts

Until early fall, it seemed that Congress would make even deeper cuts in President Bush's arms plan. The Persian Gulf crisis, however, spurred the lawmakers to take a long second look at planned reductions. Operation Desert Shield has become one of the largest US deployments since World War II, and it seems to have persuaded the lawmakers to hold off on several billion dollars of additional cuts.

The 1991 budget will have a visible impact on US force levels. For the first time in forty years—since the start of the Korean War—the number of active-duty military personnel will drop below two million. Sen. Sam Nunn, the Georgia Democrat who chairs the Armed Services Committee, maintains that this puts the Pentagon on a "manageable glide path" toward "a smaller and restructured defense establishment" by 1995.

Under Secretary Cheney's original plan, the military was to shrink to 2,038,800 service members by September 1991. That would have been 38,000 fewer than in 1990, 91,400 fewer than in 1989, and about the same as in 1980, before the Reagan rearmament program began.

However, Congress decided to reduce the force more rapidly. The new budget authorizes an active-duty force of 1,976,405, about 100,000 below 1990 levels. Because the services began 1991 some 20,000 below full authorized strength, however, one-fifth of the required reduction already has occurred.

The Air Force, for its part, is scheduled to decline in size from 545,000 in 1990 to 510,000 by October 1.

For the first time, Congress provided a long-term statutory force goal against which each military service can now plan. It establishes that the US military will drop to 1,613,000 active-duty members by the end of Fiscal 1995.

This decline will see the Air Force shrink from 510,000 to 415,000, the Army from 702,170 to 520,000, the Navy from 570,500 to 501,000, and the Marine Corps from 193,735 to 177,000.

Senator Nunn says the FY 1995 end strengths are consistent with the Pentagon's own long-term plans and represent a twenty-two percent reduction from current levels.

Congress set various sublimits on personnel. At the end of 1991, the total number of officers in all services cannot exceed 284,067, and the Air Force can have no more than 95,027. General and flag officer strength will fall from 1,030 to 858. The number of Air Force generals, 326 today, will decline to 279.

The Secretary of Defense is authorized to exceed prescribed officer levels in 1991 to the extent required by each service to avoid involuntary separations.

Congress placed new limits on troops in Europe. US forces assigned to permanent duty in European NATO nations are expected to drop by 50,000, from 311,855 today to 261,855 by the end of September. Senator Nunn reports that this provision "puts us on an orderly course" for reductions "down to a level of 75,000 to 100,000 United States troops in Europe within five years."

For the first time in forty years—since the start of the Korean War—the number of active-duty military personnel will drop below two million.

President Bush can waive this requirement if he determines that US security interests demand it.

Protecting Morale

In an effort to maintain the high morale of US troops even in a time of force reductions, Congress came through with a 4.1 percent pay raise, effective January 1. That is higher than the 3.5 percent pay hike that the Pentagon originally sought.

With its new budget document, Congress orders the services to effect force reductions first by slowing recruitment and then by encouraging early release of first-term and retirement-eligible personnel. Only after they have taken these steps may they begin to fire career personnel.

The budget authorizes a generous package of benefits for service members who are involuntarily released. It provides for payment of separation pay to officers and enlisted personnel who have six or more years of service and who are not in their initial term of enlistment, and it lifts the former $30,000 limit on such disbursements.

Also authorized are medical benefits during transition to civilian life, counseling prior to separation, employment assistance, job training assistance, commissary benefits, use of military housing, and relocation assistance for overseas personnel.

In the new budget, the troops fared better than did weapons programs. No major systems were terminated, but Congress trimmed $14.2 billion in systems-related requests. Defense Department plans called for $79 billion in new procurement funds, but Congress approved only $67.2 billion. The lawmakers also trimmed by $2 billion the Pentagon's R&D request of $38.1 billion.

For its part, the Air Force proposed $31.5 billion in new aircraft, missiles, and other hardware procurements and $13.3 billion in weapons research. Congress lopped a combined total of nearly $9 billion from these two categories.

Far and away the most controversial weapon decision focused on the B-2 bomber, USAF's principal new strategic system.

In the final budget, Congress authorized a total expenditure of $4.1 billion this year on the new radar-evading aircraft. B-2 R&D money was pegged at $1.75 billion, and $2.34 billion was approved for B-2 procurement. The lawmakers were silent, however, on the specific purpose of the procurement funding.

The House, which earlier had voted to terminate B-2 production, later maintained that the procurement funds could be spent only to cover cost overruns on the fifteen aircraft already authorized. The Senate, which favored procurement of two new bombers this year, maintained that the final bill permits the B-2 program to "go forward" and that "procurement of additional B-2s will be contingent on continued favorable results from the B-2 flight-test program." Senate leaders said that they hope the flights are successful, "which will permit additional B-2 aircraft to be procured with Fiscal Year 1991 funds."

Irreconcilable Differences

In reality, Congress deliberately left the B-2 language ambiguous so as to bridge irreconcilable differences between the two chambers. Congressional action defers a final decision on the bomber issue to this year.

The outlook is uncertain. "We went from having twenty-nine votes [in the Senate] against the B-2 to as many as forty-four this year," said Sen. William Cohen (R-Me.), a prominent B-2 opponent, in debate on the budget. "By the time next year comes around, I would expect that we would have a majority in order to terminate the program."

With regard to other Air Force strategic weapons programs, outcomes were more clear-cut and less controversial.

The Administration's two-missile program for modernization of the intercontinental ballistic missile (ICBM) force was kept alive. It will limp along at least another year and probably longer.

The final defense budget provides the Secretary of Defense with a pool of $680 million in ICBM research money, which he is free to divide between programs to develop a rail-mobile version of the ten-warhead Peacekeeper ICBM and to develop the smaller, single-warhead Midgetman missile.

In preliminary work on the budget, both houses had turned thumbs down on the Pentagon's request for $1.3 billion to start procuring rail garrisons for the Peacekeeper. Congress instructed the Pentagon to complete critical research work on the system and then mothball it for possible future use.

Congress went along with the Administration's request to make more purchases of the Peacekeeper missile itself. It approved twelve new missiles at a cost of $573.7 million.

Congress, however, declared flatly that "the two-missile mobile ICBM modernization program has failed to achieve the political consensus necessary for the deployment of both systems" and that the Bush plan is unaffordable. Lawmakers further urged the Pentagon to plan to deploy the Midgetman in silos, "while preserving a realistic option for subsequent mobile basing" if that becomes necessary.

Also provided was $66 million for the Advanced Strategic Missile Systems research program.

Elsewhere, Congress approved $365.9 million for the purchase of 100 more advanced cruise missiles, which are bomber-launched nuclear weapons with radar-evading properties and a 2,000-mile range. The Air Force had sought $107.4 million as a down payment on the purchase of 250 more ACMs in Fiscal 1992, but it was given only $43 million for this purpose.

The Strategic Defense Initiative received its biggest setback in its history, dating back to 1983 when the missile-defense research program was established by President Reagan. The Pentagon's $4.5 billion request was slashed to $2.9 billion.

Basic Research Fares Well

In general, lawmakers gave strong support to the Pentagon's basic research program and even added some funding. For Fiscal 1991, Congress:

- Added $363 million to the Pentagon's $3.4 billion request for technology base funding. This represents a ten percent real increase in funding over the Fiscal 1990 level.
- Added $30 million to the budget for high-definition display technology.
- Added $60 million to the budget for X-ray lithography research.
- Approved $100 million for Sematech, the Texas-based consortium of semiconductor manufacturers.
- Added $95 million to develop advanced submarine technologies.
- Provided $10 million to establish US-Japan management training programs.
- Increased the scope of reimbursement of independent R&D.
- Provided $100 million to establish a manufacturing technology program for the Pentagon.
- Authorized $50 million to help DARPA participate in consortiums to foster critical technologies.

Mixed Signals

Congress sent mixed signals on the principal new Air Force fighter program, the proposed Advanced Tactical Fighter.

In their policy-setting authorization bill, the lawmakers had approved most of the $1 billion in R&D funding that the Air Force wanted for continued development of the warplane. However, this bill specifically barred the Air Force from taking the aircraft into full-scale development (FSD) in 1991. Senator Nunn, among others, argued that there were "too many unanswered questions" about the ATF to justify moving into the next phase of development. He wants the Air Force to continue flight testing the ATF prototypes to gather more information. Senator Nunn also inserted $100 million to keep open the option of developing an F-15XX alternative to the ATF.

Only days later, however, Congress in its appropriations bill ordered the Air Force to start FSD this year and even included $200 million to finance the move.

There the matter lay as the new year began. Senator Nunn has explicitly warned the Air Force not to defy him. All signs are that it will heed his advice and wait until Fiscal 1992 to move the ATF to FSD. The Senator also is demanding a full mission-effectiveness analysis for alternative fighter modernization plans.

Congress essentially approved USAF's request for $1.5 billion to procure thirty-six more F-15E dual-role fighters. On the F-16, however, the Air Force was not so lucky. Congress, noting the planned decline in force structure, pared the request for $2.4 billion to buy 150 new F-16s down to $1.9 billion to buy 108. In addition, it noted that "it will not be possible" to preserve the multiyear F-16 contract with General Dynamics.

Congress authorized the Air Force to buy 450 more AMRAAMs, the new medium-range air combat missile, for $463 million. However, the lawmakers expressed frustration with continuing reliability and production problems. They noted that reliability improvements and operational tests will be completed next year and that Congress was funding the program to avoid a costly break in production pending the results of those actions.

Congress charged that USAF has "no effective modernization program for the tactical airlift fleet," despite its current "overwhelming role" in the Persian Gulf region.

Mobility programs enjoyed generally broad support. For example, the Air Force had sought $541 million for continued development of the C-17 intratheater transport, and Congress approved the full amount. Earlier, as part of its Major Aircraft Review, the Pentagon had trimmed the service's $1.7 billion request to procure six C-17s. Congress approved $400 million for two of the planes, plus $60 million for advance procurement and $80 million for initial spares.

No Effective Program?

In addition, the Air Force will receive $492.5 million to reengine twenty-four KC-135 tanker aircraft, $162.6 million to buy twenty-eight T-1A Jayhawk tanker/transport trainers, and $10 million to initiate development of an updated version of the C-130, known as the C-130J. In funding the latter program, lawmakers charged that "the Air Force has no effective modernization program for the tactical airlift fleet, despite the overwhelming role it played in Operation Just Cause [in Panama] and is playing now in the Persian Gulf region."

Largely at the behest of Senator Nunn, Congress directed the Defense Department to update its 1981 mobility study and propose new plans for meeting its airlift goals. The first installment of the new study, due in March, will focus on long-range, intertheater mobility objectives and alternatives. A second part, to be presented in June, will focus on intratheater airlift.

Senator Nunn served notice that another of the Air Force's key programs—the Milstar multimission satellite communications system—is in trouble. Though the Pentagon had sought $1.1 billion this year for the program, Congress authorized only $600 million. Subsequently, a separate appropriations bill approved $900 million.

In any event, says Senator Nunn, "Milstar clearly will not continue as the Pentagon designed, planned, and requested it." He is insisting that the Air Force radically restructure the program—to reduce costs and orient it more toward tactical use—or find an alternative. The Pentagon is to report to Congress on this by April 1.

Another expensive and controversial USAF system, the Joint STARS targeting aircraft, was fully funded at $232.5 million. The budget notes that, though the system was designed at first for use against Soviet forces in Europe, Joint STARS "has utility in contingencies other than in NATO." The Air Force currently is reevaluating its plans to buy twenty-two of the planes, however.

Congress appears as determined as the services to preserve the combat-readiness of US soldiers, sailors, airmen, Marines, and their equipment. USAF tactical fighter crews are to receive 19.5 flying hours per month. The active-duty Air Force received all but $1.4 billion of its $22 billion operations and maintenance request. The Air National Guard, with O&M funding of $2.25 billion, and the Air Force Reserve, with $1.1 billion, actually got more than they requested. ■

Five percent attrition is more devastating than it sounds. Electronic combat can make a huge difference in survivability.

The Electronics of Attrition

By Maj. Gen. George B. Harrison, USAF

IN ELECTRONIC combat, you try to increase the survivability of your aircraft by reducing the effectiveness of enemy air defenses. You seize a part of the electromagnetic spectrum, deny it to the enemy, and make it available to friendly forces.

Suppression of enemy air defenses is critical to achieving air superiority. Electronic combat measures used in SEAD (Suppression of Enemy Air Defense) frequently get short shrift in strategic and tactical analyses. One way to understand their value is to examine the concept and mathematics of attrition, which electronic combat is designed to stem.

Managing and controlling attrition of a combat force is vital. No one, of course, deliberately drives a force to take intolerable losses. The problem comes in quantifying how much attrition is, in fact, "tolerable."

On any given day, a commander may decide that a target has high value—so high, in fact, that he will take heavy losses if necessary to destroy it. Against another target, or even the same target on a different day, such losses might well be regarded as "intolerable."

The obvious but crucial point is that judgments about attrition can only be made in the context of an overall loss rate *for an entire air campaign*. That is the key to understanding how electronic combat forces contribute to battlefield success.

Even seemingly low attrition rates have a surprising long-term effect. Suppose, for example, that you have a force of 100 combat aircraft. Further assume that, on any given sortie, the force as a whole will suffer attrition of five percent.

To a casual observer, this might seem acceptable. Indeed, many might even consider the loss of only five aircraft on such a raid to be a positive, even spectacular, performance.

It might even be true, depending on the importance of the target for that sortie. More likely, however, it won't be true. Single-raid performance usually is not the best measure of the effects of attrition on a force. Over the long term, the cumulative effect of even small rates can be staggering. The chart on p. 69 shows the effect of varying rates of attrition on a 100-airplane force.

Chances Are One in Five

We might also consider the problem from the perspective of an individual crew member assigned to the hypothetical 100-plane unit for a thirty-sortie tour of duty.

From his perspective, matters look grim indeed. If the unit suffers attrition of five percent per sortie, the statistical chance that this person will survive his combat tour is twenty-two percent, or about one in five.

There is yet another way to look at the potentially far-reaching impact on the force of a low, but sustained, attrition rate: from the standpoint of the US defense industrial base.

Assume that the United States begins the campaign with a 2,000-aircraft combat force and that it suffers a five-percent-per-sortie attrition. Even if each plane flies just one sortie per day, the overall losses would quickly get out of hand. To sustain the original 2,000-plane force size in the face of such losses, US aircraft makers would have to turn out no fewer than 1,560 aircraft *each month*. That figure exceeds current fighter output by a factor of ninety-five.

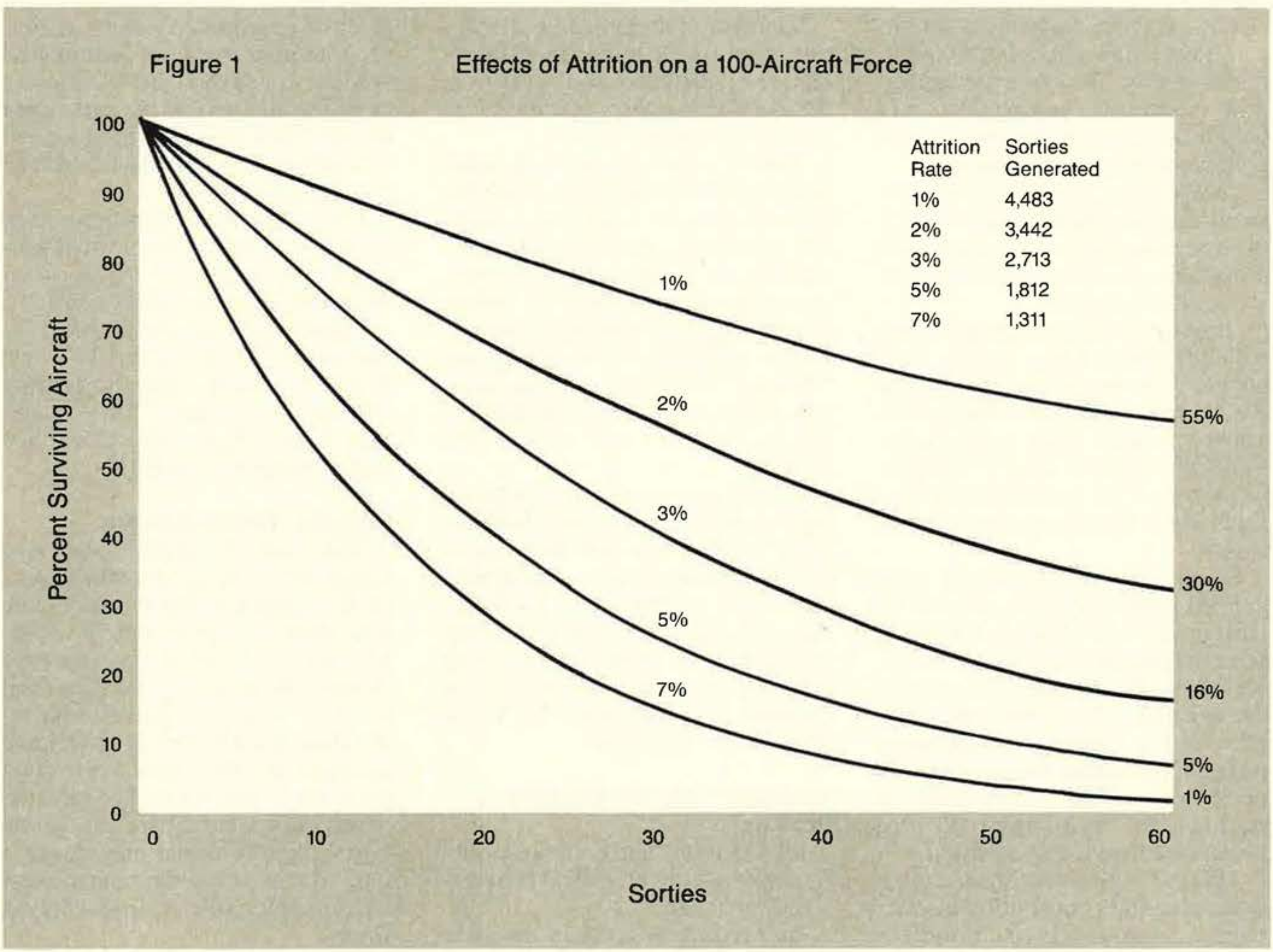
Even at one-percent-per-sortie attrition rates, the force size could be maintained only if industry produced 520 fighters per month—thirty times today's production rate.

Now let us consider the per-sortie attrition rates in some of history's best-known air campaigns: UK forces in the Battle of Britain, 2.5 percent; German forces in the Battle of Britain, five percent; US-UK bombers in Europe in World War II, 1.5 percent; US bombers in the low-level Ploesti raid, 29.1 percent; US aircraft in the Korean War, 0.2 percent; US aircraft flying Route Pack VI, Vietnam, 0.69 percent.

From these data, one can reasonably conclude that the acceptability or unacceptability of a given level of attrition is almost totally dependent on one's perspective, taken in the context of the entire air campaign. The high rate of attrition in a single raid, such as that of US bombers against the Ploesti oil fields, may be eminently acceptable on a particular day if, in fact, the military target under attack carries a very high value. Elsewhere, however, such losses might be deemed reckless and foolhardy.

The foregoing examples point up yet another reality of aircraft attrition: Small differences in per-sortie rates of attrition may spell the difference between victory and defeat if the campaign is an extended one.

This reality becomes apparent when one examines the difference between the attrition rates of the Royal Air Force and the Luftwaffe



Over the long term, the cumulative effect of even small rates of attrition can be staggering. The chart above shows the effect of varying rates of attrition on a 100-airplane force. By the time sixty sorties have been flown, a one percent difference in attrition rates can mean a twenty-five percent difference in number of aircraft surviving.

in the Battle of Britain. The percentage differences are not great, but over four months of engagement they produced decisive differences in total losses. The RAF lost 915 aircraft and the Luftwaffe 1,733.

Losses per Sortie

There is one more point to be made about attrition, and it is best explained with an example.

Assume that two fighter forces are of equal size. The first suffers an initial attrition rate of five percent per sortie, but, during the course of the air campaign, that rate drops to 4.5 percent. The second fighter force begins with an attrition rate of 1.5 percent, but it drops to one percent. Each fighter force has lowered its attrition rate by a half percent.

However, as can be seen in the chart on p. 71, the second fighter force, which started out with a lower rate of attrition, immediately begins to enjoy a much greater increase in the number of sorties it can fly. By the sixtieth day of action, it will have flown about 4,000 additional sorties. The same percentage drop in attrition, however, has had only a negligible effect on the first fighter force's sortie generation.

Conclusion: The effects of very small changes in per-sortie attrition rates become more pronounced and important as overall attrition rates move closer to zero.

Despite these facts, there is today a distressing tendency among planners to focus on the results of a single aircraft raid rather than on the long-term effect that a combat attrition rate will have on a force's performance. They seem to have lost sight of the long-term toll of small losses.

Electronic combat power can be applied either to reduce overall attrition rates to enhance the long-term preservation of a force or, selectively concentrated, to reduce the risk that a force package would face when it goes against high-value targets. The ability to diminish the enemy's weapons' effectiveness is perhaps the most powerful tool available for reducing attrition.

This factor becomes significant in evaluating the contribution of electronic combat assets to the success of an air campaign. Unless attrition can be reduced to acceptable levels, an air commander's options will be limited. He will quickly begin to see the devastating effects of prolonged attrition. As the ability to reduce that attrition lags, the commander's list of targets will be limited to less-defended sites. Intuitively, one knows a less-defended target is less valuable to the enemy.

Defense suppression, or SEAD, is defined as "aerospace operations that neutralize, destroy, or temporarily degrade enemy air defensive systems in a specific area by physical and/or electronic attack." There are many dimensions.

Lethal vs. Nonlethal

Electronic combat can be divided into lethal and nonlethal actions.

If an enemy system is destroyed, it is permanently removed as a threat. However, it requires time for the destruction of individual enemy threat systems to build up a cumulative effect. During the time required to destroy enough enemy air defenses, attrition continues.

Jamming and electronic disruption have a wide and immediate effect on air defenses, but over time their effectiveness decreases as countermeasures improve.

The evidence says that both types of action are necessary. In combination, lethal and nonlethal actions are synergistic and mutually reinforcing. Jamming causes an emitter —a radar, for example—to radiate energy longer to cope with the confusion and delay in acquiring and tracking its target. At the same time, longer radiation times help the attackers locate and destroy the emitter.

Destruction of enemy threats as they emit energy not only reduces their number but also provides a powerful inducement to equipment operators to limit their radiation time. As radiation time decreases, the operator's ability to cope with jamming decreases. His reliance on external communication for target information increases.

Compounding the Enemy's Problem

SEAD assets and techniques can be aimed at either terminal or acquisition systems.

As we destroy and jam the early warning and ground control intercept systems, the enemy shifts his reliance to terminal acquisition and tracking systems for autonomous operations. Air Force systems create an absence or ambiguity of the data that the enemy normally uses to cue and prioritize his radars. This has two effects. First, there is longer and more frequent radiation as operators try to compensate for the lack of target position information. Second, there is more wasted effort as one system attempts to engage targets already engaged by another site.

The defender's problem becomes still worse if USAF communications jamming reduces exchanges of information between sites. Increased terminal threat activity brings easier location and destruction of these threats, while the increase in autonomous operation deprives the terminal threat operator of external information needed to work through and overcome the effects of jamming.

More synergism can be achieved in the use of manned and unmanned defense-suppression assets. A preprogrammed, loitering, unmanned vehicle engages radio-frequency emitters randomly over a prolonged period. With a man in the loop, an aircraft can engage a particular site at a critical time.

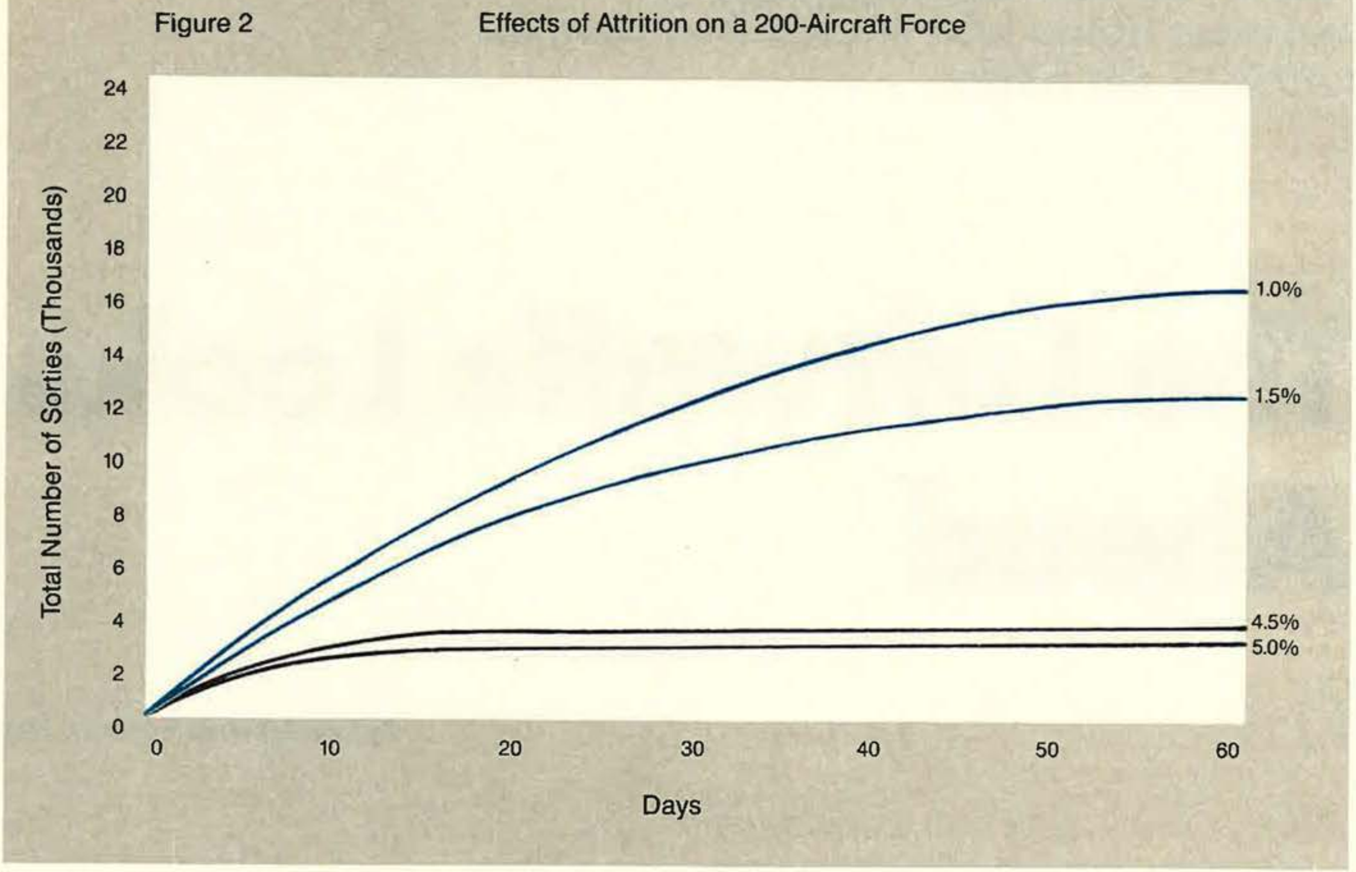
The random and enduring nature of an unmanned system would usually cause it first to engage long-duration, easy-to-locate emitters. As these systems are suppressed, the short-duration emitters are forced to radiate longer to acquire and engage targets. This makes them easier targets for both manned and unmanned systems.

Specific, Timely Attacks

The manned system's ability to mount a specific, timely attack has a slightly different effect. Suppose an unmanned, loitering system is programmed to attack a particular type of radar. If, upon arriving at its orbit point, it "sees" several of these radars in its field of view, it can initiate an attack on only one of them. Over time, these attacks will reduce the density of enemy radars, but, in the beginning, the drone may attack a radar that is not at that time a threat to the offensive mission being flown.

The manned system's capability to decide which radar to attack and when allows the strike force to di-

Figure 2



The effects of very small changes in per-sortie attrition rates become more pronounced and important as overall attrition rates move closer to zero. This chart shows the difference between two fighter forces of equal size, each lowering its attrition rate by 0.5 percent over the course of sixty days. By the sixtieth day of action, the force that began with a lower rate of attrition will have flown considerably more sorties.

rect specific weapons against that site. The combined effects of specific attacks with simultaneous, wide-area, random munitions attacks early in a campaign when the threat is thickest serve to reduce the threat density quickly while protecting individual strike packages.

A fourth symbiotic relationship in electronic combat is between standoff and on-board countermeasures.

Standoff jamming delays the enemy's target acquisition of individual elements in our strike package. Countermeasures on board the attacking aircraft are intended to disrupt, delay, and prevent a particular enemy weapon from making a successful terminal engagement.

The synergism here is that the target acquisition delay leaves the enemy with less time in which to engage, while the disruption and confusion generated in the engagement phase lengthens the process itself. If time required to engage the incoming aircraft can be drawn out long enough, the threat is negated.

A fifth relationship in electronic combat is between active and passive means. Passive measures include use of shapes and materials to reduce or distort an electromagnetic signature, as well as use of decoys or chaff. Active measures include jamming and attack with destructive weapons.

Because active systems typically radiate detectable energy, their use negates the benefits derived from application of passive, stealthy techniques. As a result, active and passive measures must be carefully coordinated so as not to interfere with each other.

If on-board passive measures are combined with off-board active measures, the results are synergistic. The presence of artificially generated clutter greatly enhances the effectiveness of passive techniques in electronic combat.

The use of low-observable technology in the presence of standoff jamming is an example. A beach ball and a golf ball would be equally visible on a putting green. Put them both in the rough, however, and the golf ball is significantly harder to find.

Electronic combat is a complex structure of intricate relationships across the electromagnetic spectrum. Individual factors by themselves may have only a small effect on force attrition, but in combination they have a great effect on long-term rates. ■

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Few of the East German troops or weapons figure into the reduced German forces of the future.

The Luftwaffe Looks Ahead

By John T. Correll, Editor in Chief

UNTIL recently, the airstrip at Fassberg in Lower Saxony was a forward operating base, situated near the dividing line between East and West Germany.

Now Fassberg is in the middle of the country and is home base for aerial patrols in the eastern part of unified Germany. From there, F-4F Phantoms fly routinely across what had been the most heavily defended border in Europe.

The control and reporting center directing the F-4F interceptor alert force has a link to the NATO air defense system but is not integrated into it.

The change at Fassberg is a small part of the transformation that began October 3 with reunification of the two Germanys. The old East German *Volksarmee* had been shedding troops, tanks, and aircraft at a rapid pace for a year prior to unification but still had a strength of about 100,000. West German forces stood at 480,000.

The unified nation cannot use a troop total anywhere near that combination. Over the next several years, the Germans plan to reduce their active-duty force level to 370,000, with a reserve of about 800,000.

The Germans considered but then rejected the idea of treating the East-West military consolidation as a merger of forces. Instead they approached it as an assumption of Eastern military assets by the *Bundeswehr* defense structure in the West. In effect, they pulled the plug on the East German forces October 3. Operations stopped, and the *Volksarmee* ceased to exist. The *Bundeswehr* picked up its troops and equipment and is still sorting out what to do with them.

East German presence in the armed forces of the future will be limited to 50,000 troops. Of these, up to 25,000 can be officers and enlisted veterans from the old *Volksarmee*, and 25,000 will be new recruits and conscripts.

The goose step has been abolished for East German troops, who are gradually exchanging their old uniforms for the kind that are standard issue in the West. The Air Force will still be known as the Luftwaffe, and it will keep the *balkenkreuz* aircraft insignia associated with that name.

The Luftwaffe's mainstay will continue to be the Panavia Tornado (here, the interdictor/strike variant). The Germans had planned to acquire additional Tornados for the strike mission, but that procurement has been canceled. The Luftwaffe also operates an electronic combat/reconnaissance variant.

—Photo by Paul Kennedy

Most high-ranking officers of the Eastern military establishment are already gone. Since only a limited number of those in lesser grades can continue in service, the Germans have begun an extensive retraining program to prepare those discharged for transition to civilian jobs.

Equipment and Manpower

Some of the weapons inherited from the East are of modern battle quality, but the force reduction and impending arms-control limits make it impossible for the Germans to keep all the equipment they now have on their hands.

The Soviet-built MiG-23s and Su-22s, for example, have already been identified for discard. The MiG-29 fighters will stay, apparently, but officials declare emphatically that keeping these airplanes is "not for operational purposes."

In 1988, the East Germans were the first Warsaw Pact nation outside the Soviet Union to get MiG-29s, and they brought a squadron of these with them to unification. More East German MiG-29s were on order from the Soviet Union, but that was canceled by reunification.

Fielding a line unit of twenty MiG-29s would be inefficient, and, as a Luftwaffe official asked, "Where should the depot maintenance be done? Should we send them back to the Soviet Union?" Most likely the MiG-29s will be held to training and proficiency flying.

The Germans also want to check out the airplane completely to learn more about its day-to-day reliability and support requirements. That knowledge could prove very useful some day, since the MiG-29 is still in service with the Soviet Union and numerous other air forces.

The older armor of Soviet origin will also be junked, but the best of it, such as the T-72 tanks, will be kept. With overall requirements decreasing, however, and since the Germans already have Leopard IIs and other excellent tanks of their own, there does not seem to be much of a future in the *Bundeswehr* for the T-72.

The East Germans brought with them a host of helicopters. The combat-tested Mi-24 "Hind," for example, was the standard attack helicopter of the Warsaw Pact. For real use, however, the Germans seem to be more interested in the assortment of transport and support helicopters from the East.

Other equipment, such as trucks and antitank weapons, could prove useful. East German chemical warfare protective gear has been reported as particularly welcome.

Kohl's Arrangement

Chancellor Helmut Kohl exerted extraordinary political and diplomatic skills in bringing his nation to this point. The prospect of a unified, militarily strong Germany tends to make other Europeans edgy, and Mr. Kohl has been reasonably successful in easing their concerns.

Last spring, popular opinion in Germany was drifting toward neutrality after unification. Mr. Kohl wanted to keep Germany in NATO, and the public eventually came around to his view.

He also had to sell Soviet leader Mikhail Gorbachev on an arrangement that included a graceful Soviet departure from East Germany and acceptance of German membership in NATO. Mr. Kohl struck that deal with Mr. Gorbachev in July but has taken some criticism for some of the concessions he made to get it. Mr. Gorbachev insisted on a cash settlement of $8 billion to cover his moving costs. "This was a plain bribe," complained *The Economist* in London.

Germany remains in NATO, but the number of Allied troops stationed there will be reduced. For now at least, the Germans remain committed to providing twelve Army divisions for NATO forward defense. They also continue their arrangement with France in the Franco-German brigade, based at Böblingen and held outside NATO supervision.

The Soviets have until 1994 to clear out of what was East Germany. Until they are gone, the Germans are approaching military deployments in the East with measured sensitivity. The *Bundeswehr Kommando Ost* (Eastern Command) was ready and waiting to take over when reunification occurred. The Army garrison force, numbering about 40,000, will be territorial troops, who are not under NATO control.

The Luftwaffe has created a new organization, the Fifth Division, for operations in the East. Its ground element, the *Radar Führung Kommando* (Radar Control Command), is in place, but the Germans are still working on the structure and makeup of the flying component. In keeping with the Kohl-Gorbachev agreement, none of the air force units in the East will be straight-wired to NATO.

In the West, air defense has also become a German rather than a NATO responsibility. There, however, the mission is conducted by both Allied and German forces within the framework of the integrated NATO air defense structure.

The Luftwaffe will keep the distinction between "command" and "assigned" forces. Command forces, responsible for air defense, are controlled directly by NATO. Assigned forces, which include the Tactical, Transport, and Training commands, are under national control in peacetime, although they would be subordinate to NATO in wartime.

When the Soviets have departed, elements of the Fifth Division will probably be redistributed to the regular assigned forces.

The Luftwaffe of the Future

Unification day left the Luftwaffe with a personnel strength of 109,000 in the West and about 20,000 from East German units that were once part of the Soviet 16th Air Army. After reductions are complete, Luftwaffe strength will level out between 80,000 and 85,000.

For some time to come, the centerpiece of the Luftwaffe will be the Panavia Tornado. The Germans operate this highly regarded aircraft in both IDS (interdictor/strike) and ECR (electronic combat/reconnaissance) variants.

Previously, the Germans had planned to buy enough IDS Tornados to replace some of their Alpha Jet attack aircraft. That procurement has been canceled.

Acquisition of the ECR Tornado continues, however, and eventually it will take over some missions now performed by the RF-4E. Equipped with high-speed antiradiation missiles (HARMs), the ECR Tornado can double as a reconnaissance and defense-suppression aircraft.

The next big step in Luftwaffe modernization will probably be the European Fighter Aircraft (EFA), scheduled to roll out in late 1991. The Germans have stated a requirement for 250 of these aircraft to re-

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German and British troops discuss a problem in the field. In years past, West Germany hosted 400,000 foreign military personnel on its soil and was the scene of 5,000 maneuvers and training exercises a year. With the collapse of the Warsaw Pact, however, Germany now looks forward to a smaller foreign military presence and a substantial reduction in its own armed forces.

Tank Forces at Time of Unification

West German		East German	
Leopard 1A1	2,130	T-34[a]	1,000
Leopard II	2,000	T-62/T-72	500
M48A2G Patton	650	T-54/T-55[a]	400
Jaguar I	316		
M48A2/A2C Patton	225		
Jaguar II	152		

[a]Scheduled for withdrawal. Others will probably be withdrawn also, but these have not yet been formally designated.

SOURCE: USNI Military Database.

The Luftwaffe's East-West Inventory
Combined Assets Before Reduction

West German		East German	
		Fighter/attack	
Alpha Jet	160	MiG-21 "Fishbed-D/J"[a]	150
Tornado	160	MiG-23 "Flogger-E"[a]	80
F-4F Phantom	150	Su-22 "Fitter-C"[a]	60
		MiG-29 "Fulcrum"	20
		Reconnaissance	
RF-4E Phantom	70	MiG-21 "Fishbed-H"[a]	12
ECR Tornado	20		
Hansa Jet	7		
		Transports	
C-160 Transall	84	An-2 "Colt"	30
Do 28 Skyservant	65	Il-14 "Crate"	20
Challenger 601	7	An-26 "Curl"	10
Boeing 707	4	L410 Turbolet	7
VFW-614	3	Tu-134 "Crusty"	5
		An-14 "Clod"	3
		Trainers	
Tornado	40	L-29 Delfin	50
T-37B Tweet	37	L-39 Albatros	50
F-4E Phantom	8	Yak-18 "Max"	50
		MiG-21U "Mongol"	20
		MiG-15UTI "Midget"	20
		Zlin 226	20
		MiG-29 "Fulcrum"	4
		Helicopters	
UH-1 Huey	95	Mi-8 "Hip"	80
		Mi-4 "Hound"	40
		Mi-24 "Hind"	30
		Mi-2 "Hoplite"	10
		Ni-1 "Hare"	5

[a]Already designated for withdrawal from service. Additional aircraft will be withdrawn, but these had not been formally identified when this chart was prepared. NATO code names are used here for Soviet-built aircraft from the former East German Air Force.

SOURCES: German Air Force. USNI Military Database.

place F-4Fs in air defense, some time around the turn of the century.

The Germans are financially committed to their share of development costs of the multinational EFA but have held open their option on participating in production.

Meanwhile, an upgrade of the F-4Fs begins this year. It will include new radars with improved electronic counter-countermeasures, cockpit modifications, digital fire-control computers, and other enhancements.

Air defense has traditionally been a high-priority mission for the Luftwaffe. Accordingly, the Germans are in the process of acquiring the advanced medium-range air-to-air missile (AMRAAM) to equip their fighters and Patriot surface-to-air missiles to improve their defenses on the ground.

The Germans are still cooperating with the French on development of the PAH-2 combat helicopter to be deployed in the late 1990s.

—Photo by Gerard Beerens

An upgrade program, now under way, promises to keep the Alpha Jet light attack aircraft effective in antihelicopter and point defense missions for several more years. A plan to trade out some of the Luftwaffe's Alpha Jets for IDS Tornados is now defunct. The next big step in modernization would be acquisition of the European Fighter Aircraft (EFA) in the late 1990s.

Army and Navy

Early reductions fall heaviest on the German Army. Thirty-six tank and infantry battalions will be pared back to cadre status by the middle of 1991.

East German border guards and forces with political overtones have been disbanded. West Germany's Federal Border Guard, including the counterterrorist units assigned to it, will be retained.

The German Navy has not, in modern times, been on a par with the Luftwaffe or the *Bundeswehr.* It emerged from unification with a combined manpower of 50,000, which will be reduced considerably.

The Navy's main strength is in the West German assets, which include submarines, destroyers, frigates, and smaller vessels as well as aircraft that operate from land bases and NATO ships. The Navy operates 105 IDS Tornados in fighter/attack missions.

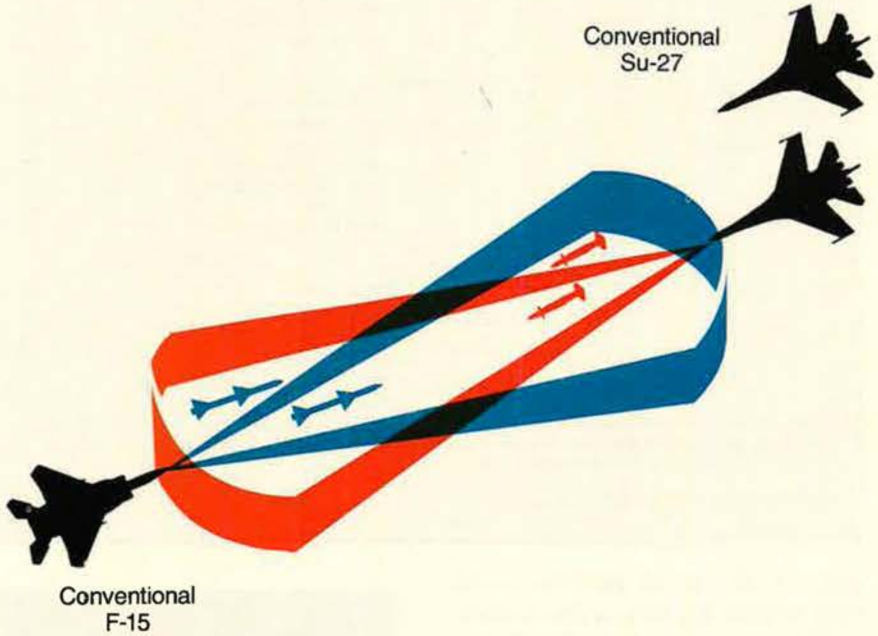
Before unification, a decreasing pool of military-age men in West Germany had pointed toward longer periods of service for draftees, eighteen months rather than fifteen. Now, with a surplus of military manpower, conscripts will serve only twelve months. East German draftees were already serving twelve-month tours. ■

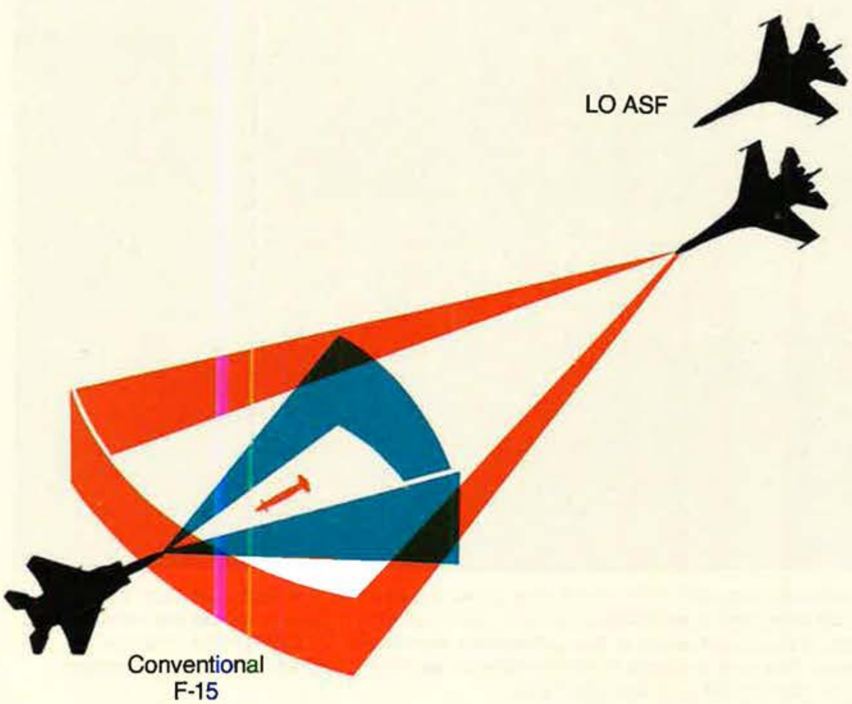
It's critical to have the enemy in your detection envelope before you fly into his.

The ATF Advantage

F-15 vs. Su-27

This diagram shows the interaction of today's front-line fighters. Both the US F-15 and the Soviet Su-27, which are of the same technological generation, are nonstealthy and have standard sensors and avionics. They have similar radar cross sections, visual profiles, and radar ranges. The cones denote detection envelopes; blue indicates the space within which the F-15 "sees" the Su-27, red indicates the space within which the Su-27 sees the F-15. Their detection envelopes are about the same size, and thus each fighter sees the other and launches missiles at the same time. Result: No advantage.



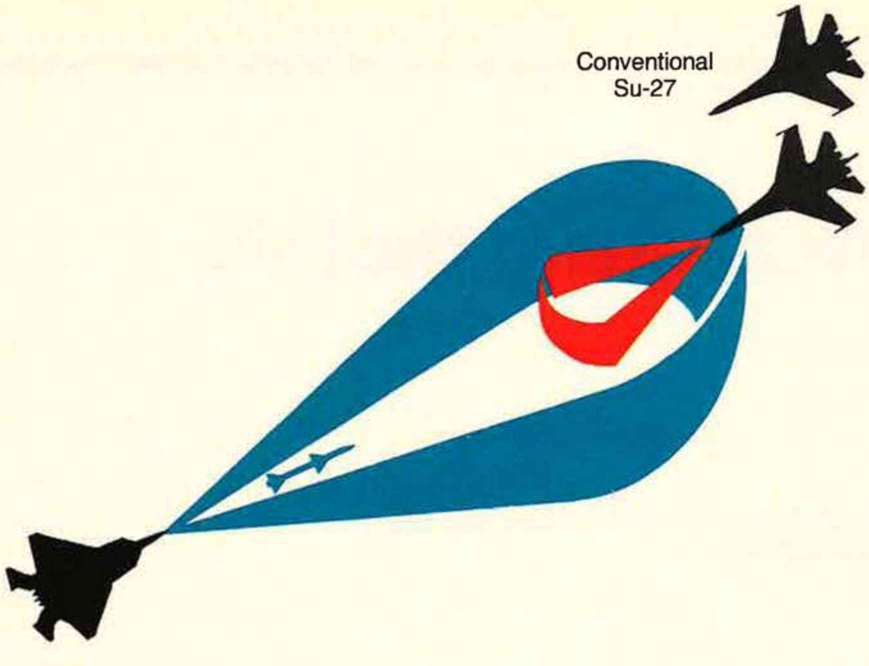


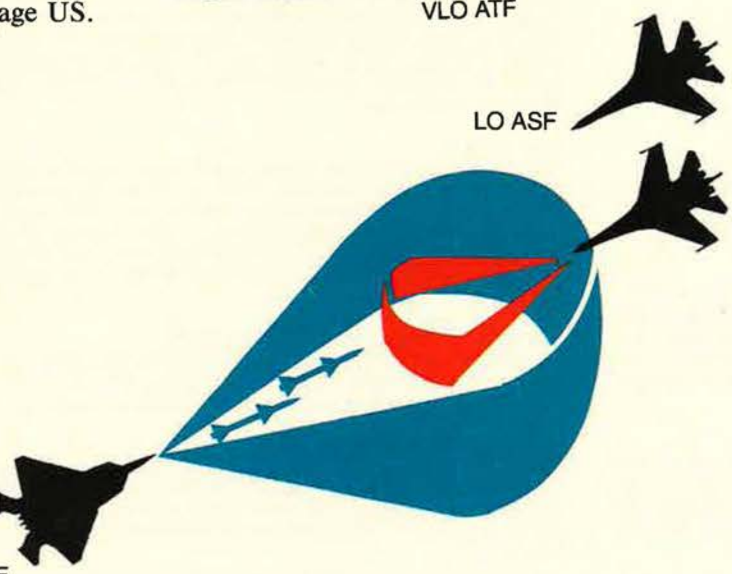
F-15 vs. ASF

The Soviets are expected to produce, perhaps by the turn of the century, two new fighters: the Air-Superiority Fighter (a follow-on to the Su-27) and the Counter-Air Fighter (a follow-on to the MiG-29). Both ASF and CAF are to be stealthy (low-observable, or LO), with advanced sensors and avionics. This diagram shows the danger an F-15 faces against an LO ASF. The ASF's stealthiness compresses the F-15's detection envelope (blue), meaning that the F-15 detects the enemy much later. Compared to the Su-27's, the ASF's sensors see further and thus provide a detection envelope (red) in which it can spot the F-15 much earlier. Result: Advantage USSR.

ATF vs. Su-27

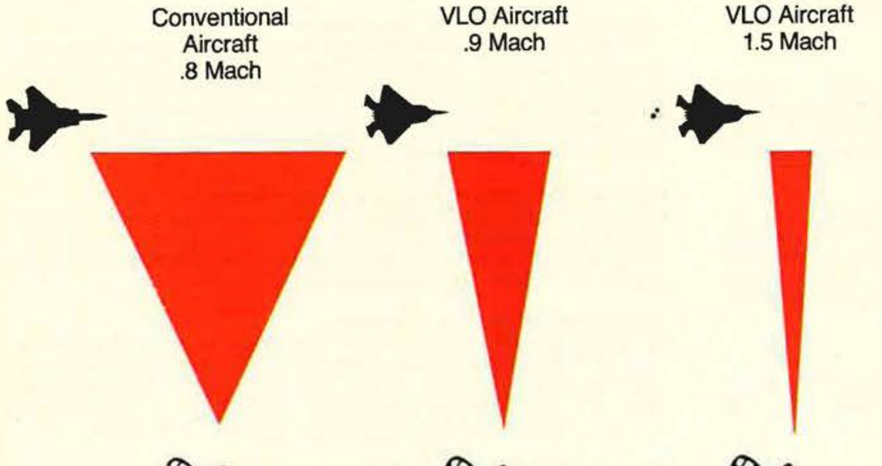
The US ATF will not just be stealthy, but very stealthy. It also will have immensely sophisticated sensors and integrated avionics. This diagram depicts the advantage that a *very* low observable, or VLO, fighter such as the ATF holds over today's best Soviet fighter. The Su-27 detection envelope (red) shrinks dramatically, meaning it would see the ATF much later than it would see the F-15. At the same time, the ATF's advanced avionics allow it to collect and process vast quantities of detection data, thus creating a large detection envelope (blue) and enabling it to spot the Su-27 much sooner than would the F-15. The ATF would gain an overwhelming "first-look, first-shot" edge. Result: Advantage US.





ATF vs. ASF

Even in combat against the future Soviet ASF—an LO fighter—the VLO Advanced Tactical Fighter would have a big edge. Against the ATF, the ASF's detection cone (red) is reduced in volume to a fraction of what it is against the F-15. The ATF's high-power sensors give it an effective detection envelope (blue) against the ASF that is far larger than that provided by the F-15. Seeing enemy planes first permits US planes to seize the initiative, achieve tactical surprise, and thereby get in the first shot—often the decisive shot—of the battle. Result: Advantage US.



Stealth vs. SAMs

Stealthiness and high speed undercut the effectiveness of enemy surface-to-air missile (SAM) defenses by reducing the enemy's targeting opportunities, indicated by the three cones. These represent the areas within which the SAM radars would be able to detect and track an airborne target and in which a missile would be able to engage and destroy it. Estimates are that Soviet radars would have to increase in power by three orders of magnitude —a thousandfold—to restore their relative capability today to detect US planes. Alternatively, the USSR could deploy 1,000 times as many radars. ■

Weapons in the Lab

Works in progress at Armament Laboratory, Eglin AFB, Fla.

Advanced 20-mm Combat Ammunition
Program to develop and demonstrate a family of advanced types of 20-mm ammunition for use in current and future gun systems. **Contractors:** KDI, AAI, *TBD*. **Status:** Advanced development.

Advanced Gun/Flight Demonstration Program
Program to develop and demonstrate simple, highly reliable, advanced aircraft gun and ammunition technologies to defeat advanced aircraft threats. Key performance parameter is the increase in muzzle velocity of rounds to 5,000 feet per second to obtain an all-aspect firing capability against fast, high-maneuverability aircraft. **Contractor:** GE. **Status:** Advanced development.

Advanced Technology LADAR System (ATLAS)
Program to develop and demonstrate an affordable, high-resolution, laser radar (LADAR) guidance system for medium- and long-range air-launched attack of high-value, fixed ground targets. Applies to cruise missiles and medium-range air-to-ground missiles. **Contractors:** McDonnell Douglas, General Dynamics. **Status:** Advanced development.

Aeromechanics Thrust
Have Slick program to develop technology options for low-cost, low-drag, low-observable, all-composite, air-to-surface munitions dispenser. Aerodesign allows standoff ranges from low-altitude release of up to 35 kilometers in the powered configuration. Aft dispensing technique allows multiple kills per pass. **Contractor:** McDonnell Douglas. **Status:** Advanced development.

Autonomous Synthetic Aperture Radar Guidance
Program to develop and demonstrate an affordable, all-weather, midcourse and terminal guidance system for medium- and long-range air-launched attack of high-value relocatable and fixed ground targets. Applies to conventional cruise missiles and medium-range air-to-ground missiles. **Contractors:** Loral, Raytheon. **Status:** Advanced development.

Beam Sight Technology Incorporating Night Vision Goggles
Program will design, develop, and test a fire-control system for crew-served weapons operated by gunners wearing night vision goggles. System will increase first-burst hit capability, reduce vulnerability by not using tracers, and increase effectiveness. **Contractor:** Baird. **Status:** Exploratory development, advanced development.

Electromagnetic Launcher Technology
Program to design and develop component and subsystem technologies for rapid-fire hypervelocity gun systems. **Contractors:** Sparta, PKD, SAIC. **Status:** Exploratory development, advanced development.

Guided Interceptor Technology
Technology program to develop sensors, seekers, processors, and integrated guidance systems for space-based conventional weapons. **Contractors:** Rockwell, Texas Instruments, Ball Aerospace, Hughes, Nicholes Research, Martin Marietta. **Status:** Exploratory development, advanced development.

Hard Target Ordnance Technology
Program to develop and demonstrate warhead, fuze, rocket motor, and integration technologies for a boosted penetrator weapon to defeat heavily hardened targets such as underground command, control, communications, and intelligence sites. **Contractors:** Lockheed, Motorola, AAI. **Status:** Advanced development.

Have Dash II
Program of experiments to develop hand-to-turn steering technology for medium-range air-to-air missiles. Flight test of this all-composite missile airframe will be the first time a nonaxisymmetric, air-to-air missile airframe has flown with bank-to-turn steering logic. This technology is critical to the development of air-breathing propulsion systems where inlet flow must be maintained over the flight environment. **Contractor:** Ford Aerospace. **Status:** Exploratory development.

Insensitive Munition Fuze Technology (IMFT)
Program will identify design concepts, critical technologies, and test techniques applicable to the development of an all-up round with insensitive munition fuzing. **Contractor:** AAI. **Status:** Exploratory development.

Insensitive Munitions Technology
Program to develop, qualify, and introduce into the Air Force inventory an insensitive high explosive that is safe to handle, store, and transport. Several candidate explosives developed in-house, by the Navy, and by a contractor are being evaluated. **Contractor:** Atlantic Research Corp. **Status:** Advanced development.

Low-Cost Antiarmor Submunition
Joint Air Force–Army program to develop a "smart" submunition to defeat ground-mobile threats. This is a program funded under the Balanced Technology Initiative. **Contractors:** Martin Marietta, LTV, Raytheon. **Status:** Exploratory development, advanced development.

Low-Cost Standoff Weapon Technologies
Interlaboratory program to develop and demonstrate key technologies that will reduce the cost of future guided standoff weapons. Participants are Armament, Materials, Aeropropulsion, and Astronautics laboratories. Goal is the development by 2000 of medium-range standoff weapon technologies for defeating a multitude of targets at one-third the cost of AGM-130. **Contractors:** *TBD*. **Status:** Advanced development.

Millimeter Wave/Infrared Common Aperture Seeker
Program to develop a countermeasure terminal guidance seeker for short-range standoff autonomous acquisition of moving and fixed clustered armored targets. Applies to short-range air-to-ground attack missiles. **Contractor:** *TBD*. **Status:** Advanced development.

Programmable Ordnance Technology
Technology program to design and demonstrate an AIM-120 advanced medium-range air-to-air missile (AMRAAM) ordnance package to defeat the post-1995 air threat. The ordnance package will include an improved target detection device, a more lethal warhead, and an electronic safe, arm, and fire device. **Contractor:** Motorola. **Status:** Advanced development.

Space Target Vulnerability/Lethality Assessments
Technology program to develop threat descriptions, kill criteria, and test conditions to evaluate the effectiveness of strategic defense initiative conventional weapons concepts. **Contractors:** GRC, SAIC. **Status:** Exploratory development, advanced development. ■

You can tell the aviators by the badges on their chests.

They Wanted Wings

By Bruce D. Callander

A few years after the Air Force went into business for itself, a small civil war broke out in the Pentagon. At issue was a proposal to give navigators a star and wreath on top of their wings and call them "command navigators."

Pilots said the idea was ridiculous: Nonpilots did not *command* aircraft—they only went along for the ride.

For a time, the rival camps refused to speak to each other, and this writer found himself in the unwelcome position of go-between. One spokesman for the navigators confided, "*They* can't discuss it rationally. *They* just get emotional." An hour later, a pilot said the same of the navigators.

In the end, the title chosen was "master navigator," but the wings did have a star and wreath. For pilots, it was just another skirmish in a battle that had begun nearly half a century earlier.

In 1912, the Army created the rating of "Military Aviator." Applicants had to reach an altitude of at least 2,500 feet, fly in a fifteen-mile-per-hour wind, carry a passenger, land within 150 feet of a mark, and make a twenty-mile, cross-country flight.

Charles deForest Chandler, Benjamin Foulois, and H. H. "Hap" Arnold were among the first to qualify, but all they got was a typewritten letter saying that their records would be duly noted. Brig. Gen. James Allen, the Chief Signal Officer, thought they should receive more recognition. He asked the Army to create a formal certificate signed by the Secretary of War and to develop some kind of badge.

The War Department agreed, but it took more than a year to come up with the badge. It included a gold bar embossed with the words "Military Aviator." From it dangled an American eagle, holding Signal Corps flags in its talons. Frank Lahm, Chandler, Foulois, and Arnold were among the first of twenty-four flyers to receive it. Arnold wore his throughout his career, even after becoming a command pilot and five-star general.

The rating itself was short-lived, however. In 1914, new legislation changed the Aeronautical Division into the Aviation Section of the Signal Corps, laid down tougher new requirements for pilots, and created two levels of aeronautical ratings.

Catch-22

For veteran flyers, it was a Catch-22. To qualify as military aviators, pilots now had to serve in the new status of junior military aviator for three years. Since the junior rating hadn't existed during their early flying years, officers such as Foulois, Arnold, and Lahm reverted to junior aviator status for another three years.

Compounding the problem was the new law's limit on the number of aviators above the grade of lieutenant. In addition, the Army still barred officers from serving more than four years away from their original branches. Few officers could make a career of flying. To help fill the gaps, the law allowed up to twelve enlisted men to train as pilots, but few applied, and only two ever became rated, both after receiving commissions.

With the onset of World War I, the rules were eased and the Aviation Section was gradually expanded. By early 1917, however, the Army had only 131 air officers, including balloon pilots and nonflyers. Most of its fewer than 300 airplanes were obsolete. None was designed for

Though the rating "Military Aviator" was short-lived, the badge signifying it was worn by some pretty big names. "Hap" Arnold proudly wore his, complete with Signal Corps flags, even after becoming a five-star general.

Balloon-busting ace Frank Luke models a pair of embroidered wings, the only adornment on an otherwise austere World War I Aviation Section uniform. Had he survived his daring exploits, his wings would have had a Medal of Honor for company.

combat. By then, sixteen aviation officers had been killed in flying accidents. Most of the survivors had little air time and no combat experience beyond that gained by Foulois and the few others who scouted for General Pershing's 1916 punitive expedition in Mexico.

On April 6, 1917, the United States declared war on Imperial Germany. Young Americans flocked to the Air Service, considered the Army's most glamorous component. If it couldn't give them adequate planes or training, at least it offered attractive costumes. The role model was dapper Eddie Rickenbacker, with his Sam Browne belt, riding breeches, and borrowed RAF flight cap. His chest-hugging tunic was spattered with medals. Above them shone his embroidered "wings."

The first *real* wings were authorized on August 15, 1917. They were silver and included the initials "US" superimposed in gold on an American shield. At first, junior aviators were allowed only half-wings. That October, however, the scheme changed. Junior and Reserve aviators were permitted the full badge, the more senior military aviators were given a star above the shield, and the half-wings passed to observers. In December, the design changed again and the shield on the observers' half-wings was replaced with an "O."

All the early badges were embroidered individually. They varied in size and shape. The Army, never tolerant of disorder, decided to standardize. In the summer of 1918, it adopted oxidized silver wings (made of stamped metal rather than embroidered cloth) with a gold "US." Military aviators and junior and Reserve aviators all wore the same badge: full wings with no star.

Another set of wings with a bomb in the center was authorized for "bombing military aviators." Observers still wore half-wings with an "O," but, in late 1918, a gold "US" was added. Enlisted pilots were given their own embroidered wings with a four-bladed prop in the center, but it was worn on the sleeve.

After the Armistice

In the wake of the November 11, 1918, Armistice, the Air Service again standardized both ratings and badges. Herbert Adams designed a basic wing shape that is still used for all aviation insignia. In December 1919, the "US" was dropped from the military aviator's shield. The design of the badge was not altered again, but the title was changed twice, first to "airplane pilot" and then simply to "pilot."

In 1921, the "US" was dropped also from the wings of the nonpilots. Now called "airplane observers," they were allowed full wings, and dual-rated officers were required to wear their pilot wings.

In 1926, the Aviation Section became the Army Air Corps; five years later, Maj. Gen. Benjamin Foulois became its Chief. By the time another war erupted in Europe in 1939, "Hap" Arnold was Chief of the Corps.

In 1941, the Air Corps was reorganized as the Army Air Forces. There were three levels of pilot ratings, with wings to match. The basic wings were unchanged, but senior pilots got a star on theirs. Command pilots had a star with a wreath around it. Airplane observers of the 1920s became "combat observers," retaining their "O." Wings with a "T" behind the "O" were adopted for "technical observers," including aerial photographers.

Japan's December 7, 1941, surprise attack on Pearl Harbor brought another flood of volunteers; again, the goal of many youngsters was to fly. This time there were more ways to earn wings. New ten-man bombers had space for navigators, bombardiers, engineers, radio operators, and gunners.

From radios and jukeboxes, a sultry voice breathed, "He Wears a Pair of Silver Wings," sending high school boys into romantic fantasies. Imported from England, the song topped the American Hit Parade in 1942 and stayed among the top ten for thirteen weeks. It rankled Navy aviators, whose wings were gold, but Army Air Forces officials loved it. (They were less pleased with the American flyers' homegrown ballad: "I Wanted Wings 'Til I Got the Goddamn Things.")

Like the aircraft industry, the wartime insignia business boomed. Nine months after Pearl Harbor, several new types of wings appeared. A bomb superimposed on a target identified the bombardier. Navigators got a ringed sphere, known in heraldry as an armillary. Also appearing were new pilot wings, with initials on the shield—"G" for glider pilots, "L" for light-plane liaison pilots, and "S" for service pilots brought in already qualified to fly.

WASP Wings

Women also flew. Nancy Love formed the Women's Auxiliary Flying Squadron for professional pilots with at least 1,800 hours of flying time. Jacqueline Cochran recruited less experienced women into the Women's Flying Training Detachment. In June 1943, the two merged into the Women's Airforce Service Pilots. The WASPs flew until December 1944.

Women could earn two types of wings, both based on the standard aviation badge. The more common type had a diamond in the center. The other had a shield emblazoned with the number of the pilot's graduating class as well as a scroll showing the number of her training detachment.

A catchall "aircrew member" badge (wings bearing the US coat of arms in a circle) was adopted in 1942. In April 1943, aerial gunners received wings with a bullet in the center, and flight engineers got a pair with a four-bladed propeller. The same year, gold wings were authorized for flight surgeons. They showed a caduceus—the winged staff entwined with two snakes—superimposed on an observer's badge. Flight nurses got a smaller set with an "N" on the caduceus. In 1944, both badges were changed to silver.

By midwar, it was getting hard to tell one specialty from another. In recently liberated countries such as Italy, however, civilians seemed to have no trouble. They would scan the badges on a group of flyers, focus on the bombardier, and berate him for bombing the village.

The market got broader and broader. Insignia makers turned out "sweetheart" badges for wives and girlfriends. Some flyers spread them around like calling cards, and some women assembled museum-class collections.

The government no longer issued embroidered wings, but still they appeared. Seamstresses from Europe to the Pacific produced them with metallic thread. Some were minor works of art—until the threads broke and the metal turned a sooty black.

If what they wanted wasn't available, crew members often took to designing their own wings. Dual-rated observers added a bomb to their navigator's wings. They weren't strictly legal, but officialdom was inclined to look the other way, particularly in the combat zones.

Some do-it-yourself projects drew official notice, however. One Fifteenth Air Force copilot had a working toggle switch soldered to his wings. Complaining that he had nothing else to do on the crew, he flicked the switch while he petitioned the group commander for a plane of

Bombardiers wore a different type of badge. Here, another Medal of Honor recipient, Lt. David Kingsley, who perished in a crash after giving his parachute to his tail gunner during a raid on Ploesti, Romania, is seen wearing the device—wings with a bomb superimposed on a target.

his own. The Old Man ordered him to remove the badge but later gave him his own B-24.

Holding on to the Wings

When the Air Force became a separate service, USAF officials wanted the uniform to be a "plain blue suit" devoid of shoulder patches, corps insignia, marksmanship badges, and other AAF accoutrements.

There were exceptions. Pilots would not give up their wings. (The Army had to design new ones for the aviators it retained.) The aircrew member badge also made the transition intact, though the Air Force eventually designed a separate one for officers, bearing a coat of arms set on an Air Force shield rather than in a circle.

The shield became the background for other aviation badges. Navigators and bombardiers shared a new set with a thunderbolt in the center. Some claimed that the new device looked like a bug, but headquarters held firm. Before long, the old bombardier rating became obsolete. By the time the senior and master ratings came in, the badge was pretty well accepted.

Changes to the flight surgeon badge were more subtle. Instead of the caduceus, it bore the Rod of Aesculapius, a stick with only one snake wrapped around it. The heraldic symbolism was the same, and the design was simpler than the full caduceus. The new flight nurse badge bore the same device superimposed on Florence Nightingale's lamp.

In time, three levels of ratings were approved for all of what the Air Force now called "aerospace specialties." Stars topped all of the single wings, and both master navigators and chief aircrew members got a wreath around their stars. Chief flight surgeons and nurses, however, were given a scroll behind the star, presumably to show that they didn't operate the aircraft.

A skirmish erupted over the parachute badge. The Army version had upswept wings with a parachute in the center. The Air Force adopted a wingless shield with a chute on a blue enameled background. Some old jumpers said it looked like something out of a Cracker Jack box and clung to their old Army wings. The Air Force eventually ruled that the Army badge could be worn only until its owner earned the Air Force equivalent.

The last major change in aviation insignia was made in the early 1960s and came during one of the periodic struggles over the future of military aviation.

Soon after World War II, the Air Force had begun to look beyond conventional aircraft to a new generation of rocket-powered vehicles. Encouraged by the success of the X-15, it hoped to put a man into orbit in the X-20, a "dynamic soaring" space glider nicknamed Dyna-Soar. But the cold war was on, and the United States was accusing the Soviets of exploiting space for military purposes. To show its own purely peaceful intentions, Washington gave the US manned space program to the civilian National Aeronautics and Space Administration (NASA).

Between tours of active duty during World War II and the Korean War, Bruce D. Callander earned a B.A. in journalism at the University of Michigan. In 1952, he joined Air Force Times, *becoming editor in 1972. His most recent article for* Air Force *Magazine, "Bombardier," appeared in the December 1990 issue.*

Almost twenty years before the first space shuttle took off, Maj. Robert M. White flew into space and returned in a winged aircraft that made a controlled landing. For that he got a new set of wings, which bore a shooting star.

The services supported the space program with everything from launchpads and recovery ships to experienced test pilots. However, NASA played down the military contribution to the point of requiring the astronauts to wear civilian clothes.

One of Its Own

On July 21, 1961, however, Air Force Capt. Virgil I. Grissom made America's second suborbital flight, and the Air Force wasn't about to let the nation forget he was one of its own. It skipped several steps in the heraldic process, added a shooting star to a pilot's badge, and presented the first pilot-astronaut badge with appropriate ceremony. Captain Grissom appeared in uniform. Aged Benjamin Foulois, who got his wings a half-century earlier, was there to shake his hand.

The Grissom achievement was cold comfort for those who had hoped to see the Air Force itself chart the way to the stars. Still, there was some fine print in the regulation covering the new pilot-astronaut rating. It said that the badge could be given to any USAF pilot who had flown to an altitude of at least fifty miles. That included not only NASA astronauts but also other high-flying pilots.

In 1962, Maj. Robert M. White piloted the X-15 to an altitude of 314,750 feet, almost sixty miles above the Earth, and flew it home. Almost twenty years before the first shuttle flight took place, the Air Force's second pilot-astronaut had flown into space and returned—not by parachute, but in a winged aircraft that made a controlled landing.

He got his new wings. ■

They wait for the ships and aircraft to return—this time carrying goods for them.

The Cargo Cults

By C. V. Glines

AFTER World War II, veterans returning from the Pacific all had stories to tell, not only about the war, but also about experiences with other cultures. There were tales of mysterious customs, strange lifestyles, and curious ceremonies. Of all the experiences, however, few were like the encounters with a number of bizarre—to Americans, at least—religious groups: the cargo cults.

"Cargoism" was, and is, a widespread religious movement among natives of the islands of Melanesia in the South Pacific. The theology and practice of the cult centers on the worship of cargo.

In simplest terms, followers of cargoism believe in the imminence of a new age of blessing which, they believe, will be heralded and fulfilled by the arrival of special cargo sent to them by supernatural powers. This belief existed long before the appearance in the Pacific of Western troops.

Western sociologists specializing in Melanesian religions say all the cargo cults are based on a curious mixture of native and Christian beliefs and rituals. The cultists believe their deities will send them ready-made goods just like those used by the military forces that came from far away. In their estimation, the goods will come from heaven, thought by some to be in Australia or, alternatively, in the sky immediately above it.

Those who hold to the latter view of paradise believe that Heaven is joined to Earth by a ladder, down which ancestral spirits carry the goods, packed in crates addressed to specific individuals. They expect that the precious cargo will come to them by ship, airplane, or truck, depending on where they live.

In both the 1970s and the 1940s, Westerners drew a crowd in certain areas of the Pacific, where the indigenous people saw them as heralds of a new age. The airmen pictured above needed the cargo for themselves, but islanders believed that next time, the gods would provide goods for cultists. The crowd at right listens as chants to ensure the return of the cargo are played back on an anthropologist's tape recorder.

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In order to ensure the return of cargo, the cultists imitate the behavior they saw the last time it arrived in bulk in their corner of the world. If the cargo does not appear, the cultists believe that it is because they have not performed the rituals correctly. Here, cultists from Vanuatu take part in close order drill, complete with "rifles" and a "drill sergeant."

The Millennium at Hand

When soldiers and airmen from the United States and other allied countries arrived in the islands with huge war cargoes, it was for the worshipers proof that those who followed the beliefs of a cargo cult were to be rewarded for their faith. Though the natives did not benefit directly from the appearance on their islands of those types of cargo, the cultists believed that their predictions were confirmed and that the cargo-millennium was at hand. A time of plenty had arrived. There was no longer a need to work. Money was unnecessary. Crops could be, and were, neglected. Pigs were randomly slaughtered for feasts. It was a time to celebrate, and the cultists lived it up.

Things didn't turn out as the cultists expected, but few lost the faith. When goods fail to appear, as in the postwar period, the followers usually assume it is because they have not yet performed the correct ritual, because foreigners have schemed against them, or because the cultists have neglected the gods.

Although the worship of cargo is basic, there are slight variations in theology among the approximately seventy cargo cults that are known to have existed. There are fewer now, and those remaining seem to be waning in re-

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The US has a special place in the hearts of the cultists who believe in John Frum, the king of America, whose return will not only bring a time of unprecedented wealth, but will also rid the islanders of the demanding ways of foreigners, especially Europeans. Anthropologists speculate that the affection for America is based on the generosity of US troops stationed on Vanuatu during World War II.

ligious fervor. However, world religion scholars say interest fluctuates and is revived by forceful, persuasive leaders who appear from time to time.

Typically, all cargo cults begin when someone claims that, through a dream or vision, supernatural powers have told him or her that a messiah and the ancestors or spirits of the dead will soon return bringing huge supplies of manufactured goods. Their arrival will usher in a wonderful new era when the believers will have their identity, dignity, and honor restored. Inequality, suffering, and death will cease. The riches of those they think have so far monopolized wealth and defrauded them of their share will then belong to the cultists.

The cargo cult members do not know how the goods of foreigners are made. They believe that the arrival of cargo must be stimulated by some kind of religious ritual, because the gods will respond only to correctly performed ceremonies. Cult leaders and sometimes whole native communities demonstrate that they have received news about the coming of cargo by falling into ecstatic states.

Typical of cargo dogma is a belief adopted by three groups in Vanuatu (formerly the New Hebrides). They worship a god named John Frum, king of America, who is said to have arrived in the islands before the appearance there of Christian missionaries in the mid-1800s. John Frum also is expected to return.

The cultists embrace the deity of Frum because he promised them a life untroubled by economic strife and the demanding ways of foreigners, especially Europeans. Although Frum hasn't shown up, Frum followers saw great significance in the arrival of cargo-rich foreign troops on the island Tana in the New Hebrides during World War II. Cargo cult believers on other islands of Melanesia were likewise convinced that the cargoes they saw being unloaded were heaven-sent and that a god or messiah would soon follow.

Worshiping George V

In Papua New Guinea, cargo cults are numerous. The first to be discovered were the Baigona, reported by researchers in 1912, and the Vailala, first described by sociologists in 1919. Researchers found that cultists often were seized by mass hysteria that led to violent shaking fits and ecstatic trances. The Marching Rule movement is popular in the Solomon Islands. Another cult worships a faded portrait of King George V of England, declaring that it is the picture of Ihova, also known as God.

Some cult members believe they must imitate the foreigners. They even drill with wooden rifles and hold flag-raising ceremonies. They adopt Western dress and imitate Western behavior. They have built wharves, storehouses, airfields, "radio masts," and lookout towers in anticipation of the arrival of good fortune. Cult leaders make contact with the deities by using "wireless telephones," often nothing more than wooden posts or carved totem poles.

Cargo is expected to appear in local cemeteries, on altars, or in other places they consider holy and where the deity is expected to emerge. Cultists of Vanuatu have not lost faith in the long-absent John Frum; believers still await his return.

If someone tells you that he has seen natives of the South Pacific building airstrips and piers to prepare for the return of vast cargoes, don't pass it off as just another tall war story. There are still hundreds of cargo cultists out there, patiently awaiting the day when their lookouts will spot a great armada on the horizon and a string of giant aircraft lined up on final approach to their airstrips. ■

The island women also take part in rituals designed to bring back the cargo. The fervor of the cults waxes and wanes but persists, despite efforts by missionaries to quash it. The cults are seen as harmful because cultists have been known to squander money and slaughter livestock profligately, in the belief that all their needs would be taken care of by the return of the cargo.

C. V. Glines is a regular contributor to this magazine. A retired Air Force colonel, he is a free-lance writer and the author of many books. His most recent article for AIR FORCE *Magazine was "The Visions of Hector Bywater," which appeared in the December 1990 issue.*

By John L. Frisbee, Contributing Editor

Sacrifice at Sniper Ridge

Every gun destroyed would save American lives as Chinese Communist masses surged toward Sniper Ridge.

THE "Valor" series has told the stories of several Air Force men who made conscious and unequivocal decisions to sacrifice their lives for some moral or martial imperative that to them was more valued than life itself. Precisely what inspired such acts of heroism will never be known. Among such men was Maj. Charles Loring, one of only four airmen to be awarded the Medal of Honor during the Korean War. All those awards were posthumous.

Charles Loring was no neophyte when he joined the 8th Fighter-Bomber Wing in Korea in June 1952. On completing flying training in February 1943, he had spent several months with the 36th Fighter Squadron patrolling the Caribbean in P-39s and P-40s. The squadron then returned to the States, converted to P-47s, and was sent to the European Theater in the spring of 1944. From its base at Kingsnorth, England, the squadron, part of Ninth Air Force, primarily flew interdiction missions in preparation for Allied landings in Normandy on June 6, 1944. A month after D-Day, the 36th moved to a series of bases on the Continent, flying close support and interdiction, paving the way for ground forces in their drive toward Germany.

On every mission, the fighter-bombers faced ground fire ranging from heavy antiaircraft artillery to rifles. Loss rates for Ninth Air Force fighter-bombers were high compared to the escort groups of Eighth Air Force. Early in his tour, Lieutenant Loring was wounded on a close support mission, but soon he was out of the hospital and back to the war. On his fifty-fifth mission, December 24, 1944, during the Battle of the Bulge, Loring's luck ran out. Hit by ground fire, he crash-landed in Belgium and spent the next four months as a POW.

Today Loring AFB in Maine commemorates the extraordinary heroism of this honored son.

Charles Loring decided to make the Air Force a career. He spent six years in nonflying positions, including two years as an instructor at the Army Information School at Carlisle Barracks, Pa. Then the Korean War broke out. Loring, now a major, requested assignment to a combat unit and waited impatiently for two years until his request was granted.

When Major Loring reported to the 8th Fighter-Bomber Wing, it had been in combat for two years, first with F-51s, then in F-80s. Initially he was assigned to Headquarters and Headquarters Squadron in charge of training and indoctrinating replacement pilots. But Loring had come to Korea to fight. A month later he began flying combat missions and was made a squadron operations officer. The combat environment was in most ways a replay of his World War II experience, except that now he was flying a jet fighter. Ground fire was there as always, but the chance of escape or evasion if shot down in an Oriental land was practically nil. The prospect of becoming a POW of the Chinese was not attractive.

The Chinese Communists had, as we know, entered the war with massive forces in December 1950, driving United Nations troops back to positions near the Demarcation Line. For the next eighteen months fighting was sporadic, interrupted or slowed by fruitless peace negotiations. During the late summer and fall of 1952, the war heated up. With enormous sacrifice of their troops, the Communists recaptured Triangle Hill in early November and were threatening US ground forces at Sniper Ridge.

On the morning of November 22, 1952, Major Loring, on his fifty-first mission, led a flight of four F-80s in a close support strike against enemy formations in North Korea. He was directed by an airborne controller to dive-bomb gun emplacements that were pinning down UN forces near Sniper Ridge. Ground fire, as usual, was heavy.

After locating his target, Loring rolled into his bomb run. Enemy fire concentrated on his F-80. Other members of his flight saw Loring's plane take severe hits. They expected he would pull out of his dive and attempt to reach friendly territory. Instead, he continued the attack, altering his course some forty-five degrees in a deliberate, controlled maneuver and dove directly into active enemy gun positions, destroying them at the cost of his own life. There was no indication that Loring had been mortally wounded when his aircraft was hit or that it could not have been flown to safety. What impelled Major Loring's calculated act of self-sacrifice that "exemplified valor of the highest degree"? No one could say.

Today Loring AFB in Maine commemorates the extraordinary heroism of this honored son. ■

AFA/AEF Report

By Daniel M. Sheehan, Assistant Managing Editor

AFA's National Committees

The makeup of AFA's National Committees for 1990–91 has been determined. The following members have been named to serve on the committees.

• **Executive Committee:** Oliver R. Crawford (Chairman), George M. Douglas, Martin H. Harris, Thomas W. Henderson, John E. Kittelson, William V. McBride, Thomas J. McKee, Jack C. Price, William N. Webb, Gerald V. Hasler, *ex officio* (nonvoting), James M. Keck, *ex officio* (nonvoting), Monroe W. Hatch, Jr., *ex officio* (nonvoting).

• **Resolutions Committee:** Thomas W. Henderson (Chairman), Oliver R. Crawford, George M. Douglas, Martin H. Harris, John E. Kittelson, William V. McBride, Thomas J. McKee, Jack C. Price, William N. Webb, Gerald V. Hasler, *ex officio* (nonvoting), James M. Keck, *ex officio* (nonvoting), Monroe W. Hatch, Jr., *ex officio* (nonvoting).

• **Finance Committee:** William N. Webb (Chairman), Charles H. Church, Jr. (Vice Chairman), John R. Alison, R. L. Devoucoux, William J. Gibson, William L. Ryon, Jr., Harold A. Strack, Oliver R. Crawford, *ex officio* (voting).

• **Constitution Committee:** Joseph A. Zaranka (Chairman), Edward J. Monaghan (Vice Chairman), Charles McGee, William C. Rapp, Mary Ann Seibel, Oliver R. Crawford, *ex officio* (voting).

• **Membership Committee:** John E. Kittelson (Chairman), Don Anderson, A. C. Burleson, H. R. Case, Robert Fisette, Robert W. Gregory, Cecil H. Hopper, Alwyn T. Lloyd, Robert N. McChesney, Robert A. Munn, Raymond W. Peterman, Jack G. Powell, Roy P. Whitton, Oliver R. Crawford, *ex officio* (voting).

• **Long-Range Planning Committee:** James M. McCoy (Chairman), Phil Lacombe (Vice Chairman), Earl D. Clark, Jr., E. F. Faust, Ellis T. Nottingham, William J. Schaff, William W. Spruance, A. A. West, Oliver R. Crawford, *ex officio* (voting).

• **Science and Technology Advisory Group:** Robert T. Marsh (Chairman), Thomas E. Cooper, Charles G. Durazo, Charles A. Gabriel, David Graham, H. B. Henderson, Thomas McMullen, Wayne A. Schroeder, Henry C. Smyth, Jr., Charles F. Stebbins, James Tegnelia, Richard E. Thomas, George R. Weinbrenner.

• **Veterans/Retirees Council:** Gene Smith (Chairman), John P. Flynn (Advisor), Richard Carr, David R. Cummock, Don Harlow, Nathan Mazer, Robert Puglisi, James E. Smith, Paul D. Straw, Robert H. Waldrup, Sherman W. Wilkins.

• **Advisors:** Ken Daly (Junior ROTC), Lt. Col. Roy A. Davis (Senior ROTC), Mike McRaney (Communications), Patricia Turner (Medical), Capt. Paul Willard II (Civil Air Patrol).

AEF News

AFA National President Oliver R. Crawford has appointed the following AFA National Directors to serve one-year terms on the Aerospace Education Board of Trustees: Earl D. Clark, Jr., William J. Gibson, Martin H. Harris, Jan M. Laitos, James M. McCoy, William C. Rapp, William W. Spruance, Edward A. Stearn, and Kenneth C. Thayer.

In other AEF news, SSgt. Michael Philliber was named an AEF Scott Associate for his tireless efforts in aerospace education. AFA's **Heart of the Hills (Tex.) Chapter** President Edward Fox and Vice President for Aerospace Education Fred Eubanks presented the award to the local recruiter.

Homage to "The Few"

Proudly taking their name, "The Few," from Winston Churchill's historic remarks about how much the grateful nation owed them, Britain's RAF veterans, though today even fewer in number, retain a fierce pride in their brave accomplishments of a half-century ago. That pride was on display as the RAF celebrated the fiftieth anniversary of the Battle of Britain last year, and AFA representatives were on hand to join in honoring the thwarting of Hitler's Operation Sea Lion.

Dorothy Brierton Wadsley, a World War II WAAF veteran, New York State AFA vice president, charter member of AFA, and former president of the **Gen. Daniel "Chappie" James Memorial (N. Y.) Chapter,** led the delegation. She went to Britain laden with honors for veterans of the Battle and seeking even stronger ties with British counterparts in the Royal Air Force Association (RAFA).

Ms. Wadsley, along with Beresford Sealy, secretary-treasurer of the James Chapter, presented gifts to

New York State AFA Vice President Dorothy Brierton Wadsley presents a plaque to Air Chief Marshal Sir Christopher Foxley-Norris, RAF (Ret.), during ceremonies commemorating the fiftieth anniversary of the Battle of Britain. Ms. Wadsley's visit helped strengthen AFA's ties with its British counterpart, the Royal Air Force Association.

Mark Tompkins, secretary-general of RAFA; Norma Bearblock, RAFA liaison officer; Jackie Evans, an RAF wing commander; and Air Chief Marshall Sir Christopher Foxley-Norris, RAF (Ret.), chairman of the Battle of Britain Fighter Association. The 180,000-strong force of women who served alongside the RAF in the Battle of Britain and afterward were not forgotten. Josephine Robins-Fairclough, a recipient of the Medal of Valor, and Sadie Younger, of Fighter Command Headquarters, received commemorative gifts from the New York delegation.

Among the gifts given by the New Yorkers were several high-quality briefcases containing autographed pictures of Gen. Jimmy Doolittle, copies of "High Flight," an inspirational message from Mrs. Ira Eaker, and several reprints of AIR FORCE Magazine articles of special interest to veterans of the Battle of Britain.

Ms. Wadsley terms it a "privilege" to have been involved in the festivities surrounding the anniversary of such a storied chapter in aviation history, which many US citizens (who were soon to be soldiers, sailors, Marines, and airmen) found so inspirational fifty years ago.

"Hurry up and wait," a time-honored tenet of military life, has been made a little easier to bear for veterans patronizing the VA Outpatient Clinic in Tulsa, Okla., thanks to a worthwhile effort by the Tulsa Chapter. Chapter President Harry Burt and Vice President for Veteran Affairs Jim Carl (pictured here with Dr. Laura Goldburg, director of the clinic) led the effort that placed three new television sets in the clinic's waiting rooms.

Chapter News

Not everyone could make it to Britain for the festivities, but some who could not wanted to take note of the anniversary just the same. The **Tacoma (Wash.) Chapter** did so by combining its recognition of the Battle of Britain with its forty-third annual celebration of the Air Force's birthday, held at McChord AFB, Wash. Highlights of the Birthday Ball included the presentation of two checks by Chapter President Rainer Willingham. The first, for $2,000, went to Col. Rodney Chiapusio, commander of the 62d Combat Support Group at McChord, for the base's youth activities program. The second, for $1,500, went to Ronald I. Powell, president of the McChord Air Museum, in support of museum activities.

National Vice President (Northwest Region) Alwyn T. Lloyd was on hand to present an Exceptional Service Award to Jack Gamble, chapter vice president for communications, and Medals of Merit to Eugene Nuss and Jack Sandstrom, former presidents of the Tacoma Chapter.

New chapter officers were installed, including President Joseph E. Tucker, First Vice President Thomas H. Swarner, Second Vice President Richard A. Seiber, and Secretary Robert L. Hollister. Mr. Powell was installed as treasurer.

Guests responded enthusiastically to a fine presentation on a hot topic, Operation Desert Shield. Lt. Col. Julian Allen, commander of the 8th Military Airlift Squadron, spoke of MAC's excellent efforts during the events of last summer. Maj. Russel G. Frasz and Capt. R. Tracy Mead, participants in the tremendous airlift that made Desert Shield possible, were also on hand to mingle with the guests, who evinced a high level of curiosity about the operation. Other distinguished attendees included Washington State President and Mrs. Ted Wright and Adm. and Mrs. James S. Russell, USN (Ret.). The Admiral, a strong supporter of AFA, has been inducted into the National Museum of Naval Aviation Hall of Honor.

An earlier operation that saw a major contribution by MAC, Just Cause, was the topic of a speech by Col. Daryl L. Bottjer, director of current operations for MAC, to a meeting of the **Everett R. Cook (Tenn.) Chapter.** The Colonel talked about MAC's role in deployment, operations, evacuation of casualties, and the eventual transport of captured Gen. Manuel Noriega to the US. Chapter President William Freeman welcomed the Colonel and other distinguished guests, including former National Vice President (South Central Region) Everett E. Stevenson.

Kentucky State AFA President James R. Jenkins, former president of the **Lexington (Ky.) Chapter,** took the opportunity on a recent trip to Washington, D. C., to escort teacher Sue Darnell, this year's winner of AEF's

At the Dacotah Chapter's symposium on the "Guard and Reserve in the Nineties" were (from left): Bob Johnson, then Dacotah Chapter president; Bob Jamison, then South Dakota AFA vice president; Hon. George S. Mickelson, Governor of South Dakota; Joyce Hazeltine, South Dakota Secretary of State; Maj. Gen. Alexander P. Macdonald, ANG, North Dakota Adjutant General; Maj. Gen. Roger P. Scheer, Chief, AFRES; and John Kittelson, AFA national vice president (North Central Region).

Christa McAuliffe Memorial Award, through the halls of Congress. They were able to meet with Kentucky congressmen from both sides of the aisle, Republican Larry Hopkins of Lexington, a member of the Armed Services Committee, and Democrat Carroll Hubbard of Mayfield.

In other dealings with the legislative branch, **Colorado Springs/Lance Sijan (Colo.) Chapter** members got a chance to talk with Rep. Joel Hefley (R-Colo.) at a luncheon meeting. Frank R. Wisneski, chapter president at the time, reports that Representative Hefley, a member of the Readiness Subcommittee of the Armed Services Committee, is well positioned to keep his AFA constituents informed on matters of great concern to them. Also at the luncheon were Gen. Donald Kutyna, Commander in Chief of NORAD and US Space Command, and Gen. Jim Hartinger, USAF (Ret.), former CINCNORAD and the first commander of Air Force Space Command.

President Louis Maddalone of the **Lloyd Schloen–Empire (N. Y.) Chapter** was proud to honor the memory of the late Col. James Kehoe at a recent meeting. He presented a plaque to Mrs. Kehoe as a token of appreciation for her husband's efforts as one of the chapter's founders.

The **Gus Grissom (Ind.) Chapter** held a successful meeting in Lafayette, Ind. It was a Boilermaker reunion of sorts as the meeting was addressed by Purdue University graduate Col. Dan McGrath, USAF (Ret.), now a Northrop executive. He was able to impart much valuable information on the B-2 Stealth bomber program from an insider's perspective. Henry Yang, dean of Purdue's school of engineering, donated some Purdue memorabilia and wrote a special letter of recognition of the Colonel's achievements. Chapter President "Buck" Hudgens, Chapter Vice President for Aerospace Education James Wagner (also of Purdue), and Chapter Treasurer Don James, a former U-2 pilot, thanked Colonel McGrath for his presentation.

Sgt. Brian L. Klein did not find out until after he won the prestigious Commandant's Award of the Lowry Noncommissioned Officers Leadership School, Lowry AFB, Colo., that his achievement had a special poignancy for his family. Sergeant Klein, administrative assistant to the 3415th Air Base Group's deputy commander, had been unaware that his father, MSgt. Russell L. Klein, who was later killed in Vietnam while serving as a flight engineer on a C-7A that was shot down, had won the same award while stationed at Mountain Home AFB, Idaho, in 1962. It made for an emotional moment when Sergeant Klein received his plaque and citation from Bob Cardenas, then-president of the **Mile High (Colo.) Chapter,** sponsors of the award.

Have AFA News?

Contributions to "AFA/AEF Report" should be sent to Dave Noerr, AFA National Headquarters, 1501 Lee Highway, Arlington, VA 22209-1198. ■

Bulletin Board

Orders are being taken for a history of the **301st Bomb Group/Wing,** a 15th Air Force B-17 combat group, to cover the period from 1942 to 1979. **Contact:** Erwin H. Eckert, 14215 Hunter Hill, San Antonio, TX 78217.

Seeking information and photos of any and all **Air Force planes,** from 1907 to the present. **Contact:** Thomas Murphy, 59 E. Browning Rd., Spruce Mason Apartments, Apt. 525F, Bellmawr, NJ 08031.

Seeking contact with anyone who knew **Irma Jack Medley,** who was in the 12th Observation Squadron, 2d Division, Air Corps, stationed at Fort Sam Houston in San Antonio, Tex., in 1927. Also seeking people who knew **Robert Grayson,** who was born in 1918 or 1919 in Indiana and was at Fort Bliss, Tex., in 1941. **Contact:** Penolope Giacoletti, P. O. Box 276, Morenci, AZ 85540.

Seeking contact with veterans who served in the **461st Bomb Group** in Italy between 1943 and 1945. **Contact:** Edward Chan, P. O. Box 117, New Hyde Park, NY 11040.

Seeking contact with anyone who knew **Lt. John M. "Woody" Woodward,** a B-17 pilot with the 65th Squadron, 43d Bomb Group, who was shot down on June 13, 1943. **Contact:** John M. Woodward, 209 Parkview, Luling, TX 78648.

For a book on **USAFE Fighter and Reconnaissance units from 1946 to 1956,** I would like to borrow photos or slides of aircraft from the following units: 10th and 66th Tactical Reconnaissance Wings; 20th, 48th, 81st, and 406th Fighter/Bomber Wings; and 31st and 55th Fighter Groups. **Contact:** MSgt. David W. Menard, USAF, (Ret.), 5224 Longford Rd., Dayton, OH 45424-2547.

Seeking models of the **C-124 Globemaster** and the **KB-50** refueling aircraft. **Contact:** MSgt. Richard J. Gronowski, USAF (Ret.), 140 N. Garfield Ave., Traverse City, MI 49684.

Seeking **RAF Sculthorpe yearbooks** from 1955 to the present. Also seeking any Tornado base magazines from the 47th Bomb Wing. **Contact:** Herbert Foster, 58 Hammerton St., Pudsey, West Yorkshire LS28 7DD, England.

Seeking reminiscences, photographs, names, nose art, and other items relating to **USAF, Vietnamese Air Force, and USN Skyraider** pilots or ground crews. **Contact:** Dan Medeiros, 5605 Valhalla Dr., Carmichael, CA 95608.

Seeking contact with anyone who knew **SSgt. John Louis Scala,** who was a gunner on a B-17E with the 16th Reconnaissance Squadron, 68th Reconnaissance Group, at Foch Field, Tunisia, when he was killed in a crash December 6, 1943. He also served with the 358th Bomb Squadron, 303d Bomb Group, and is buried at Lorraine, France. **Contact:** Tony Scala, 64 Sunnymead, West Green, Crawley, West Sussex RH11 7DZ, England.

Seeking members of the **453d Bomb Group** who served in England during World War II and are not already members of the 453d Bomb Group Association. **Contact:** Wib Clingan, 8729 Samoline, Downey, CA 90240.

Seeking contact with members of the **59th Air Base Depot Group** (later NAMA) at RAF Burtonwood, England, who had dependents attending the American high school at Burtonwood during the 1950s. **Contact:** Veda Fae Richards Hobbs, 9009C Contee Rd., Laurel, MD 20708.

For books on these subjects, seeking information on the **Eagle Squadrons, the Battle of Britain,** and **B-17 Bomb Groups. Contact:** Raymond Heward, 16 The Moorlands, Coloreton, Leicestershire LE6 4GG, England.

Seeking photographs or slides of **Air Defense Command F-102 Delta Daggers,** especially from the 5th, 27th, 84th, and 456th Fighter Interceptor Squadrons. **Contact:** Thomas G. Izbrand, 2540 W. Maryland #274, Phoenix, AZ 85017.

Seeking contact with people who knew **Maj. Alton C. Williams,** who was in the 774th Troop Carrier Squadron in Vietnam in 1967. Especially seeking contact with members of his crew: Lt. Toby Skinner, copilot; Lt. Pete Daly, navigator; SSgt. Art Doyle, flight engineer; and A2C Dave Bloss, loadmaster. **Contact:** David C. Williams, 223Y Brookhollow Dr., Abilene, TX 79605.

Seeking members of my crew from **301st Bomb Group,** 353d Bomb Squadron, 15th Air Force, who served in Foggia, Italy during World War II. Also seeking **William Mackey,** who trained with the squadron at MacDill Field, Fla., but didn't deploy to Europe. **Contact:** P. M. Gahagan, 2660 N. 66th St., Wauwatosa, WI 53213.

Seeking contact with the **USAF lieutenant colonel from Jamestown, R. I.,** who responded to my request for information on my father, saying he knew a Walter Y. Lucas. **Contact:** P. Slatcher, 51 Woolmer Rd., The Meadows, Nottingham NG2 2FA, England.

Seeking contact with a US glider pilot named **Boyne** who tried to contact his father's relatives in London during World War II. **Contact:** Irene (Boyne) Moore, 25 Westbrook Dr., Macclesfield, Cheshire SK10 3AQ, England.

Seeking contact with as many NCOs as possible who were at **RAF Brize Norton,** England, between 1953 and 1954, for a publication called *The Flying Times,* including a "where they are now" feature on you. **Contact:** CMSgt. Jim Bailey, (Ret.), 2 Sunbury Ln., Battersea, London SW11 3NP, England.

Seeking contact with other **patch collectors** and information on any patch clubs. **Contact:** Jerry Cecil, 4627 Ave. De Las Flores, Yorba Linda, CA 92686.

Seeking a book, ***History of the 445th Bomb Group,*** by Ralph J. Bursic. **Contact:** MSgt. Robert H. Murray, USAF (Ret.), 11165 Cochise Cir., Dewey, AZ 86327.

Seeking information on **W. G. Ehart,** a B-17 crew member with the 413th Bomb Squadron, 96th Bombardment Group, 8th Air Force, in England between 1942 and 1945. **Contact:** Jan P. Reifenberg, P. O. Box 1805, Rosamond, CA 93560.

Collector seeks photos or negatives of **nose art** on F/B-111s, B-1Bs, B-52s, KC-10s, and KC-135s. Also seeking any F-4 memorabilia. **Contact:** Randy P. Walker, 412 S. W. 46th St., Oklahoma City, OK 73109-7418.

Seeking color or black-and-white **photos** of military aircraft, personnel, equipment, markings, and camouflage. **Contact:** Sait Yorukel, 600 Evler, Akincilar Sk. 26, 10220 Bandirma, Turkey.

Collector seeks **USAF patches.** Will trade French Air Force patches. **Contact:** J. C. Cechetti, 53, Rue du Cormier, 41200 Romorantin, France.

Seeking contact with people who knew the **crew of B-24 #41-23711** of the 328th Bomb Squadron, 93d Bomb Group, 8th Air Force, which was shot down October 1, 1943, two months after participating in the raid on Ploesti. I am especially seeking the following 93d Bomb Group veterans: SSgts. Naum "Curly" Diltz, Kermit Morris, Charles Bates, and Robert O. Bochek; 2d Lieutenant McQuinn (the plane's former copilot); and Maj. Roy G. Martin. **Contact:** Gregg Jones, 2400 Riverfront Dr., #2232, Little Rock, AR 72202.

Seeking the whereabouts of **Lowell Janke** and **Elias Coury,** who were with the 18th Composite Squadron at Andrews Field (Great Saling), Essex, England, in 1943–44. **Contact:** G. Inglis, 2013 Collins Blvd., Gulfport, MS 39507.

Seeking information on USAF unconventional warfare and special operations activities in Southeast Asia between 1963 and 1975. I would especially like information on the following aircraft and units: **Duck Hook C-123s** of the 1st Flight Detachment; **Combat Spear C-130 Combat Talons** of the 15th, 90th, and 1st Special Operations Squadrons; **Green Hornet UH-1s** and **Pony Express CH-3s** of the 20th Special Operations Squadron; and **Knife CH-53Cs** of the 21st Special Operations Squadron. **Contact:** Maj. Bernard V. Moore II, 1683A Strickland Ct., Gunter AFB, AL 36115.

Seeking information on **Capt. Harry L. "Larry" Golding,** a base commander in Greenland from 1942 to 1943 who later served in India. **Contact:** Richard E. Golding, 125 West Parrish Rd., Sequim, WA 98392.

Seeking photos, recollections, and unit histories of **Army Air Fields in Florida** during World War II. **Contact:** Walter E. Houghton, Broward County Aviation Dept., 1400 Lee Wagener Blvd., Fort Lauderdale, FL 33315.

For a history of the 25th Bomb Group, I am seeking the whereabouts of personnel involved in secret **OSS missions called "Redstocking"** in England during World War II. **Contact:** Norman Malayney, 519 Semple St., Pittsburgh, PA 15213-4315.

Seeking the whereabouts of **William Walker,** who was stationed in Thailand from 1972 to 1976 and lived with Somret Phetsena in the village of Korat. **Contact:** Montan Phetsena, 7270 Heather Rd., Macungie, PA 18062.

Collector of military aviation **flight gear** seeks contact with other collectors to trade items from World War II to present. **Contact:** Jeffrey D. Guidry, 114 Oak Leaf Dr., Slidell, LA 70461.

Seeking information on a **swastika-like insignia** used by the 55th Pursuit Squadron, 20th Fighter Group, in the late 1920s or early 1930s. The insignia was changed when Hitler came to power. **Contact:** Dick D. Cato, 2602 Woodridge, Abilene, TX 79605.

Seeking the whereabouts of USAAF Night Fighter personnel, especially **John G. Smith, Edward "Ted" Collegan,** and **Hardin E. Ross** of the 425th Night Fighter Squadron. **Contact:** A. E. "Bud" Anderson, 8885 Plumas Cir., D-1116, Huntington Beach, CA 92646.

Seeking the whereabouts of former students who attended **Ramey High School,** on Ramey AFB, Puerto Rico, between 1955 and 1975. **Contact:** Glenn & Cindy Greenwood, 1424 Corona Dr., Austin, TX 78723.

Patch collector would like to trade or purchase **USAF patches and pilot scarves.** Also seeking memorabilia relating to the FB-111, the 509th and 380th Bomb Wings, and Pease AFB, N. H. **Contact:** MSgt. Jordan Murphy, CAP, 10 Farm Pond Ln., Hollis, NH 03049.

Seeking the whereabouts of **Pfc. Robert Brown,** who served with the 817th Engineer Aviation Battalion, Company C, based at RAF Chelveston, England, in 1952–53. **Contact:** John Stiles, 48 Squirrel Rise, Marlow Bottom, Bucks, England.

Seeking contact with members of the **652d Bomb Squadron, Weather Reconnaissance,** who were stationed at RAF Watton or RAF Alconbury, England, in 1944–45. **Contact:** R. J. Hunt, 1487 Lupine Dr., Santa Rosa, CA 95401-3936.

Seeking contact with veterans who took part in the **April 16, 1944, "Black Sunday" raid on Hollandia** by these units: 3d, 22d, 43d, 312th, 345th, and 417th Bomb Groups; 8th and 475th Fighter Groups; and 26th Photoreconnaissance Squadron. **Contact:** Col. Russell L. Sturzebecker, USAF (Ret.), 503 Owen Rd., Westchester, PA 19380.

Seeking information on **2d Lt. Richard M. Merrill,** a B-24 navigator with the 777th Bomb Squadron, 464th Bombardment Group, 15th Air Force, at Pantanella AAB, Italy, who was killed October 17, 1944 in Vienna, Austria. **Contact:** K. Reading, P. O. Box 1689, Pendleton, OR 97801.

If you need information on an individual, unit, or aircraft, or if you want to collect, donate, or trade USAF-related items, write to "Bulletin Board," AIR FORCE Magazine, 1501 Lee Highway, Arlington, VA 22209-1198. Letters should be brief and typewritten. We cannot acknowledge receipt of letters to "Bulletin Board." We reserve the right to condense letters as necessary. Unsigned letters are not acceptable. Photographs cannot be used or returned.—THE EDITORS

Seeking information on two World War II bombers, ***Spirit of Autauga County, Ala.***, and ***Pride of Autauga***, which were purchased with war bonds by the citizens of Autauga County. **Contact:** Elizabeth Boone Aiken, 410 Cary Dr., Auburn, AL 36830.

For a book, seeking contact with anyone who was on the **low-level mission to Ploesti on August 1, 1943,** or who worked on the aircraft that flew that mission. **Contact:** Michael Hill, 1405 8th St. S. W., Minot, ND 58701.

Seeking contact with members of the **366th and 367th Air Service Squadrons** of the 96th Air Service Group who served in Italy during World War II. **Contact:** Edmund Wilkinson, 6425 Gaelic Glen Dr., Oklahoma City, OK 73142.

Seeking historical data, photos, anecdotes, and memorabilia relating to the **12th Tactical Reconnaissance Squadron. Contact:** 1st Lt. Walter L. Jablow, 12th TRS/DO, Bergstrom AFB, TX 78743.

A memorial fund has been established for the families of **MSgt. Samuel M. Gardner, SSgt. Marc H. Cleyman,** and **SSgt. Rande J. Hulec,** who were killed when their Air Weather Service C-5 crashed last August en route to Saudi Arabia to take part in Operation Desert Shield. **Contact:** Air Weather Association Memorial Fund, 5301 Reservation Rd., Placerville, CA 95667.

Historian seeks oral histories, correspondence, anecdotes, and reminiscences relating to the training, test and evaluation, deployment, and deactivation of the **Ground-Launched Cruise Missile (GLCM)** at any operational, test, or training location. **Contact:** David Ramagos, 235 Thames Dr., Colorado Springs, CO 80906.

For an alumni book, the public affairs staff of the **207th AFROTC Cadet Wing** is seeking addresses, photos, and job descriptions of all graduates of Detachment 207 and Detachment 206. **Contact:** C/3C Sean P. Brady, 207th AFROTC Cadet Wing, Parks College of St. Louis University, Cahokia, IL 62206-1998.

Seeking information on **Walter "Wally" Holkstead,** who was with the 513th Troop Carrier Group, stationed at Kaingwan AB, China, and was killed in late January or early February 1946 near Hankow (now Wuhan), China. **Contact:** Robert M. Kirkpatrick, 3562 Artesian St., Riverside, CA 92503.

Seeking information on and a copy of a photo that was taken on **September 22, 1944,** by a member of the **15th Air Force near Termoli, Italy.** The photo shows a group of people who had been in a crash landing of an aircraft, including the pilot and his wife, a General Naday, a Colonel Howie (a South African, wearing civilian clothes), and possibly another member of the flight crew. **Contact:** Philip Markham, 85 Avenue Rd., Ottawa, Ontario K1S 0P1, Canada.

Seeking the whereabouts of **Marion O. Wilson, Selma McDougle, Maxie B. Seale, Ronnie McCullok,** and **Corwin Giese,** who were assigned to the Palace Hotel, Southport, England, during World War II. **Contact:** R. C. Harris, Jr., 4813 Burton SE, Albuquerque, NM 87108-3419.

Seeking contact with anyone who knew **Henry Schreier,** a tail gunner on *Snow White*, a B-24 of the 98th Bomb Group, in Italy, who was later a POW in Germany. **Contact:** Margaret L. Cawood, Confederate Air Force, 1419 Quamasia, McAllen, TX 78504.

For a biography, seeking information on **Antoine de Saint-Exupéry,** who was part of a French group attached to the American 23d Photo-reconnaissance Squadron, flying P-38 Lightnings on reconnaissance missions from North Africa to Sardinia in 1943. **Contact:** Stacy Schiff, 125 Cedar St., Apt. 4S, New York, NY 10006.

For a history of **Air Refueling Units**, seeking contact with members who served with the 11th, 77th, 100th, 311th, 334th, 335th, 336th, 497th, 499th, 500th, 4045th, 4050th, 4060th, 4061st, 4108th, 4397th, or 4505th Air Refueling Wings. **Contact:** SSgt. Mike L. Lambert, 4000 E. Dunham St., Wichita, KS 67210.

Unit Reunions

Bataan and Corregidor
Members of the American Defenders of Bataan and Corregidor will hold their national convention May 2–5, 1991, at the Airport Hilton Hotel in Memphis, Tenn. **Contact:** John Crago, 615 Lehmeyer St., Huntington, IN 46750.

Foster/Aloe Fields
Military and civilian personnel stationed at Foster and Aloe Fields (Matagorda Gunnery Range/ Matagorda Peninsula), Tex., during the 1940s and 1950s will hold their fiftieth-anniversary reunion in June 1991. **Contacts:** Paul A. Kneblick, 601 Cambridge, Rte. 6, Victoria, TX 77901. Phone: (512) 575-5840 or (512) 575-7560 (Helen K. Welch).

2d Bombardment Group
Members of the 2d Bomb Group will hold a reunion September 12–15, 1991, at the Stouffer Hotel in Dayton, Ohio. **Contact:** Kemp F. Martin, 8433 Katy Freeway, Suite 102, Houston, TX 77024. Phone: (713) 467-5435.

6th Bomb Group
Members of the 6th Bomb Group (Very Heavy) stationed on Tinian in 1945 will hold a reunion May 30–June 2, 1991, in Newton, Mass. **Contact:** Newell W. Penniman, Jr., 6 Porter Ln., South Hamilton, MA 01982. Phone: (508) 468-2806.

9th Service Squadron
Members of the 9th Service Squadron, 321st Service Group, 13th Air Force, will hold a reunion in June 1991 in Hot Springs, Ark. Please send a postcard for additional information. **Contact:** MSgt. Laurence F. Mirick, USAF (Ret.), 14 Grasswood Ln., Rockland, MA 02370-2834. Phone: (617) 878-3934.

33d Tactical Fighter Wing
Veterans of the 33d Fighter Group/33d Tactical Fighter Wing will hold their fiftieth-anniversary reunion April 3–5, 1991, in Fort Walton Beach, Fla. **Contacts:** Lt. Col. Ibrie Beatty, USAF (Ret.), 18 Sherwood Rd., N. W., Fort Walton Beach, FL 32547-1635. Phone: (904) 862-8891. Lt. Col. William Jones, USAF (Ret.), 25 Country Club Rd., Shalimar, FL 32579. Phone: (904) 651-5859. Clay McCutchan, 33d TFW/HO, Eglin AFB, FL 32542. Phone: (904) 882-4885.

Readers wishing to submit reunion notices to "Unit Reunions" should mail their notices well in advance of the event to "Unit Reunions," Air Force Magazine, 1501 Lee Highway, Arlington, VA 22209-1198. Please designate the unit holding the reunion, time, location, and a contact for more information.

53d Weather Recon Squadron
The 53d Weather Reconnaissance Squadron and Weather Detachment "Hurricane Hunters" will hold a reunion February 22–24, 1991, in Biloxi, Miss. **Contact:** Lt. Col. James L. Donnelly, USAF, 53d WRS/CC, Keesler AFB, MS 39534-5000. Phone: (601) 377-2377.

307th Bomb Group/Wing
Members of the 307th Bomb Group and Wing who served between 1947 and 1954 will hold a reunion May 16–19, 1991, in Dayton, Ohio. **Contact:** Harold K. Sams, 4100 Tonawanda Trail, Dayton, OH 45430. Phone: (513) 429-0639.

404th Fighter Group
Members of the 404th Fighter Group, which included the 506th, 507th, and 508th Fighter Squadrons, will hold a reunion June 20–23, 1991, in Abilene, Tex. **Contact:** John S. Freeman, 404 S. West St., Box 508, Kempton, IN 46049. Phone: (317) 947-5231.

450th Bomb Group
The 450th Bomb Group "Cottontails" will have a return trip to Manduria, Italy, for a memorial dedication on April 8–16, 1991. **Contact:** Col. Robert H. Gernand, USAF (Ret.), 1054 San Remo Rd., St. Augustine, FL 32086. Phone: (904) 797-7348.

4135th SW/39th BW
The 4135th Strategic Wing and the 39th Bomb Wing will hold a reunion March 8–10, 1991, at the Elks Lodge, Greenwood Motel, in Fort Walton Beach, Fla. **Contact:** Rex Nevill, 123 Sortir St., Fort Walton Beach, FL 32548. Phone: (904) 862-2819 or (904) 897-2312.

Retired USAF Musicians
Seeking names and addresses of retired US Air Force musicians for a roster for future reunions and to plan a 1992 reunion. **Contact:** Louis C. Kriebel, 1521 East Boulevard., Maitland, FL 32751.

Pilot Class 52-A
For the purpose of planning a reunion in 1992, I would like to hear from Pilot Class 52-A. **Contact:** Stan Nelson, 2012 W. 49th Terrace, Shawnee Mission, KS 66205. Phone: (913) 362-1325.

314th Tactical Airlift Wing
I would like to hear from members of the 314th Tactical Airlift Wing stationed at Ching Chuan Kang (CCK) AB, Taiwan, in 1967 and 1968 who would be interested in holding a reunion in May 1991. **Contact:** John Powell, 210 Southland Station Dr., #41, Warner Robins, GA 31088.

367th Air Service Squadron
I am trying to locate members of the 367th Air Service Squadron and the 96th Air Service Group who served in Italy during World War II and who would be interested in holding a reunion. **Contact:** Edmund Wilkinson, 6425 Gaelic Glen Dr., Oklahoma City, OK 73142. Phone: (405) 722-2153.

DON'T LET MEDICAL EXPENSES SOAR
GET PROTECTION WITH AFA's CHAMPLUS®

A CHAMPUS Supplement Which Helps Limit Your Unreimbursed Medical Expenses.

CHAMPUS is a federally-funded health benefits program designed to help service families pay for medical care in civilian medical facilities, including doctor charges. However, with CHAMPUS there is a gap as to what percentage of medical expenses get reimbursed and what you have to pay out-of-pocket. That's why you need CHAMPLUS®. As a member of the Air Force Association, you are eligible to purchase one of the best CHAMPUS Supplements available, with competitively low rates.

FEATURES THE NEW EXPENSE PROTECTOR BENEFIT

This benefit limits out-of-pocket expenses for CHAMPUS covered expenses in any single calendar year to $1,000 for any one insured person (or $2,000 for all insured family members combined). Once those out-of-pocket expense maximums are reached, CHAMPLUS® will pay 100% of CHAMPUS covered charges for the remainder of that year.

An example of how the Benefit works:

You are hospitalized for 35 days and the hospital charges you $330 per day -- $95 per day more than allowed by CHAMPUS. Your out-of-pocket expense would be $3,325. With the Expense Protector Benefit your cost would be limited to $1,000. All covered costs over this amount -- for the entire calendar year -- would be paid.

ELIGIBLE APPLICANTS

All AFA members under age 65 who are receiving retirement pay based on their military service, spouses under age 65 of active duty or retired members and their unmarried dependent children under age 21, or 23 if in college, are eligible. Upon reaching age 65, your coverage will automatically be converted to AFA's Medicare Supplement Program.

RENEWAL PROVISION

Your coverage will continue as long as you remain eligible for CHAMPUS benefits, the Master Policy with AFA remains in force, your membership continues, and you pay your premiums.

There is no waiting period for active duty members who enroll within 30 days of retirement if their dependents have been insured for two years previously.

EXCEPTIONS AND LIMITATIONS

There is a 12-month waiting period for conditions which were treated 12 months prior to the effective date of insurance. After the coverage has been in effect for 24 consecutive months, all pre-existing conditions will be covered. Children of active duty members over age 21 (age 23 if in college) will continue to be eligible if they have been declared incapacitated and if they are insured under CHAMPLUS® on the date so declared. Coverage for these older age children will only be provided upon notification to AFA and payment of a special premium amount.

EXCLUSIONS

This plan does not cover and no payment shall be made for: routine physical examinations or immunizations; domiciliary or custodial care; dental care (except as required as a necessary adjunct to medical or surgical treatment); routine care of the newborn or well-baby care; injuries or sickness resulting from declared or undeclared war or any act thereof or due to acts of intentional self-destruction or attempted suicide, while sane or insane; treatment for prevention or cure of alcoholism or drug addiction; eye refraction examinations; prosthetic devices (other than artificial limbs and artificial eyes), hearing aids, orthopedic footwear, eyeglasses and contact lenses; expenses for which benefits are or may be payable under Public Law 89-614 (CHAMPUS).

LOOK AT WHAT AFA CHAMPLUS® PAYS

Care	Retired	Active Duty
Inpatient civilian hospital care	the 25% of allowable charges not paid by CHAMPUS, plus 100% of covered charges after out-of-pocket expenses exceed $1,000 per person (or $2,000 per family) during any single calendar year	the greater of the total daily subsistence fees, or the $25 hospital charge not paid by CHAMPUS
Inpatient military hospital care	the daily subsistence fee	the daily subsistence fee
Outpatient care (covers emergency room treatment, doctor bills, pharmaceuticals, and other professional services; see exclusions for limitations)	the 25% of allowable charges not paid by CHAMPUS, after the deductible has been satisfied, plus 100% of covered charges after out-of-pocket expenses exceed $1,000 per person (or $2,000 per family) during any single calendar year	the 20% of allowable charges not paid by CHAMPUS after the deductible has been satisfied, plus 100% of covered charges after out-of-pocket expenses exceed $1,000 per person (or $2,000 per family) during any single calendar year

CHAMPLUS® offers many attractive benefits. For a complete description of the Plan, including exceptions and limitations, please refer to the Certificate of Insurance, or call our Insurance Division toll-free at

1-800-727-3337
x4905

To enroll in the program, complete the application. →

RATES

For Military Retirees and Dependents
QUARTERLY PREMIUM SCHEDULE
In-Patient Benefits Only

Member's Attained Age*	Member	Spouse	Each Child
under 50	$25.27	$54.15	$17.97
50-54	37.76	59.03	17.97
55-59	55.35	63.18	17.97
60-64	66.13	79.66	17.97

For Military Retirees and Dependents
QUARTERLY PREMIUM SCHEDULE
In-Patient and Out-Patient Benefits

Member's Attained Age*	Member	Spouse	Each Child
Under 50	$39.00	$79.32	$40.84
50-54	51.25	87.34	40.84
55-59	70.85	115.33	40.84
60-64	89.00	132.80	40.84

*Note: Premium amounts increase with the member's attained age.

For Dependents of Active Duty Personnel
ANNUAL PREMIUM SCHEDULE

	Member	Spouse	Each Child
In-Patient Benefits Only			
All Ages	None	$12.89	$7.72
In-Patient and Out-Patient Benefits			
All Ages	None	$51.52	$38.61

APPLICATION FOR AFA CHAMPLUS®

Group Policy GMG-FC70
Mutual of Omaha Insurance Co.
Home Office: Omaha, Nebraska

Full name of Member________________________________
Rank Last First Middle

Address________________________________
Number and Street City State Zip Code

Date of Birth__________Current Age____Height______Weight________S.S.N.____________
Month/Day/Year

This insurance coverage may only be issued to AFA members. Please check the appropriate box below: ❑ I am currently an AFA Member ❑ I enclose $21 for annual AFA membership dues. (includes subscription ($18) to AIR FORCE Magazine)

PLAN & TYPE OF COVERAGE REQUESTED

Plan Requested (check one)
❑ AFA CHAMPLUS® PLAN I (for military retirees & dependents)
❑ AFA CHAMPLUS® PLAN II (for dependents of active-duty personnel)

Coverage Requested (check one)
❑ Inpatient Benefits Only ❑ Inpatient and Outpatient Benefits

Person(s) to be insured (check one)
❑ Member Only ❑ Member & Children
❑ Spouse Only ❑ Spouse & Children
❑ Member & Spouse ❑ Member, Spouse & Children

PREMIUM CALCULATION

All premiums are based on the attained age of the AFA member applying for this coverage. Plan I premium payments are normally paid on a quarterly basis, but, if desired, they may be made on either a semi-annual (multiply by 2), or annual (multiply for 4) basis.

Quarterly (annual) premium for member (age ____) $________
Quarterly (annual) premium for spouse (based on members' age) $________
Quarterly (annual) premium for ____ children @ $ $________
Total premium enclosed $________

If this application requests coverage for your spouse and/or eligible children, please complete the following information for each person for whom you are requesting coverage.

Names of Insured Dependents Relationship to Member Date of Birth (Month/Day/Year)

____
____
____

(To list additional dependents, please use a separate sheet.)

In applying for this coverage, I understand and agree that (a) coverage shall become effective on the last day of the calendar month during which my application together with the proper amount is mailed to AFA, (b) only hospital confinements (both inpatient and outpatient) or other CHAMPUS-approved services commencing after the effective date of insurance are covered and (c) any conditions for which I or my eligible dependents received medical treatment or advice or have taken prescribed drugs or medicine within 12 months prior to the effective date of this insurance coverage will not be covered until the expiration of 12 consecutive months of insurance coverage without medical treatment or advice or having taken prescribed drugs or medicine for such conditions. I also understand and agree that all such preexisting conditions will be covered after this insurance has been in effect for 24 consecutive months.

Date____________, 19____ ________________________________
(Member's Signature)

Form 6173GH App.

Application must be accompanied by a check or money order. Send remittance to:
Air Force Association, Insurance Division, 1501 Lee Highway, Arlington, VA 22209-1198


Bob Stevens'
"There I was..."
...AT RICHARDS-GEBAUR AFB, KANSAS CITY, FOR "OPERATION HANDSHAKE"-THE ANNUAL AIRSHOW EXTRAVAGANZA PLANNED and DIRECTED ENTIRELY BY AIR RESERVE UNITS. THIS IS ONE OF THE TOP SHOWS IN THE NATION and RECEIVES 110% SUPPORT FROM K.C. BOOSTERS-
A-10
303 TFS
OVER A HALF-MILLION FOLKS PACK THE RAMP FOR TWO DAYS. ONE STRANGE BIRD ON DISPLAY CAME FROM GERMANY-
DADDY, IS THAT A STINGER BACK THERE?
YEAH, FOR SUBS IT IS!
MARINE
WIE GEHTS, KAMERAD?
IT'S A BREGUET 1150 "ATLANTIC" FROM AIRWING 3, NORDHOLZ
YANKEE INGENUITY AT ITS BEST-303 TFS PERSONNEL HAWKED MEMENTO'S OF LAST SUMMER'S DEPLOYMENT-
CHIP OFF THE BERLIN WALL
STRIKE A BLOW FOR FREEDOM
C'MON, GET 'EM WHILE THEY'RE HOT!
DAD, THEY'RE ONLY A BUCK A POP. LET'S BREAK 'EM IN TWO & RESELL 'EM AT A $1.00 EACH!
ONE OF THE HIGHLIGHTS WAS 4 PASSES BY THE USAF'S F-117 STEALTH FIGHTER!
WHOOSH!!!
GRAMPS, I DIDN'T SEE ANYTHING!
YOU'RE NOT SUPPOSED TO, LADDY!
AND, OF COURSE, THE THUNDERBIRDS WOUND UP THE DAY WITH A PRECISION PERFORMANCE (IT WAS THEIR "FLAT" ROUTINE DUE TO LOW CLOUDS THE FINAL DAY).
THEY MAY CALL IT FLAT-I CALL IT FLAT OUT!
Bob Stevens
(ON LOCATION)