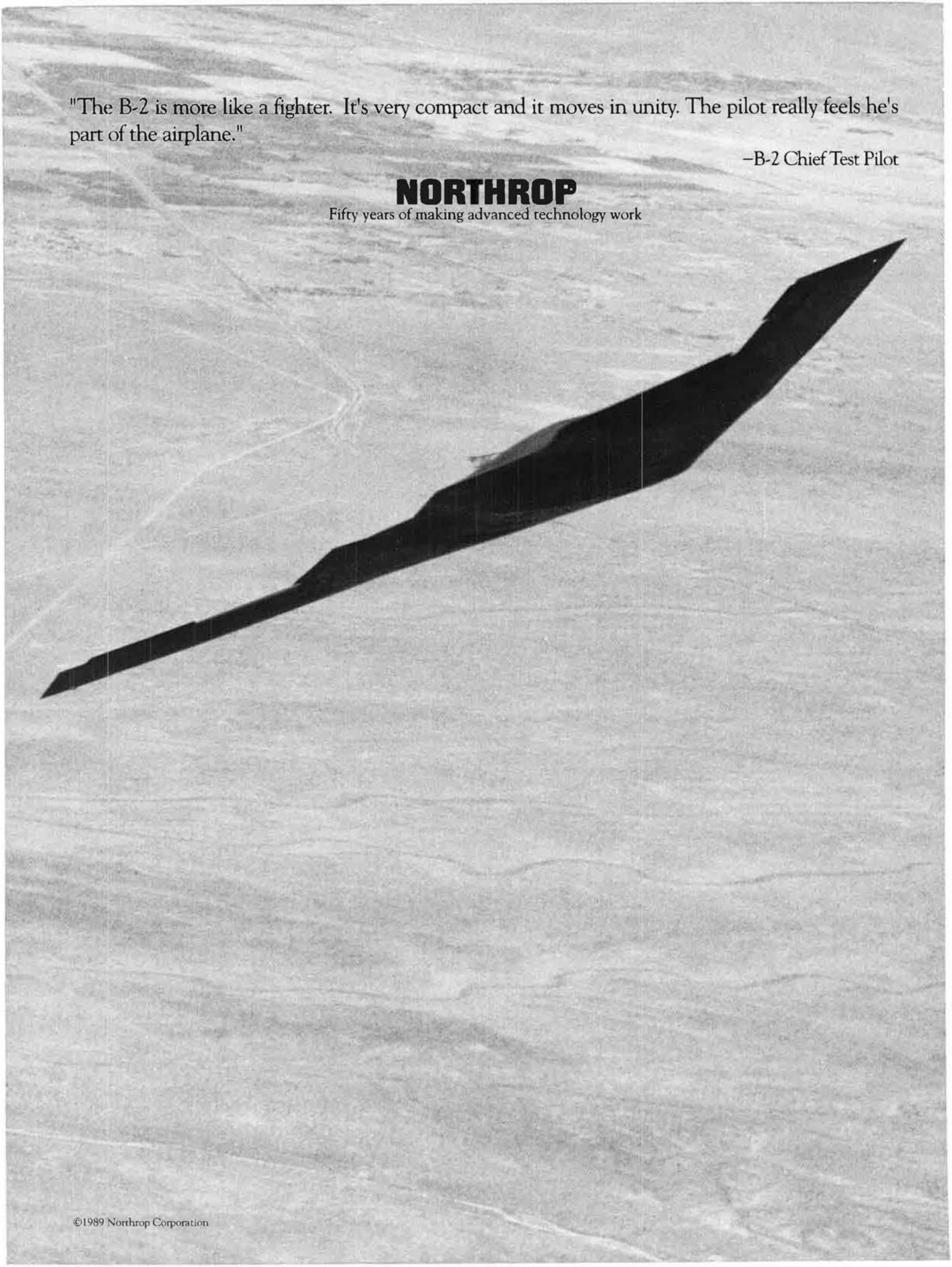
JANUARY 1990/$2

AIR FORCE MAGAZINE

PUBLISHED BY THE AIR FORCE ASSOCIATION

Aeronautics: The Year of the Airplane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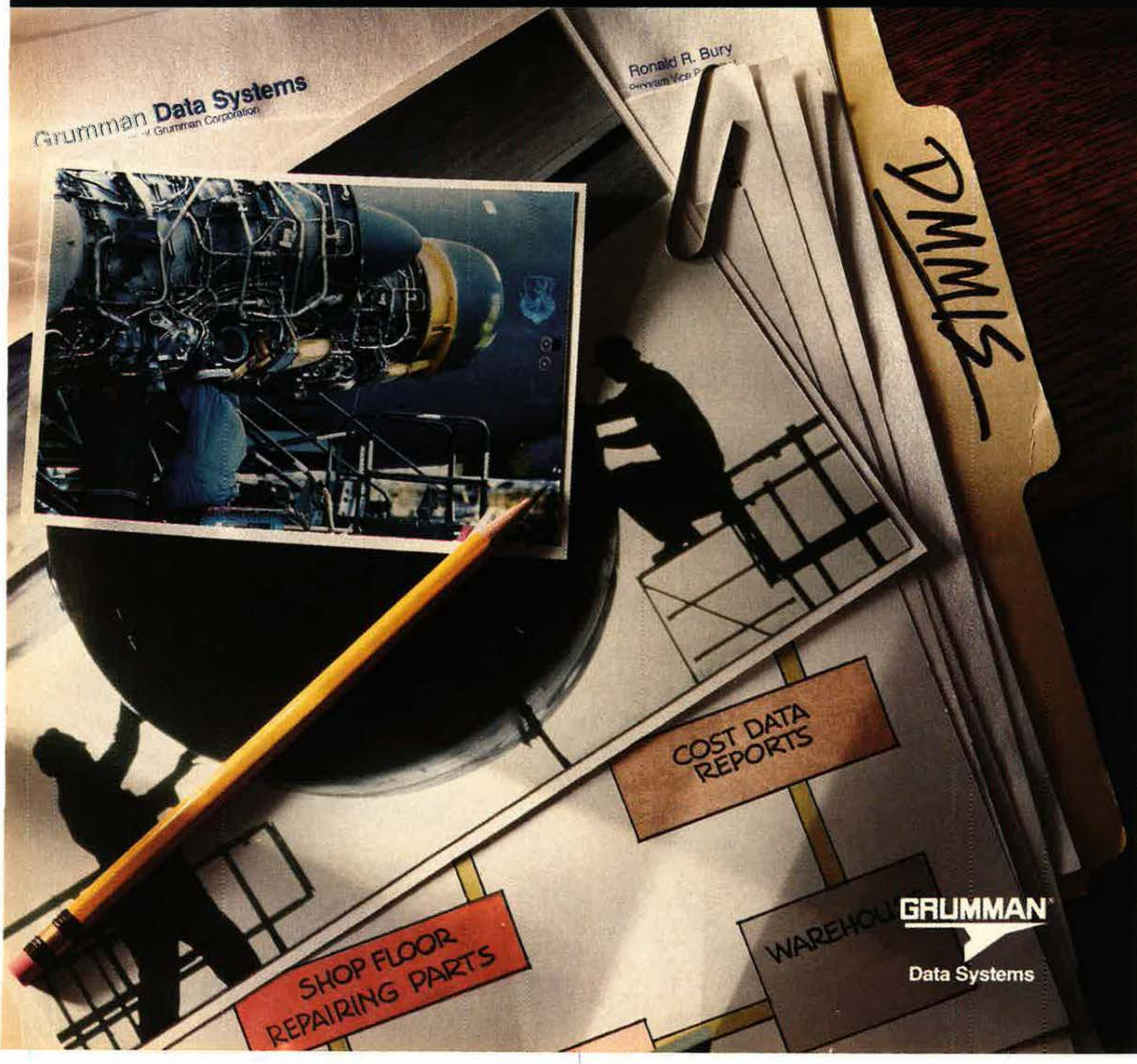
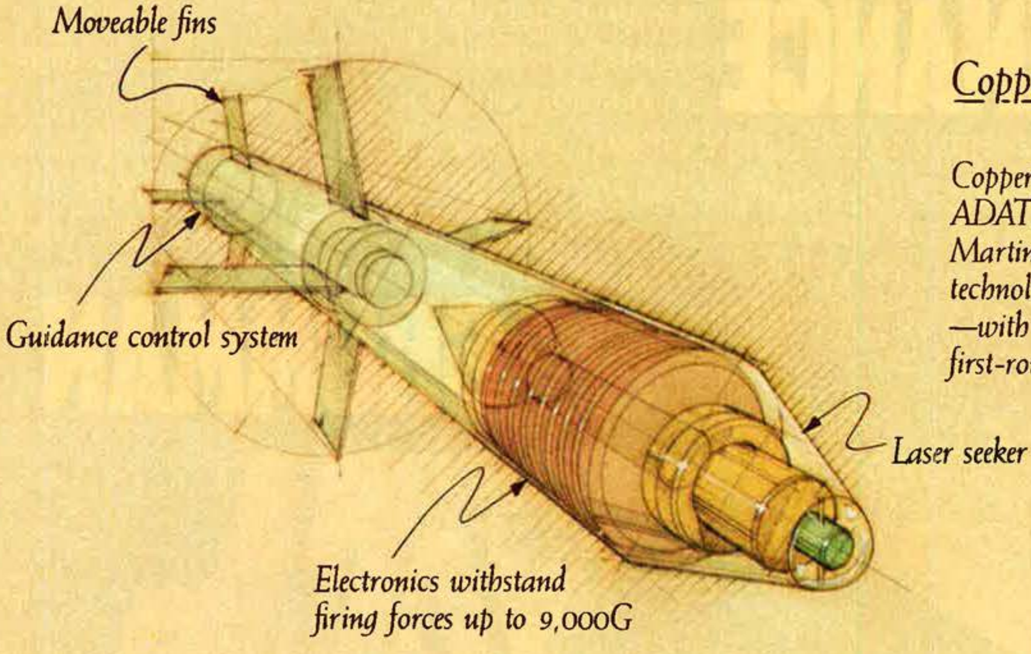


Systems that search, sense, seek...and succeed.



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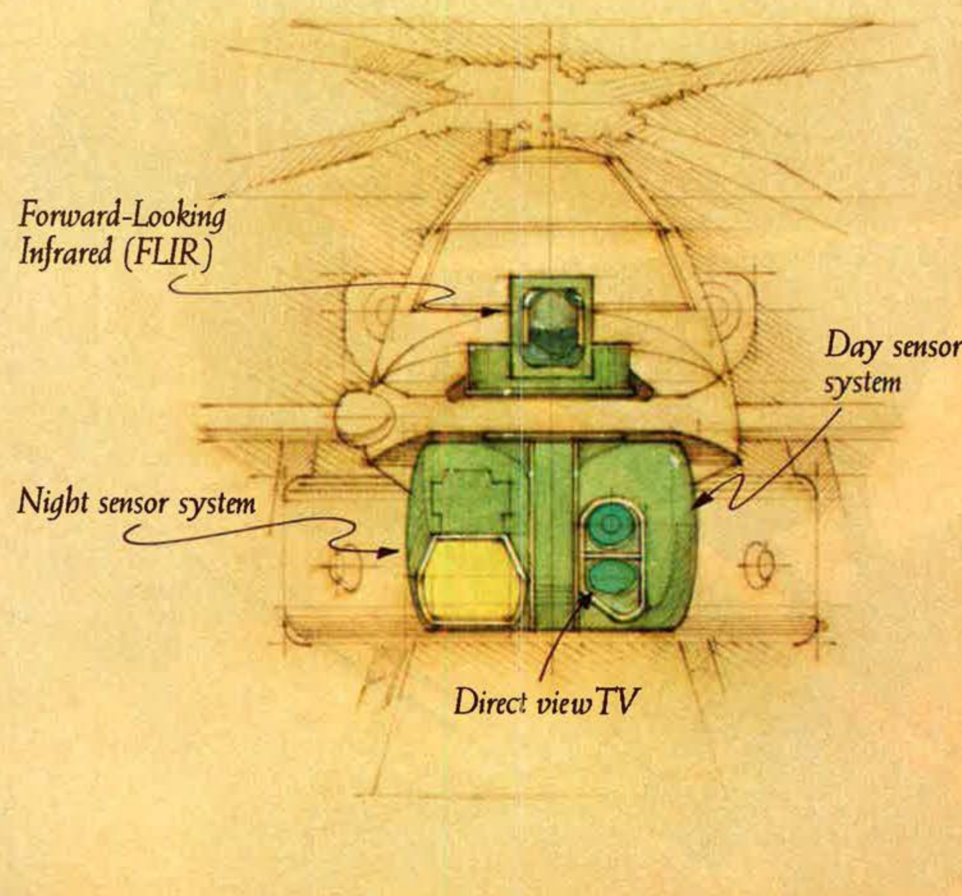

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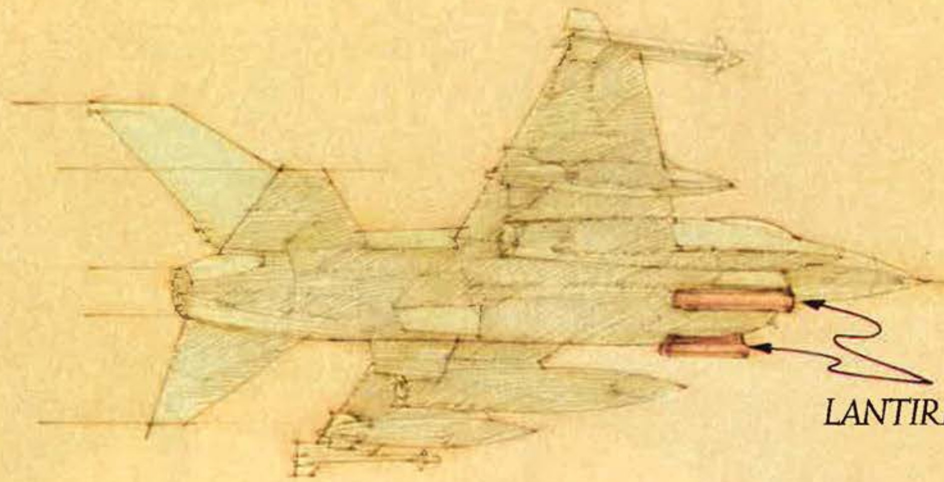

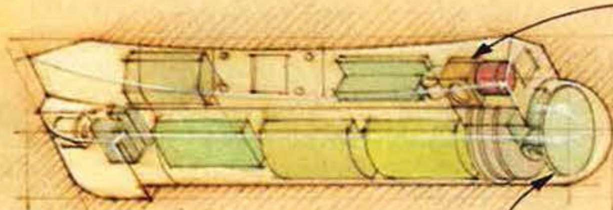

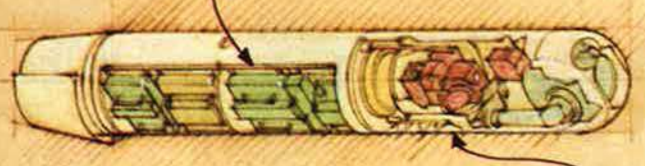

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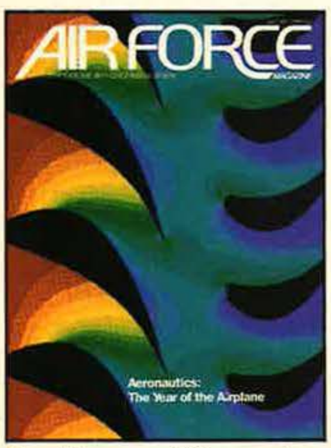

About the cover: This computer-generated computational fluid dynamics image of airflow around engine turbine blades illustrates just one of the many uses of computers in aircraft design. Photo courtesy of Rocketdyne, a division of Rockwell.

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By John T. Correll, Editor in Chief

The Peace to End All Wars

According to a new study from the Brookings Institution, we can safely cut defense spending by half over the next ten years. The author, William W. Kaufmann, figures that our pint-size forces of the twenty-first century will encounter few real challenges. And, he says, we should count on at least three months' warning to mobilize for significant conflict.

If we need to reinforce Europe, the Reserve and the National Guard can do that. Navy submarines, backed up by a diminished complement of bombers and ICBMs, will provide plenty of strategic deterrence. As for force modernization, why bother? The study postulates defense outlays of $160.1 billion (in 1990 dollars) for 1999.

For shock value, though, the Brookings study wasn't a patch on a November directive from the Defense Department telling the services to find reductions of $180 billion in budget authority between 1992 and 1994. That suggests a 1994 budget in the $280 billion range, a twenty percent retrenchment from Secretary of Defense Richard Cheney's spending forecast last April.

Such a reduction would disband units, abolish infrastructure, and close production lines, but some critics see it as a limited step. Larry Korb of Brookings, for example, accuses Mr. Cheney of playing a numbers game because the entire $180 billion cut does not fall in a single year and because the reduction is from planned budget levels rather than from current ones.

Mr. Kaufmann, Mr. Cheney, and Mr. Korb are hardly alone in planning reductions to defense. Deep cuts seem to be a foregone conclusion. The politicians and pundits are already spending the anticipated "peace dividend," and the public is cheering them on.

National security planning is in chaos. The speculation list of what forces might be disbanded or demobilized changes by the day. The nation seems blissfully eager to bet the works on optimistic assumptions.

It is tempting to believe that collapse of the Soviet empire and the new détente in Europe signify an era of permanent peace. World War I was supposed to be the war to end all wars. We emerged from that conflict—and from the next world war as well—with no enemies in sight, but we had not seen the last of war.

Nations today are still at odds over ideology, values, and economic interests. Ballistic missiles and chemical weapons are proliferating. The spread of nuclear weapons is probably inevitable. There is little chance that we have begun a peace to end all wars.

Deep cuts seem to be a foregone conclusion. The politicians and pundits are already spending the anticipated "peace dividend," and the public is cheering them on.

In Europe, we must now reckon with the factor of instability. The Cold War gave the East and the West long decades to scope out each other's capabilities, options, and order of battle. They had time to plan, prepare, and exercise for specific scenarios of conflict. The result was a stable standoff. Suddenly, the old assumptions and strategies may no longer apply.

If Germany reunifies—and the probability of that is high—will it be neutral? To what extent would a unified Germany, nonaligned or otherwise, dominate the rest of Europe? How will the Soviet Union react if Germany drifts Westward? How will we react if it drifts Eastward? The world has not been faced with such questions for more than forty years.

The Warsaw Pact nations have slipped the Communist Party leash. Will they also defy Moscow and leave the military alliance? It is inconceivable that a power vacuum could persist for long in eastern Europe.

In the USSR itself, the non-Russian republics are rumbling with nationalism. The example of eastern Europe will almost surely stimulate them to demand greater self-determination. At what point will the Russians feel compelled to react as their sphere of influence shrinks and their borders recede?

Soviet leader Mikhail Gorbachev has not delivered many benefits at home to compensate for the disruption and change. The economy is as bad as ever. Conditions are volatile, and if the lid blows off, Mr. Gorbachev may not be able to get it back on.

The awesome military power of the Soviet Union survives virtually intact. Even with radical reductions, it would still be awesome. Power and instability make a combination that is both unpredictable and dangerous.

Tremendous pressures are building from the Atlantic to the Urals. Those pressures may dissipate with time, or they might find some peaceful channel for release. It is equally possible that the aspirations, fears, and energies of nations in transition may propel events in some strange new direction.

As the entire Gorbachev phenomenon demonstrates, world affairs can take unexpected turns, and sweeping change can be upon us quickly. If we knew that our security and interests were free from danger, we would not need *any* defense. It would be pointless to spend even the $160 billion that Mr. Kaufmann would allow us.

Almost everyone concedes, however, that we will need *some* defense. Despite the happy visions so popular at the moment, there is a strong possibility that we will need quite a bit of it. ■

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Letters

Applauding Dissent

Rarely have I agreed with Gen. T. R. Milton, but his item in the November 1989 issue hit a responsive chord *[see "Viewpoint: What the Dissenters Add," p. 112]*.

When I received my copy of *Proceedings*, I was amazed to read that Cmdr. David R. Carlson had expressed my views with respect to the *Vincennes* incident. Now I am happy to see that General Milton appears to agree that the dissent expressed by Carlson may be a good thing.

Dissent in the military, as in the corporation, is risky business. We have only to look at Billy Mitchell to see the extent to which retribution against dissenters can be carried by [their superiors]. Growing up in the infantry, I learned about the danger of dissent early in life.

In a more recent issue of *Proceedings*, another Naval officer appears to feel strongly that dirty linen should not be aired in such a public forum. I could not disagree more strongly. We live in an open society, we have a Bill of Rights, and we have a right to speak our piece. As a former member of the military, now retired, where else am I going to read the pros and cons? So far as I am concerned, I (and all Americans) have a right to know what is going on in the various services. I have a right to know about the warts, as well as the good PR.

General Milton is to be applauded for his recognition of the problems facing the Air Force (and the other services) and for speaking out in favor of constructive criticism.

Lt. Col. Rhodes F. Arnold,
USAF (Ret.)
Reserve, N. M.

Redefining Doctrine

I read Mr. James W. Canan's article "Global Power from American Shores" with considerable skepticism. *[See October 1989 issue, p. 38.]* The ideas on air doctrine, as reported by Mr. Canan, are not new and are already officially articulated in Air Force Manual 1-1 (1984 edition). The idea that strategic and tactical are indivisible is the manifestation of "flexibility" inherent in air forces, as exemplified by the fact that B-1Bs can be employed in tactical, nonnuclear missions. Also not new is the flawed notion that no distinction exists between "the combat locations of air and space." As the preface to our official air doctrine points out, the terms "'aerospace' and 'air' are used interchangeably." This is reiterated in Mr. Canan's article as though it were something to be developed anew by Maj. Gen. Charles G. "Chuck" Boyd, who is now updating Air Force doctrine at the Air Staff.

It is important for the Air Force to scrutinize its doctrine in light of such new developments as the B-2, the changing threat, and an evolving geopolitical scene. As most of Mr. Canan's article points out, this is the thrust of General Boyd's work. However, in his quest to address space, General Boyd is obviously drawing future space missions from well-proven airpower doctrine on what works best for air, *e.g.*, "close air support, interdiction, offensive counterair, defensive counterair, or whatever." Most of this fantasy is relegated to dependence on technology in the National Aerospace Plane (NASP), which is at least a decade away. NASP is not a credible means for conducting future space missions, but is merely another potential vehicle for access to space. We learned these lessons the hard way with the shuttle, and it should at long last be reflected in our doctrine.

The Air Force is about to repeat a fundamental flaw in its doctrine that somehow airplanes and satellites are alike and that they perform the same missions. Nothing could be further from the truth, and a well-founded spacepower doctrine would reveal that space is distinct from air, that a host of formidable military capabilities is available to *all* terrestrial forces from space, that the missions are different, and that force structure and employment concepts are unique. If our doctrinal architects had the experience of military space operations, they could realistically expand their thinking to the realm of space, and it would become clear to them just why some military missions can be conducted (in General Boyd's words) "more efficiently, more effectively, and at less cost from space. . . . "

It would be a grave error at this juncture to again bury space doctrine within well-proven air doctrine and to hide the truth and experience already gained in a quarter century of real military space operations. If it is so unimportant to General Boyd "whether the flying machines . . . are flown in air or space or both," why not extend his thinking to include missions and employment concepts for tanks and ships within our new Air Force doctrine? Moreover, if it is true that "Most, if not all, of the missions that we perform in the atmosphere today we will be able to perform from space," then why can we not conduct most, if not all, of the missions that we perform in space today in the atmosphere?

Until our Air Force leadership recognizes that space does offer unique military capabilities, it will continue to delay and hamper proper employment of space and thereby risk losing future conflicts to the types of threats envisioned in Mr. Canan's article. It would appear that General Boyd and his Air Staff counterparts are about to confuse a sound, well-proven airpower doctrine with a poor understanding of a unique spacepower doctrine that could actually have a devastating "effect on the enemy in pursuit of US military and political objectives."

Col. Kenneth A. Myers,
USAF
Peterson AFB, Colo.

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 are sorry 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

Thank you for your outstanding article on the potential uses of US-based bombers. It was a very informative overview of the present and future taskings of the conventional manned bomber. But please tell me that you were joking when you suggested (on p. 44) that the B-2 be employed to drop bags of flour on potential targets.

There are good arguments both for and against the Air Force's idea of using a vital resource like the Stealth bomber in conventional attacks against Warsaw Pact or terrorist targets, but at least they are all based on doing real damage to the targets. To risk two or three lives and an aircraft worth several hundred million dollars to drop a sack of flour on someone's weapons plant would be a crime, since the plane is difficult, not impossible, to shoot down. If a crew were found who would willingly fly such a mission, and they survived, they would have endangered other crews' lives by telling the enemy one of our most closely guarded secrets—which target(s) we are planning to bomb.

In a Warsaw Pact scenario, we would have just wasted a valuable sortie that could have easily destroyed a vital target. If the section subheaded "Shows of Strength" refers to a political statement against a terrorist country, such a warning shot would backfire completely. Rather than scare the terrorists, it would strengthen their belief that the United States lacks the resolve to use deadly force in its own defense. The most effective political statement can be made with iron, not flour.

1st Lt. Douglas Fries, USAF
Loring AFB, Me.

Educational Priorities

I share your opinion that many of our youth are unprepared to progress into the work force *[see "Unskilled and Unprepared," by John T. Correll, October 1989 issue, p. 6]*. On the other hand, I feel that the source of this great problem does not lie in the educational system. It goes much deeper. When confronted with this editorial, most of my students replied, "So what?"

Schools have some of the hardest-working individuals teamed together, but no amount of instruction (be it hands-on, with industry, discussion, or repetition) can overcome the lack of motivation and apathy that have been impressed on these kids from birth. Students are so overcome by TV, music, designer clothes, drugs, sex, social life, booze, and rebellion that the last thing on their list of priorities is their own education. I am not quick to point a finger, but, in my opinion, the decay of the home is a prime candidate. Today's schools are as progressive in taking on the challenge of these issues as they have ever been. It is difficult to employ the concern of individual parents when more than half of them are divorced and many work or don't seem to "find the time" to get involved. Kids are not stupid, and they share the lack of concern. A possible future editorial might be beneficial if directed also to parents. I am glad you spoke out about this issue.

Bob Severs
La Porte, Ind.

Cold War Meteorology

It's no wonder Americans are giving away their overcoats on the first "Sunny Day in January." *[See editorial by John T. Correll, November 1989 issue, p. 8.]* It seems more like May. The "winter" has been long and harsh. I figure that more than half of the population hasn't seen the fall, much less the spring or summer. I recall the Cold War "blizzard" of 1962, when I lived in a Portland, Ore., cellar

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for several days because, my parents told their impressionable seven-year-old, missiles in faraway Cuba might somehow kill us all. The "temperature" fell below freezing for a decade or more as a senseless, undeclared war claimed many thousands of good men and women, such as "Mac the FAC" (on what would have been his last mission) *[see "Valor," November 1989 issue, p. 116]*, who today could be making the world a better place to live. Even as temperatures thawed into the 1970s, we endured "tropical storms" in the form of embassy seizures, suicide bombings, threats, and counterthreats to remind us of an uncontrollable climate. We still have occasional flurries but, for the first time in my life, the forecast calls for clear skies; and even if it's only temporary, which I doubt, just believing that tomorrow will be sunny and clear is quite enough, considering the hellish, long winter the last four decades represent.

Maj. James R. Dart, USAF
Riyadh, Saudi Arabia

Mistaken Identity

I appreciated having my picture in your November issue, which showed me talking with Generals Russ and Hatch at the AFA National Convention *[see "Information by the Acre," p. 31]*. Unfortunately, your picture was miscaptioned. I work for Unisys (not GE, as the caption stated), and the generals and I were discussing the increased combat capability of the new ABCCC III capsule, not aircraft engines. The Unisys exhibit also included displays on the North Warning System short-range radars, the Fiber Distributed Data Interface used in SACINTNET, the Royal Thai Air Defense System, and a model of the AN/TPS-73 Air Traffic Control Radar.

William H. Benner
Unisys Defense Systems
Williamsburg, Va.

Military Bird Dogs

I enjoyed reading John L. Frisbee's article, "One-Man Show at Bong Son," in the November 1989 issue. Unfortunately, he is mistaken when he states that the O-1 Bird Dog was "designed for private pilots back home, not for war." The O-1, like its "older brother" the L-19, was specifically designed by Cessna for the military. In August 1949, the Army, in cooperation with the Air Force, issued a joint specification for an all-metal observation aircraft. The roles envisioned for this aircraft included observation, reconnaissance, rescue, resupply, artillery fire control, forward air control for fighter-bombers, and pilot training. On May 29, 1950, Cessna was notified that it had been awarded a contract for production of its Model 305 (L-19A) after competing with Piper, Temco, and Taylorcraft.

The Bird Dog first saw action during the Korean War, where it was used in multiple roles. Cessna's L-19 would go on to be built in five different models and serve with all branches of the service.

Anyone wishing more information about this "True Warbird" should contact The International Bird Dog Association (IBDA), 3939 C-8 San Pedro NE, Albuquerque, NM 87110.

Bernard J. Cortese, M.D.
Haddon Heights, N. J.

Guns and Medals

The "Valor" article in the November 1989 issue contains a noticeable error. You state that Major McAllister fired an "M1" from his aircraft while flying a nighttime FAC mission in Vietnam. It's hard to believe that the major was using an M1 rifle or carbine of World War II/Korean War fame during his 1965 mission. More likely, he was firing an M16. This weapon, in fact, was mentioned in your fine article on "Mac the FAC's" historic mission that appears in AFA's Valor anthology (1985, Volume 2, No. 1, p. 115).

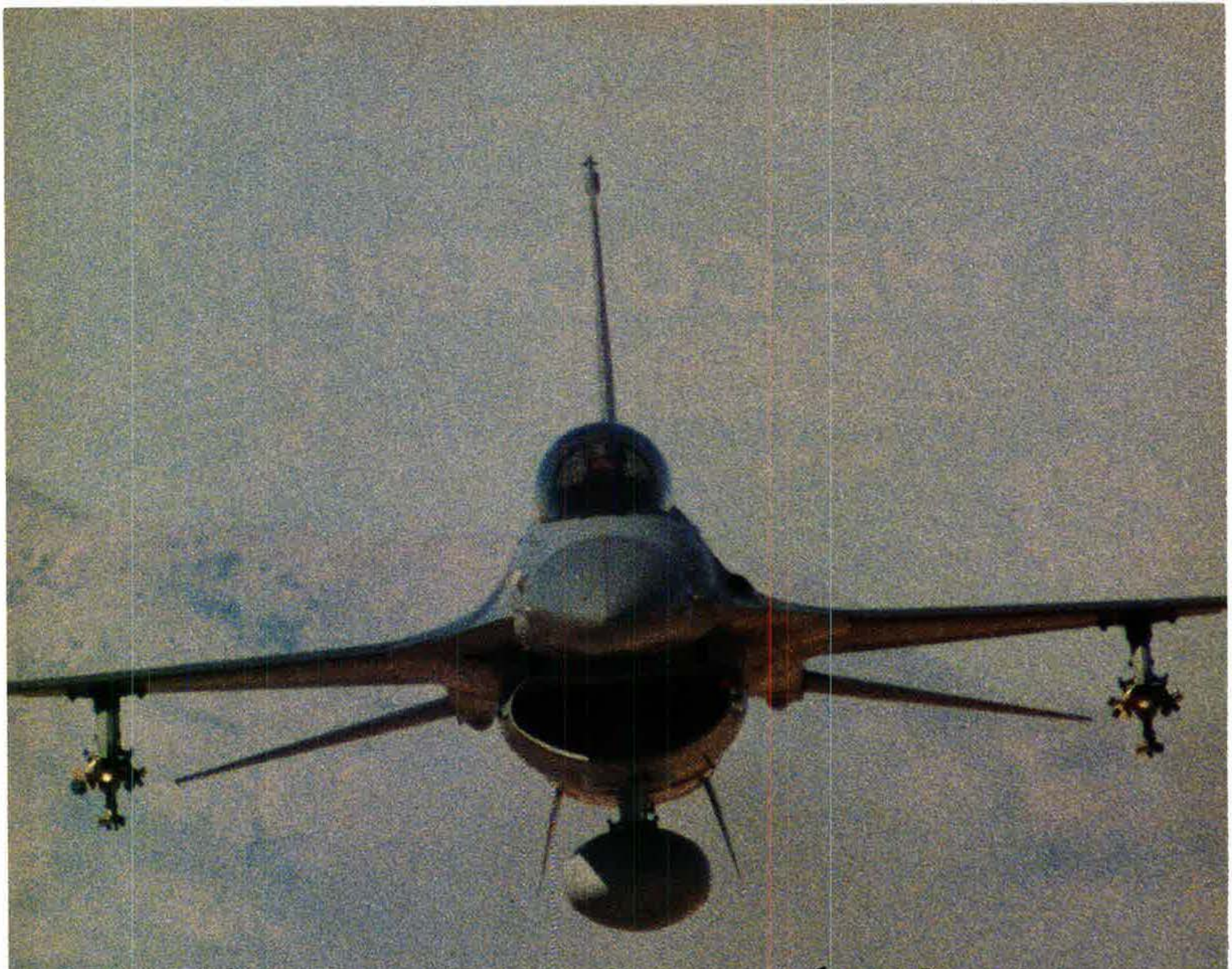
An error also appears in another recent "Valor" article. The narrative in the August issue says that TSgt. Maurice Henry won the Distinguished Service Medal for his heroic World War II B-17 mission. Not true. Sergeant Henry received the Distinguished Service Cross. There's a world of difference in the award criteria of these two decorations. It's the *DSC* that is "second only to the Medal of Honor." The DSM does not require personal bravery in combat, but is awarded for any accomplishment in a duty of great responsibility. General officers are the most common recipients.

MSgt. James B. Walker, Jr., USAF (Ret.)
Dayton, Ohio

Wrong Armament

The November 1989 "Airmail" comments by Gerald D. Coke *[see p. 11]* regarding World War II B-29 armament are wrong in one respect—specifically regarding the upper forward two-gun turret. He states that the upper forward two-gun turret B-29s never saw combat over Japan—not true.

Apparently he never knew of 58th



F-16s Dominate Gunsmoke. Again.

The best fighter in the world proved it again at the U.S. Air Force's recent worldwide bombing competition.

Of the 16 teams that competed, six flew the F-16. Those F-16 teams won the top five places in the Top Team Competition, the top six places in the Top Gun Competition, first place in all five individual bombing events, and first in all ground crew competitions.

General Dynamics congratulates all F-16 pilots and ground crews on their outstanding performance.

F-16 OVERALL TEAM RESULTS AT GUNSMOKE '89	
1st Place:	169 TFG McEntire ANGB (ANG)
2nd Place:	944 TFG Luke AFB (AFRES)
3rd Place:	432 TFW Misawa AB (PACAF)
4th Place:	388 TFW Hill AFB (TAC)
5th Place:	347 TFW Moody AFB (TAC)
7th Place:	86 TFW Ramstein AB (USAFE)

TOP TEAM AND TOP GUN RESULTS
Top Gun: Capt. Pat Shay, 944 TFG Luke AFB
Top Crew Chief: SSGT. Joedy Pack, 944 TFG Luke AFB
Top Maintenance & Loading Teams: 944 TFG Luke AFB
Top Aircraft Maintenance Teams: 944 TFG Luke AFB
Top Aircraft Combat Servicing Team: 944 TFG Luke AFB

GENERAL DYNAMICS

A Strong Company For A Strong Country

Bomb Wing based in the CBI, the first B-29 combat wing. I was in the 58th when it arrived in April 1944, and we flew many missions with the two-gun upper forward, including eight missions over Japan.

The four-gun upper forward B-29s in the CBI began to trickle in about August 1944. We still had old two-gun upper forward turret B-29s in my squadron as late as January 1945.

As I recall, the 73d Bomb Wing didn't fly its first mission until November 1944, and by then they probably had all four-gun UFTs. By that time, the 58th Bomb Wing had flown fifteen missions, most of them with a two-gun UFT.

By April 1945, the 58th Bomb Wing arrived on Tinian, joining the XXI Bomber Command, departing the XX Bomber Command.

Col. Neil W. Wemple,
USAF (Ret.)
Tucson, Ariz.

RAF Flareships

The letter in the November 1989 issue referring to flareships in Korea was interesting *[see "Airmail," p. 15]*. I wonder if you and the good Col. William H. Ramsey are aware that the RAF used flareships in World War II. They were called "Pathfinders." I know—I was in the RAF.

Eric E. Harris
Victor, Colo.

Overlooked CAP

Paying tribute to veterans is something that just cannot be done often enough. However, there is one group of veterans that is often overlooked. These are the volunteer men and women of the Civil Air Patrol.

Civil Air Patrol was founded on December 1, 1941, with a view toward providing volunteer civilian assistance in the defense efforts of America. The founders were strongly aware of America's shortcomings in airpower compared with its potential enemies in the early stages of the war in Europe.

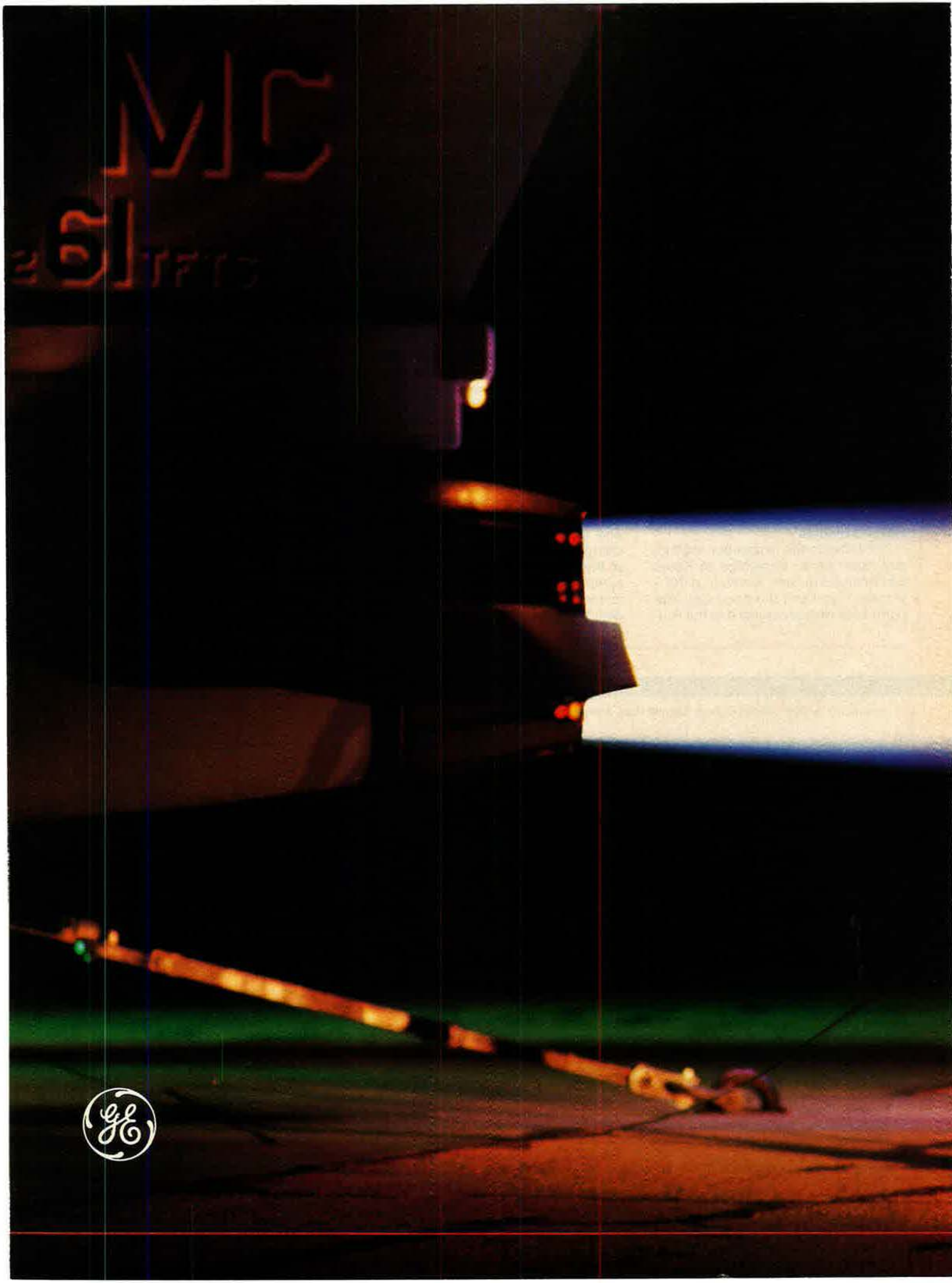
During World War II, CAP achieved a high point, flying light airplanes on coastal patrol and spotting 173 enemy submarines along the Atlantic and Gulf coasts. Bombs or depth charges were dropped on fifty-seven of them, and CAP received credit for sinking at least two. CAP also performed a great variety of other civilian defense tasks during the war in order to relieve military units that were needed in a more direct combat role. Sixty-four CAP members died serving in wartime operations.

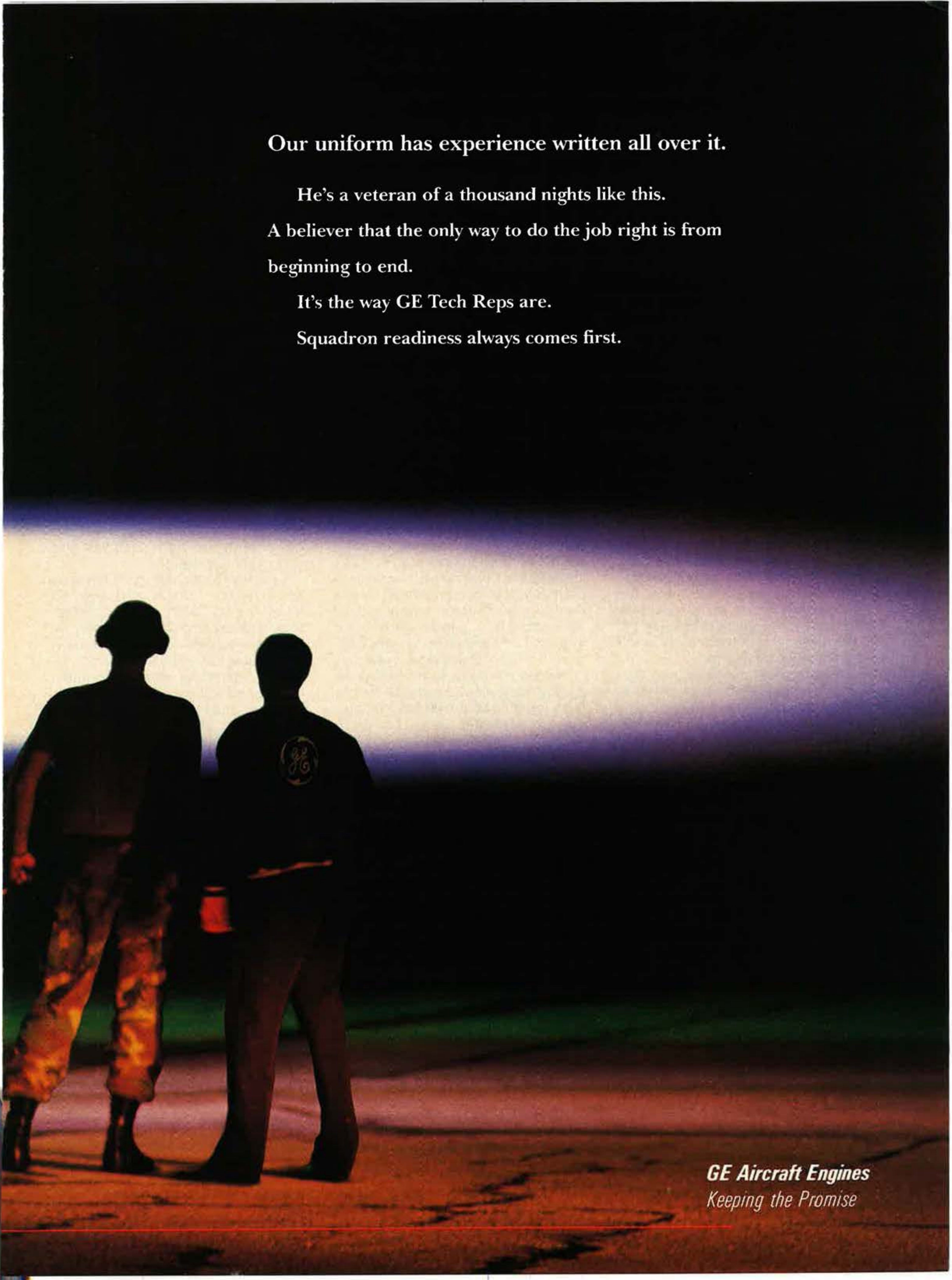
Since World War II, CAP has devoted its efforts to search and rescue, performing numerous humanitarian missions during local or national emergencies. CAP is always there to lend a hand, whether it be filling sandbags to prevent a flood, directing traffic away from a disaster site, searching the woods from the ground or the air for a lost hiker or pilot, or flying a donor organ to a transplant.

With its Aerospace Education program, CAP seeks to promote America's continued advancement in aviation and related sciences. This advancement is accomplished through a cadet program designed to develop in teenage girls and boys the knowledge and skills necessary to become leaders in aviation and space technology.

CAP invites the rest of the US to join us in recognizing the veterans and the current 73,000 civilian volunteers of the Civil Air Patrol.

1st Lt. David J. Albanese,
CAP
Buffalo, N. Y.




Our uniform has experience written all over it.
He's a veteran of a thousand nights like this.
A believer that the only way to do the job right is from beginning to end.
It's the way GE Tech Reps are.
Squadron readiness always comes first.
GE Aircraft Engines
Keeping the Promise

By John T. Correll, Editor in Chief

Partners in Technology

Does today's basic research program aim at the options the Air Force really needs for the future? The technologists want the operators to help plan an investment strategy.

Washington, D. C. Nobody knows for sure what kind of aircraft and weapons the Air Force will field in the twenty-first century. That depends on budgets, politics, and other cosmic uncertainties. We do know that the options open twenty years from today will be defined—and limited—by the basic research and exploratory development work begun now.

Over the past year, Air Force Systems Command has taken stock of the current Science & Technology program, which consists of more than 3,000 discrete investments. AFSC is now ready to tell the operational Air Force what choices and capabilities this program might be expected to yield. The big question is whether that menu matches the requirements foreseen by the operators, planners, and strategists.

For example, do strategic planners envision manned military operations in space? The S&T program invests in space-based capabilities to support operations in the atmosphere, but it is not developing technologies for a space-based military force structure. If the Air Force wishes to keep that option alive, it must change the S&T investment strategy.

The technologists are trying to ensure that their program is in tune with actual requirements. In addition, however, they are seeking to forge a new, more cooperative partnership with the operators.

In the past, the operational community has been inclined to leave technology to the technologists, regarding the S&T program as mysterious, speculative, and out of step with reality. The technologists are now attempting to change the relationship by making their work easier to understand and more responsive to the operational customer.

The first step was translating the array of S&T investments into a tangible set of operational implications. The next is to ask whether these technology options are the ones the Air Force really thinks it will need in the years ahead. From there, the technologists are inviting the operators to take a stronger role in shaping the S&T investment strategy.

What they want in return is for the operational commands to accept a degree of "ownership" of major S&T initiatives as they emerge from the exploratory development stage. By the time a project moves into advanced development, it should have backing—and perhaps some funding support—from an operational customer.

"We would like to have a higher degree of customer acceptance for our 6.3A [advanced development] programs," says Maj. Gen. Thomas R. Ferguson, DCS/Technology for Systems Command. "We can't just push our technology into the operational world. There's got to be a pull from the other end."

This does not mean that Systems Command is shedding its leadership role in science and technology or converting the program to a cash-and-carry basis. It will stay out front on leading-edge technologies, even if the operators have not yet identified exact applications or requirements.

For example, Systems Command remains the sponsor of the Integrated High-Performance Turbine Engine Technology (IHPTET) program, which promises to double the performance of present-day engines while reducing fuel consumption. There isn't much doubt that sooner or later the Air Force will need such an engine.

At the same time, AFSC will probably spend more of its effort on opportunities to insert new technologies into aircraft and systems already in the fleet, General Ferguson says. For instance, the "super cockpit" conceived in Project Forecast II for advanced fighter applications might show up as a modification for existing F-15s.

With defense budgets headed downward, the Air Force does not expect to begin work on many new systems in the next ten years. General Ferguson predicts that there will be relatively more emphasis in the S&T program on basic research and exploratory development and relatively less on advanced developments and system prototypes.

Under the circumstances, it is of particular importance for the long-lead S&T program to concentrate on developing the right technologies and capability options.

Systems Command has a tentative list of seven critical problems on which the S&T program might focus. Identified as critical were strategic relocatable targets, spacecraft survivability, assured and secure communications, electronic warfare, technologies for Special Operations Forces, software, and logistics support—with emphasis on cost.

Part of the exercise in talking to the operators is to determine the validity of this list. General Ferguson admits that while the list is "a good first cut," it is also intended to act as a lightning rod. If the operators object because an important problem has been left off, that gives the technologists exactly the kind of feedback they're after.

The current S&T program is paced by the concept of a follow-on multirole fighter—which could be either an all-new platform or a derivative of an existing one—and, to a lesser extent, by plans for an advanced tactical transport that might replace the C-130.

About 200 separate technology investments converge in the vision of a fighter that, like today's F-16, could swing back and forth between air-superiority and ground-attack assignments.

The swing-role aircraft could come with "balanced observables" (meaning at least some Stealthy features), agile movements, and vastly improved avionics. Capabilities would probably include short takeoff and landing (STOL) and, perhaps, vertical landing (STOVL). Since propulsion is the enabling technology for STOVL, the engine for this fighter is the focus of the high-performance turbine program. As with any system the Air Force develops from here on, cost, reliability, and maintainability will be big factors.

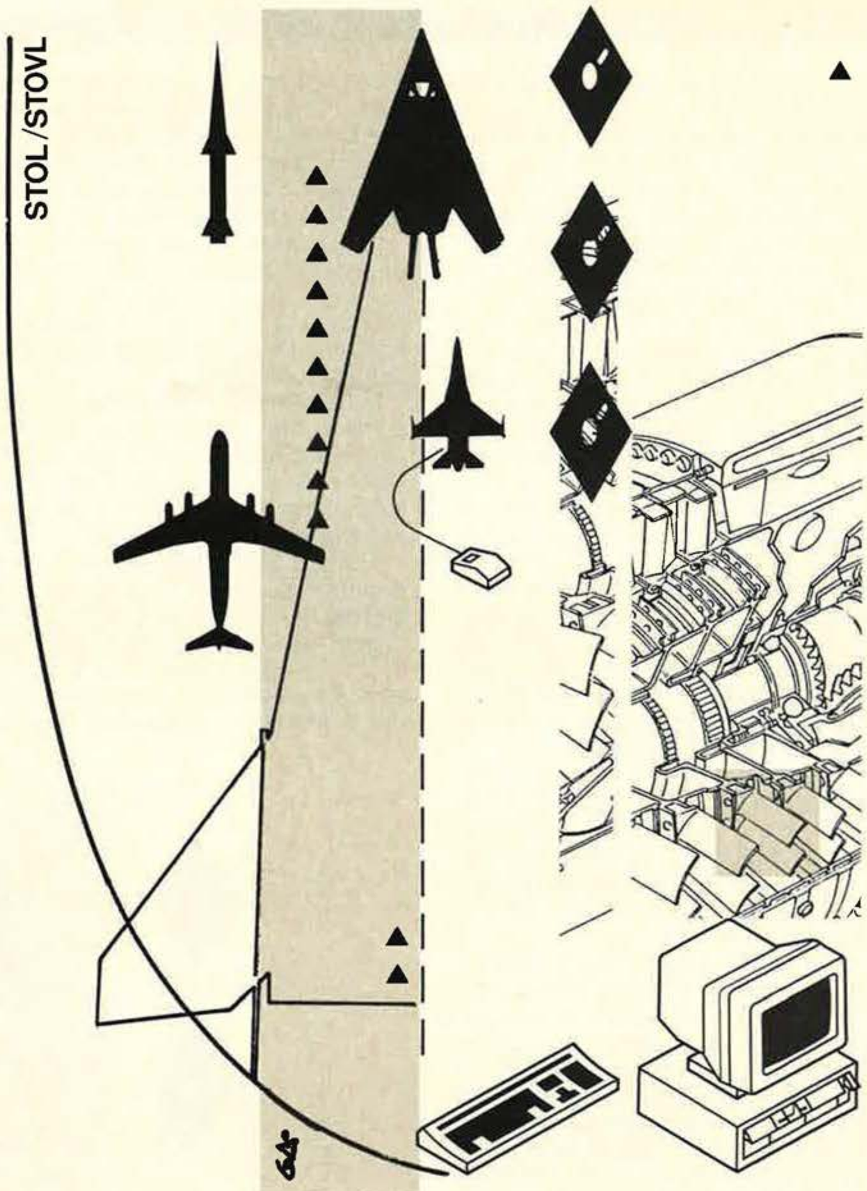
Both Military Airlift Command and the Special Operations Forces are in line for aircraft to replace their C-130s, and it is not yet clear whether this will require two different airplanes or a special operations variant of the advanced tactical transport. In either case, the S&T effort will be tailored to high reliability under punishing circumstances; operations from small, austere airstrips; and some Stealth for survivability. Special Operations Forces will probably need a particular package of features, including "covert intraflight data links."

The technologists are working on a concept called the "More Electric Airplane," in which flight controls, landing gear, fuel pumps, ignition, and other functions would rely on electricity to a greater degree than they do today. This would improve both performance and reliability while minimizing the weight of the aircraft. "Our vision is to ultimately generate electrical power within the main engines and distribute this power throughout the aircraft," Systems Command says.

Ever since the Soviet Union began deploying mobile ICBMs, the problem of "strategic relocatable targets" has been high on the Pentagon's worry list. These missiles pose a particular threat because the US has no credible counterforce weapons to oppose them. They can elude our best ICBMs today simply by moving around, and our present technology isn't good enough to chase them down with bombers and cruise missiles.

The S&T program is working on two possible solutions. "We are making a major investment in conjunction with Strategic Air Command to locate, track, identify, and strike these targets with the bomber force," says Alan Goldstayn, director of technology plans and programs at Systems Command.

The second possibility is the Advanced Strategic Missile System program, leading toward an ICBM-based maneuvering reentry vehicle that could search, find the target, and strike it promptly. "Current reentry vehicles do not have the maneuvering capability to go looking for a target," Mr. Goldstayn says. "You'd need an advanced maneuvering vehicle that would have enough aerodynamic capability to search a pattern and still come back and strike."



The S&T program also addresses the long-standing problem of distinguishing friends from foes in a tactical battle. *[See "Which Ones Are the Bad Guys?" by Maj. Gen. William A. Gorton, June 1989 issue.]* This initiative would allow US fighters, using equipment in their own cockpits, to locate and track enemy aircraft. Given that ability, they could engage from beyond visual range with greater confidence, assured that they were not shooting at friendly aircraft by mistake.

"The answer will probably come through multimode, multispectral sensor fusion," Mr. Goldstayn says. "By looking at various parts of the spectrum both passively and actively—passively if you can get enough information, otherwise, actively maybe to refine it—you should be able to make identification."

Cockpit-level capability can be augmented, if need be, by data from an Airborne Warning and Control System (AWACS) aircraft and other intelligence. It would help, of course, if surveillance could pick up enemy airplanes as they took off from their home airfields, but Mr. Goldstayn says that "conclusive ID does not necessarily require tracking from origin."

Owing in part to Air Force work on the SDI "Star Wars" program, Systems Command is well along on technology options in ground-based surveillance "up to and including the most stressing level of target low observables." When the Soviet Union begins flying Stealth airplanes—and, in the opinion of most experts, that's only a matter of time—the US should have some defenses ready. As with the tactical identification problem, these techniques will probably depend on a combination of multimode, multispectral techniques.

There is no specifically focused S&T investment, however, in enhanced airborne surveillance and detection. This is one of the gaps that may raise some eyebrows as the technologists talk to the operators about where the program is heading.

Another question for the operators is whether they would just as soon see the Air Force stop developing new guns and ammunition and simply buy what it needs, relying on the Army, the Navy, or initiatives from industry. The technologists say they're not getting much demand for such work now from the using commands.

It may be, however, that the force is going through a transition in this area. "We've had for too long a single-customer [referring to Tactical Air Command] view, relative to gun work," General Ferguson says. "The emerging customer, the one that's going to have a great deal more interest in this technology, may be the Special Operations Force."

The S&T program does make a significant investment in guided armament, and it has a full kit of technology—components, subsystems, mature seekers, and tested warheads—ready if the operators call for advanced armament.

The big sticking point on weapons is cost. "If you're going after an aircraft carrier that costs a billion dollars, and you can take it out, you've taken the punch out of a $3 billion carrier battle group," Mr. Goldstayn observes. "You can spend a fortune to get that guy. But if you're going after an armored column where the tanks are maybe a million dollars apiece, you're risking a $40 million airplane. You rapidly get down to how much you can afford to spend to kill a tank."

The upcoming round of discussions will include plenty of talk about how to field effective weapons at affordable cost.

Looking further ahead, the S&T program is heavily invested in directed-energy weapons small enough to carry aboard an airplane. As early as 1994, Systems Command might demonstrate high-power microwave devices, capable of jamming or destroying enemy electronics. It also has a "very serious commitment" to compact, lightweight, and highly efficient lasers at various power levels.

The "Visions and Opportunities" portion of the S&T plan describes still other possibilities, ranging from materials engineering to the protection of aircrews in hypersonic regimes of flight. Here is a sampling.

• **Revolution in materials.** The day is coming when materials can be designed to specification, with properties tailored to the function or functions desired. Communication links or sensor materials may be incorporated into structural materials.

Composites and alloys of the future will be much lighter and stronger. Today's structures weigh twenty-five percent less than their predecessors. Additional weight reduction of fifty percent is feasible.

Lubricants and seals for the increased high-performance turbine engine will hold up at temperatures of 700 degrees Fahrenheit. Eventually, solid lubricants for turbine engines will withstand 1,800 degrees.

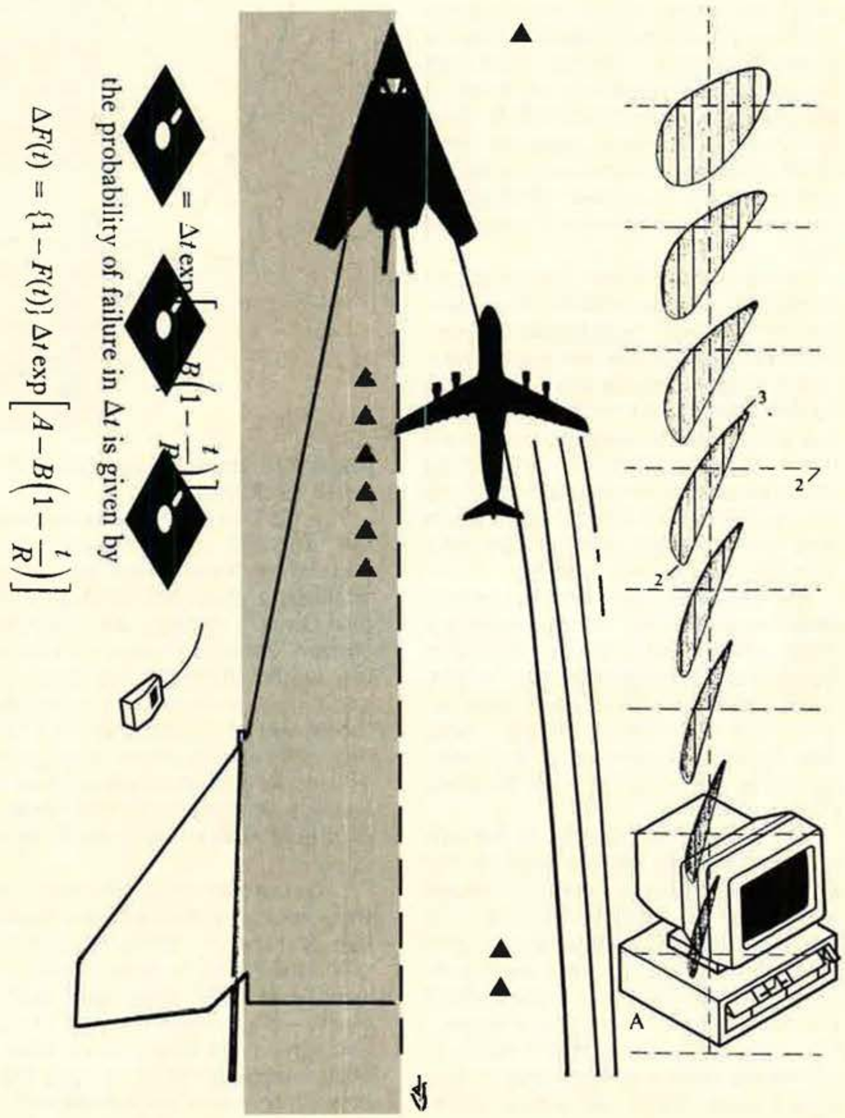
• **Smart BIT.** Artificial intelligence promises a cure for the maintenance headache known as "CND/RTOK" (Could Not Duplicate/Retest OK). This is the familiar situation in which a sensor indicates a problem with a system component, but the maintenance people can't find anything wrong when they check it.

Currently, about eighty-five percent of the failure alerts turn out to be false alarms. Thirty percent of the confirmed failures cannot be duplicated in maintenance.

"Smart" BIT (built-in test) technology may be able to reduce these percentages significantly, leading to savings in cost and time as well as to gains in system readiness.

• **Bare-base operations.** Aircraft of the future will be able to operate with a 2,000-hour net mean time between failures. That may not stir the imagination as some of the flashier "Visions and Opportunities" do, but it could make a great deal more difference in how the Air Force of tomorrow is structured.

With a much-diminished need for logistics and support, small units (squadron-sized or smaller) would be able to carry out missions in forward



locations. New techniques will reduce the time and effort required to prepare an airstrip and keep it open. "Emerging technologies in both materials and equipment controls are rapidly overtaking the barriers that once stood in the way of developing the truly mobile Air Force," Systems Command says.

• **Avionics for almost everything.** Electronics for aircraft are expected to get better and more versatile in the years ahead. The time is coming, Systems Command says, when no mission will be aborted because of electronic failure. When components go bad, the fault-tolerant architecture in the avionics suite will divert their function to a backup capability.

It will be possible to reconfigure avionics suites quickly and on the spot. This will eliminate, for example, the wait for a specialist somewhere else to reprogram threat-warning receivers and self-protection devices as the electronic combat situation changes rapidly in an operational theater.

The avionics suite of the future will be able to perform many of the routine tasks that occupy the pilot's hands, eyes, and attention today. "Thus," Systems Command says, "the pilot can be elevated from a system operator to a mission director with singular responsibility to orchestrate operations in a system."

• **Computing with light.** Photonics is a tricky technology, but it can perform rings around electronics in certain applications. Systems Command is projecting digital optical computers with processing power 100 or even 1,000 times greater than existing semiconductor electronic computers.

• **Hypersonic flight.** The S&T program is exploring how far beyond Mach 5 sustained flight is possible with conventional propulsion. After some threshold, cryogenic fuels will be required, and that introduces a whole new set of problems.

Beginning in 1991, research on aircrew protection will be refocused to concentrate on the rigors of severe acceleration and hypervelocity flight.

Not all of the concerns in the S&T program are technological. The loss of scientists and engineers from the Systems Command work force is serious and getting worse.

"It is already difficult for us to recruit in certain areas and in certain disciplines," General Ferguson says. "A very large concentration of our people with doctorates and advanced degrees is in the aging part of the work force. We need to bring in a new group to replace these senior scientists and lead researchers."

In an initiative called "Palace Knight," Systems Command hopes to grow some of its own Ph.Ds. It would offer a very attractive work-study package to undergraduates with top credentials in critical disciplines.

These young people—perhaps 100 of them a year—would obtain their master's degrees at Air Force expense, then work in AFSC's labs for two or three years, after which they would return to school for sponsored doctorates. Upon receiving their Ph.Ds., they would have an eight-year commitment to the Air Force.

At its present spending pace, the Air Force will be modernizing its laboratories on a cycle that approaches 200 years. Developing the right technology options for the future calls for top-quality researchers working in state-of-the-art facilities, and the Air Force is dangerously near a shortfall on both counts. ■

By Brian Green, Congressional Editor

The Thanksgiving Eve Budget

Congress invents a new wrinkle: the 130-day sequester. The damage is less than full Gramm-Rudman, but the reductions hurt, especially in personnel.

Washington, D. C.

Appropriations Provisions

The FY 1990 appropriations bill adopted funding levels for major strategic programs contained in the defense authorization bill. These include a general cut of $150 million to the rail-garrison Peacekeeper and Midgetman ICBM programs, $4.3 billion (of $4.7 billion requested) for the B-2 Stealth bomber, and $3.8 billion (of $4.9 billion) for SDI. The bill also earmarked $50 million in unobligated FY 1989 R&D funds "to resume and continue integration and testing of B-1B cruise missile carriage capability." Air Force Chief of Staff Gen. Larry Welch had earlier testified that the Air Force has no plans for the foreseeable future to convert the B-1B to a cruise missile carrier.

The bill provides $911 million for development of the Advanced Tactical Fighter, a cut of $200 million. According to the Air Force, this level of funding could require renegotiation of existing ATF contracts. The House version of the bill had deleted all funding for the ATF, but the conferees were "encouraged" by DoD and Air Force management initiatives. The bill provides $1.2 billion for thirty-six F-15Es, a cut of $103 million, but "in no way prejudges action on possible F-15E termination." Secretary of Defense Richard Cheney proposed terminating the F-15E after FY 1991 procurement. The FY 1990 authorization bill concurred with the termination, but the authorization conference report accompanying that bill states that the "conferees will reconsider the F-15E termination decision next year . . . and are prepared to amend this provision if studies and reports indicate that the risk caused by termination is too great."

The Navy F-14D fighter received additional funds for eighteen new aircraft and modification of six others. Beyond that, no new aircraft will be funded. The V-22 tilt-rotor aircraft received $255 million in research and development funding, but no money for procurement. Both programs had been proposed for termination by Secretary Cheney.

The Milstar communications satellite program also survived a House move to terminate it. The bill, however, provides "definitive and nonnegotiable program direction," requires program restructuring, and cuts $226 million from the Milstar budget.

Action on other key programs in the final FY 1990 appropriations bill included:

- An additional $50 million cut from the C-17 airlifter program "based on additional program perturbations and schedule slippages."
- Approval of full requests for the Tacit Rainbow long-loiter antiradar missile and the new short-range attack missile (SRAM II) for carriage on strategic bombers. House appropriators had sought to kill funding for these programs as well.

Budget Slogs Through

The Air Force is faced with the difficult task of absorbing additional cuts in the wake of Congress's Thanksgiving Eve approval of a budget reconciliation bill that will reduce Fiscal Year 1990 defense outlays by about $2 billion. The reconciliation measure imposes a full year sequester, equivalent to 130 days of the Gramm-Rudman-Hollings sequestration in effect at the time of passage. A sequester at the higher level would have cost DoD $5.6 billion in outlays and $7.6 billion in budget authority, the Senate Budget Committee estimated.

Congress also approved an FY 1990 defense appropriations bill consistent with a total defense budget of about $303 billion in budget authority, a small reduction from the $305.5 billion level agreed to last spring by White House and congressional negotiators. About $2 billion was skimmed to provide additional money for an antidrug bill and to fund aid to Poland. Sequestration further reduces this figure. At $303 billion and after adjusting for the effects of inflation, the FY 1990 budget is about two percent smaller than last year's budget.

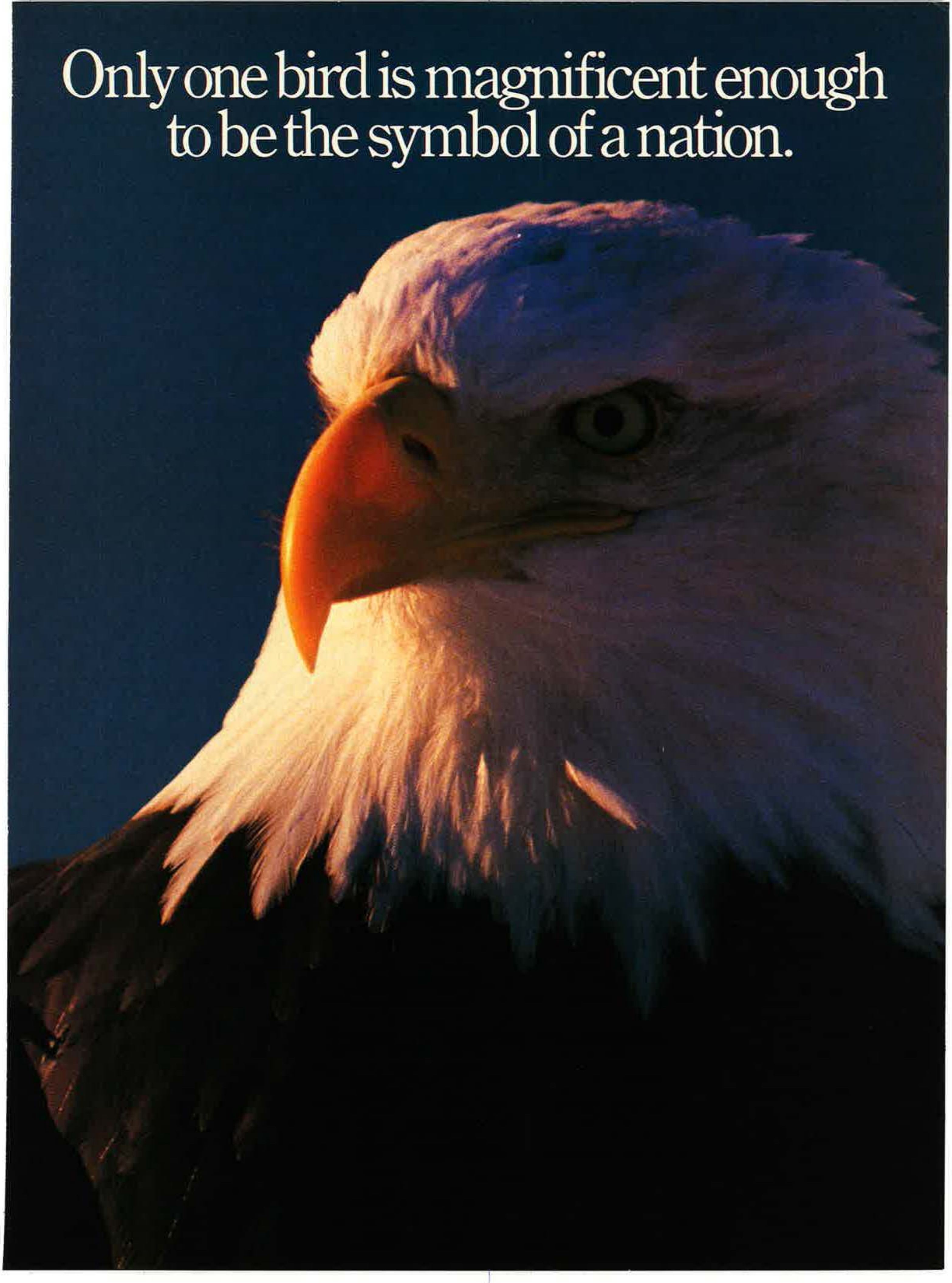
Programs, projects, and activities in those accounts affected by the sequester will be hit with across-the-board reductions of up to 1.5 percent from the FY 1990 appropriations level. Initial studies indicate that the Air Force will be hit hardest in the personnel area, losing about $178 million and up to 34,000 people. According to Vice Chief of Staff Gen. Monroe Hatch, the Air Force would have lost about 80,000 active-duty personnel, 12,000 in the Guard and Reserve, and 26,000 civilian employees in the full Gramm-Rudman sequester threatened earlier.

The impact of the sequester will be greatest on "contract-bound" programs that may have difficulty absorbing cuts. DoD can reprogram up to $3 billion to mitigate the effects of sequestration, but each separate reprogramming action must be approved by Congress. A DoD request to Congress for authority to reprogram another $3 billion has already died.

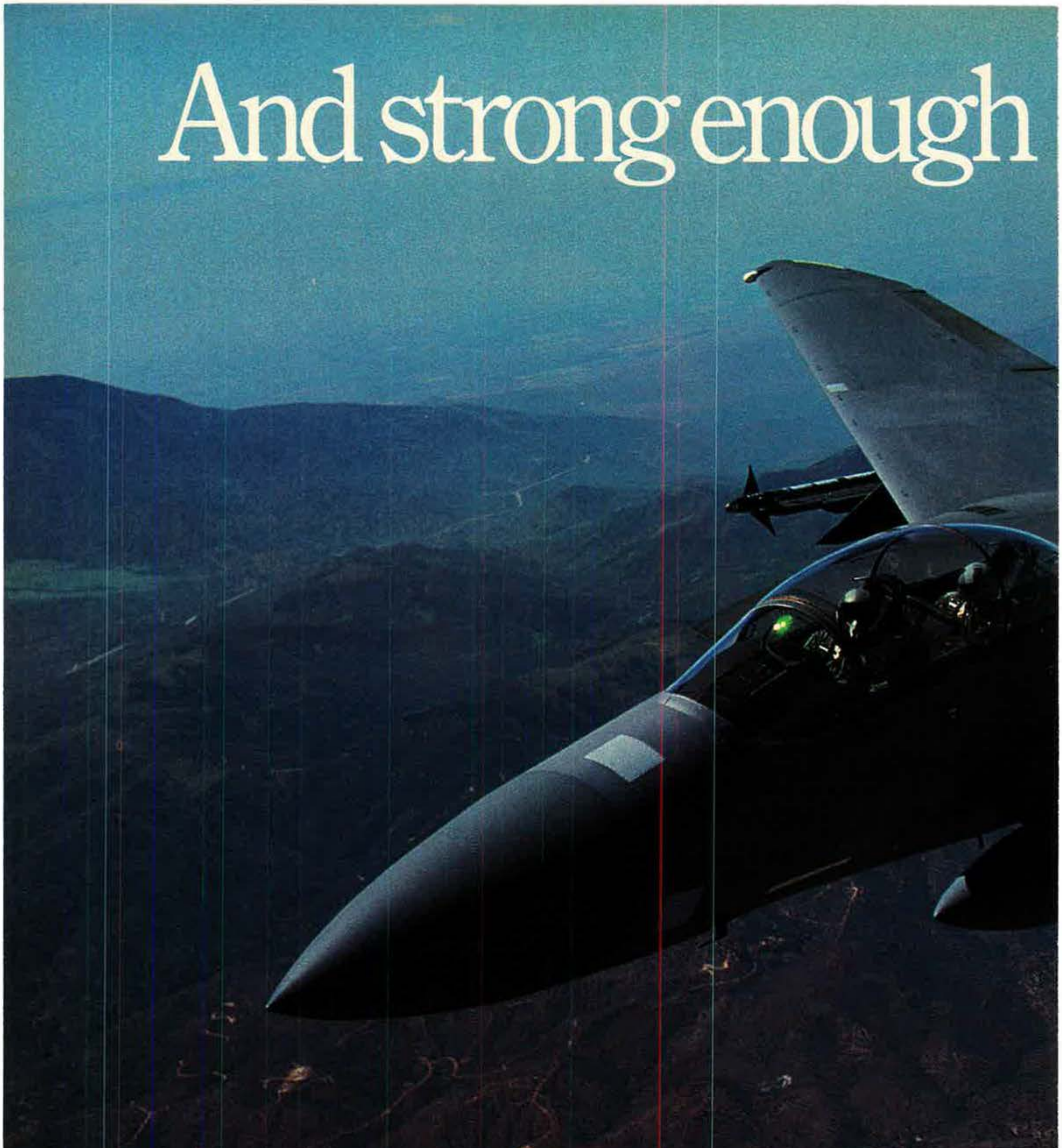
Big Cuts Pending

"The next defense budget will be Gorbachev-driven," according to House Armed Services Committee Chairman Rep. Les Aspin (D-Wis.). He maintains that intelligence estimates provide evidence that the Soviet military buildup is slowing. This, he believes, in combination with dramatic political changes in Eastern Europe and the Soviet Union, will shape the defense debate in the future.

In November, Secretary Cheney ordered the services to devise plans that could generate $180 billion in defense budget authority cuts from FY 1992 through FY 1994, in response to changing threat perceptions as well as fiscal constraints. The DoD budget (excluding Department of Energy defense programs), originally projected at close to $350 billion in FY 1994, could fall to around $272 billion. ■


Only one bird is magnificent enough
to be the symbol of a nation.

And strong enough



America's Eagle, the F-15E. So powerful it can climb like a rocket to knock enemy aircraft —or even a satellite—out of the sky. So agile it maneuvers the way only an Eagle can. So advanced it is the perfect partner for 21st century fighters.

Built for the U.S. Air Force by McDonnell Douglas, the F-15E is right for a time when more must be done with fewer resources. When we must expect greater capability from a smaller arsenal. And America's Eagle comes through. It stands alone, ready to deliver the


to be its guardian.

Aerospace World

By **Jeffrey P. Rhodes,** Aeronautics Editor

Washington, D. C.

★ While aircraft are the order of the day at Air Force Systems Command's Aeronautical Systems Division (ASD) at Wright-Patterson AFB, Ohio, this year [*see "Year of the Airplane" on page 36 of this issue*], ASD is also developing an important unmanned component of the country's strategic modernization effort—the Boeing AGM-131A/B Short-Range Attack Missile (SRAM II).

"We have been out of the public eye," said Col. Stan Boyd, the SRAM II Program Manager. "But this is a great program. We have had some development problems; however, I think they are pretty much coming under control now. We are working hard to field a replacement for the AGM-69 [SRAM-A], which has lasted well past its intended lifetime."

The AGM-131's solid rocket-motor propellant has been cracking in cold temperatures. The Air Force, Boeing, and Hercules, which makes the missile's two-pulse motor, have spent considerable time and effort trying to correct this deficiency and are on the verge of a solution. "The key is getting a [solid rocket motor] design that satisfies the performance goals [SRAM II will be supersonic] and still meets the cold-temperature structural requirements," noted Colonel Boyd.

The filament-wound solid rocket case is made of composite materials and supports most of the rest of the missile. The composite case is covered with aluminum foil (which acts as a moisture barrier and a shield against electromagnetic interference) and accounts for slightly more than 200 pounds of the missile's 1,920-pound weight. The case has exceeded burst requirements by a wide margin and has survived a battery of tests equivalent to three lifetimes. The motor has a two-stage igniter.

The new W89 nuclear warhead, designed by the Department of Energy for the missile, grew from initial estimates over a year ago. This size and weight increase necessitated a corresponding increase in the missile diameter. The AGM-131A is now 15.6 inches around and fourteen feet long. The W89 is the first digitally controlled warhead. Digital control will make it much more reliable and safer.

Reliability is a prime requirement. "SRAM II will basically be a wooden round," noted Col. Boyd. "Once it's in the igloo [weapons storage area on an operational base], it can be left there until it's needed." The missile will have a fifteen-year service life, with virtually no scheduled maintenance. Maintainers at bases can pull the Line Replaceable Units, but they will not be fixing circuit cards. The LRUs will be sent to depot for repair instead.

The missile will have a number of built-in test functions, and its dual VHSIC computers will detect ninety-eight percent of testable mission-critical failures. All of the avionics boxes, which are sealed and nitrogen pressurized, will be located for easy access under raceway covers on the missile's back.

Boeing is working under a $320 million full-scale development contract issued in April 1987. The company is acting as a single prime contractor with subcontractors that include Litton (ring-laser gyroscope), Boeing Aerospace (central computer), Hamilton Standard (controllers), and Moog (actuators). During low-rate initial production, scheduled to begin in June 1991, second-source subcontractors will be qualified. These include Aerojet (solid rocket motor), Litton Canada (RLG), and Delco (computer). Moog and Hamilton Standard will switch roles on the controllers and actuators.

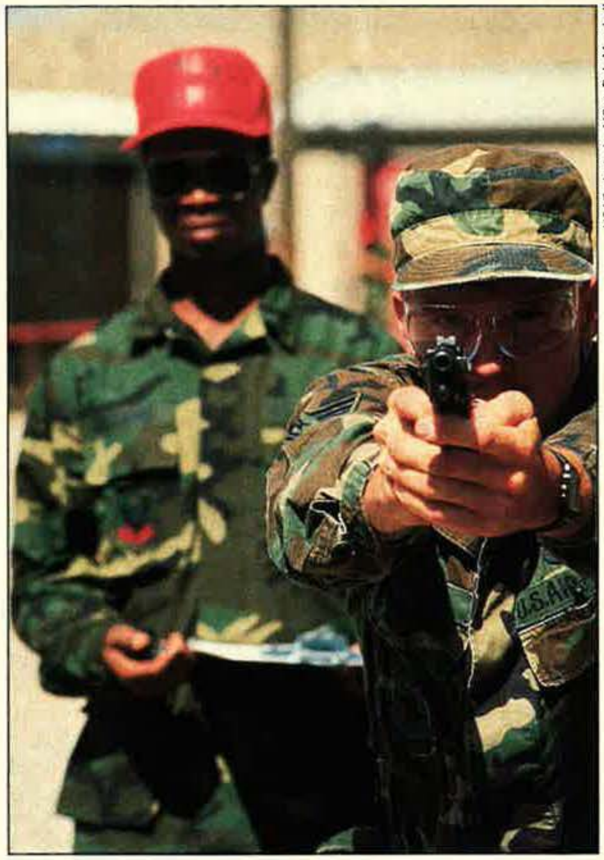
The B-1B test aircraft modified to carry SRAM II is flying now, and the missile will undergo nine months of tests before its first launch, including

The first two Bell-Boeing V-22 Osprey prototypes flew in formation for the first time on November 3, 1989, during scheduled test flights for initial handling qualities evaluation. The number one aircraft was piloted by Dorman Cannon and Dick Balzer; the second, by Ray Dunn and Roy Hopkins.

captive carry, vibration, and jettison. The first launch is scheduled for later this year. The Air Force plans to acquire 1,633 production SRAM IIs and thirty flight-test missiles for the B-1 and B-2 fleets. Initial operational capability is scheduled for 1993.

There are currently no plans to incorporate the AGM-131 on B-52s, because some significant avionics changes would have to be made on the bombers, but the missiles do fit on the Common Strategic Rotary Launcher. There are also no plans for a SRAM II with a conventional warhead.

Just entering development is a variant of the missile for the tactical air forces, the SRAM-T, or AGM-131B. SRAM-T will have a slightly different warhead, plus minor differences in computer memory cards and connectors, but will have ninety-five percent commonality with the A model. Windtunnel testing of the AGM-131B on an F-15E has already begun, and feasibility studies with the F-16, F-111, and Tornado are under way. If approval is given for full SRAM-T development, it is expected to be fielded in 1995.



—USAF photo by MSgt. Rob Marshall

Air Force Reserve competitor SSgt. Jeffrey Whitehead of Westover AFB, Mass., fires his M9 9-mm pistol from behind a barricade at a silhouette target during the first phase of the handgun competition at Peacekeeper Challenge, the Air Force's annual Security Police competition. The meet, now in its ninth year, serves primarily as a proficiency check for the SP profession. Peacekeeper Challenge is held at Kirtland AFB, N. M.

★ The "best of the best" in the Security Police (SP) world once again vied for team and individual honors at Kirtland AFB, N. M., last fall during the ninth annual Peacekeeper Challenge competition. Had the all-star meet been scored (the competition is designed to be more of a status check for the SP profession), it would have been tough to name an overall winner, because no team won more than one event. The events showcase combat-related skills such as use of tactics, weapons employment, and physical fitness. Seventeen teams from the major commands, Air National Guard, Air Force Reserve, Air Force Academy, and the Royal Air Force competed.

Here is a list of the events and winners at the 1989 Peacekeeper Challenge: **Combat Rifle** (two four-member teams firing M16s from standing, kneeling, and foxhole positions on a 1,100-meter course)—Strategic Air Command; **Machine Gun** (gunner and assistant firing an M60 7.62-mm machine gun from both tripod and bipod at point and area targets)—Air Force Space Command; **Handgun** (firing an M9 9-mm pistol from a standing position at targets, plus a tactical exercise with shoot/don't-shoot targets)—Air Force Logistics Command; **Grenade Launcher** (engaging point and area targets at up to 230 meters while traversing a 300-

meter course)—Air Force Systems Command.

Defender Challenge (combat tactics)—US Air Forces in Europe; **Team Physical Fitness** (nineteen obstacles on a 2.4-kilometer course)—Royal Air Force Regiment; **TIG Challenge** (individual honors on the obstacle course)—A1C Dale Oie, Pacific Air Forces.

Special presentations included the following awards: RAF Regiment Commandant General's Award (for leadership and professionalism)—MSgt. Doyle B. Horton, Air Force Systems Command; Air Force Sergeant's Association Chief Master Sergeant of the Air Force Award (meet's outstanding enlisted competitor)—SSgt. Christopher Robbins, Air Force Academy; Noncommissioned Officers' Association Chief's Award (team spirit, enthusiasm, and unity of effort)—Air University; Albuquerque Chamber of Commerce Logistics Support Award (individual support to the competition)—Sgt. Bradley H. Forslund, Kirtland AFB, N. M.

★ **APPOINTED**—Navy Capt. **Robert Crippen,** who flew on the first space shuttle mission in 1981, has been named the **new Director of the National Space Transportation System.** He replaces retired Rear Adm. Richard Truly, who is now NASA Administrator. Captain Crippen, who had been the Deputy Director for Shuttle Operations at the Kennedy Space Center (KSC) in Florida, also served as mission commander for missions STS-7, 41-C, and 41-G. Air Force Col. Brewster Shaw will fill Captain Crippen's position at KSC.

★ **HONORS—Col. Herbert C. Hawkins III** (Clark AB, the Philippines), **Capt. Diana E. Francois** (Spangdahlem AB, Germany), **MSgt. Marvin D. McTique** (Rhein-Main AB, Germany), and **TSgt. Sandra S. O'Konek** (Ramstein AB, Germany) have been named the 1989 recipients of the **Lance P. Sijan USAF Leadership Awards.** The awards are presented annually to two Air Force officers and two enlisted troops who have demonstrated the highest qualities of leadership. The awards are named for Capt. Lance P. Sijan, who evaded capture and withstood torture in Vietnam and was posthumously awarded the Medal of Honor.

The Low-Altitude Navigation and Targeting Infrared for Night System Program Office **(LANTIRN SPO)** of ASD at Wright-Patterson AFB, Ohio, received the **Air Force Organizational Excellence Award** in October. The LANTIRN SPO was cited for the successful development and acquisition of the $4 billion two-pod system for tactical aircraft, despite numerous challenges.

A new exhibit covering the three phases of Igor Sikorsky's aviation career opened at the National Air and Space Museum in Washington, D. C., in mid-November. The exhibit features the VS-300, the world's first practical single-rotor helicopter, and many other artifacts. This painting by artist Jim Dietz was made for the exhibit to illustrate Sikorsky's epic flight from St. Petersburg to Kiev, Russia, in his four-engine aircraft,* Ilya Muromets, *during June 1914.

★ **PURCHASES**—The **Building Division of B. G. Danis Co.** was awarded a $5.7 million contract on October 26 **to build an IMAX theater addition to the Air Force Museum** at Wright-Patterson AFB, Ohio. The 500-seat theater will be constructed in front of and attached to the existing lobby. An eighty-foot-high glass dome atrium will also be added. The new theater will be operated by the Air Force Museum Foundation and will open in the spring of 1991. The main museum building was constructed at a cost of $6 million in 1971.

Ebasco Constructors and Gust K. Newberg Construction were awarded a $173,992,977 Army Corps of Engineers contract in early November **to build a new rocket test cell** at the Arnold Engineering Development Center at Arnold AFB, Tenn. The facility, designated J-6, will fill a national need for a place to safely test large, solid-propellant rocket motors (between 15,000 and 500,000 pounds of thrust) with highly explosive fuels at simulated altitude conditions of up to 100,000 feet. Construction is expected to take three years to complete and will be followed by a one-year activation period to calibrate and certify the facility before it becomes operational.

Northrop was awarded a $93.5 million Air Force contract in mid-October **for production tooling and special test equipment for** the air-launched AGM-136A **Tacit Rainbow** loitering antiradiation missile. This award also supports the FY 1990 purchase of ninety missiles for follow-on flight test. Production of these missiles will verify the master tooling, final integration, assembly, and checkout prior to the decision to proceed to initial production of the missile. Tacit Rainbow will be built in Northrop's Perry, Ga., plant. The team of Raytheon, McDonnell Douglas, and E-Systems was recently selected to be the second-source producer of the AGM-136A and the full-scale developer of the Army's BGM-136A ground-launched version of Tacit Rainbow.

Loral Defense Systems Akron was awarded a $55 million Air Force contract in early November **to supply a fourth F-15E weapon-systems trainer.** The two-seat simulator gives the pilot and weapon systems officer air-to-air and air-to-ground training in all avionics and sensor systems on the aircraft. Loral designed, produced, and maintains the other three F-15E WSTs at Luke AFB, Ariz., and Seymour Johnson AFB, N. C. Although not disclosed, the destination of the fourth trainer will likely be Clark AB, the Philippines, recently announced as the location of the second operational F-15E wing.

In October, **Boeing Helicopters** signed an intention to proceed for a contract with the United Kingdom Ministry of Defence **to modernize the Royal Air Force's fleet of more than thirty Chinook HC Mk.1 heavy-lift helicopters to the HC Mk.2 standard.** The actual contract, valued in excess of $200 million, is expected to be signed by spring of this year. This upgrade program, set to begin in 1991, will bring the helicopters up to the US Army's CH-47D standard and will significantly reduce the operation and support costs of the Chinooks.

Eaton's AIL Systems division was awarded a $3.4 million Air Force contract in October **to design and build a Reprogrammable Electronic Warfare System Test (REWST) facility** at Strategic Air Command headquarters at Offutt AFB, Neb. When the facility is completed in 1993, SAC will be able to evaluate its fielded electronic warfare systems against simulated operational environments without taking operational aircraft off the flight line. System evaluation flights will also be kept to a minimum. The facility will allow SAC to measure system performance accurately and to get adjustment information on existing EW equipment out to the field quicker. TRW and Martin Marietta are the principal subcontractors on the REWST project.

The controversial **sale of sixty additional** General Dynamics **F-16A/B aircraft to Pakistan was approved** in October. The $1.5 billion package includes planes, ten spare Pratt & Whitney F100-PW-220 engines, tools, spare parts, technical publications, maintenance training, technical services, support equipment, and ferry services. Delivery of the first aircraft is scheduled for September 1992. Pakistan bought forty F-16A/Bs in 1982.

★ **DELIVERIES**—The **first of twelve F-16A/B aircraft for Indonesia was delivered** in ceremonies at General Dynamics's facility in Fort Worth, Tex., on October 20. The single-seat A model was scheduled to be flown to Indonesia in December, along with the first two-seat B model. Indonesia is the fifteenth country worldwide and the third in Southeast Asia to fly the F-16. Total orders for the F-16 now number more than 3,000.

The **Harry G. Armstrong Aerospace Medical Research Laboratory** at ASD, Wright-Patterson AFB, Ohio, **recently opened a clearinghouse for human factors engineering data** for defense scientists, technicians, and contractors. The staff of the new center, called the Crew System Ergo-

Shown on an acceptance flight near General Dynamics's facility in Fort Worth, Tex., is the first of twelve F-16s the company will deliver to Indonesia. Indonesia is the fifteenth country to fly the F-16. GD recently received approval to sell Pakistan an additional sixty F-16s.

nomics Information Analysis Center (CSERIAC), will analyze and provide information based on users' specific requests or projected needs, rather than simply offering references or access to documents. CSERIAC's purpose is to support requirements to incorporate human factor considerations into the design and operation of military systems. The University of Dayton Research Institute manages the center.

★ **MILESTONES**—The Air Force carried out the **first aerial refueling of the Northrop B-2 bomber** during a six-hour-and-five-minute test flight on November 8. Three hours into the flight, the B-2's crew of Air Force Lt. Col. John Small and Northrop chief test pilot Bruce Hinds lined up the aircraft below and slightly behind a KC-10 tanker flying out of March AFB, Calif. They then performed several hookups and disconnects prior to taking on more than 40,000 pounds of JP-8 fuel. This was the sixth test flight of the new bomber.

The **last of 470** McDonnell Douglas **F-15C/D fighters was delivered to the Air Force** on November 3. The milestone aircraft, a single-seat C model (serial number 86-0166), was flown from the company's plant in St. Louis, Mo., to Eglin AFB, Fla., by Col. Rick Parsons, Commander of Eglin's 33d Tactical Fighter Wing. Deliveries of the 409 F-15Cs and sixty-one two-seat F-15Ds began in 1979. The final C/D-model aircraft built will be delivered to Saudi Arabia (twelve) and Israel (five) in 1991 and 1992. The company delivered 365 single-seat F-15As and fifty-nine F-15Bs from 1974 to 1979. More than sixty of the new dual-role F-15Es have been delivered to date.

One of the **US Army's first parachute units,** the 1st Battalion (Airborne)/501st Infantry, **was reactivated** on October 23 at Fort Richardson, Alaska. The unit, nicknamed "Geronimo," was activated in 1940 and was disbanded in 1984. The 1st (Airborne)/501st is part of the 6th Infantry Division (Light), one of the new, highly mobile, light divisions. A planned mass parachute jump to celebrate the reactivation had to be canceled because of unusually heavy snowfall.

The **first captive-carry flight of the Pegasus air-launched space booster was successfully carried out** over Edwards AFB, Calif., on November 9. The flight lasted approximately ninety minutes. During the flight, the functioning of the vehicle's guidance, navigation, control, and telemetry systems was checked, as was the telemetry system on board the NB-52D carrier aircraft. The Pegasus vehicle had inert rocket motors and carried a heavy instrument load to provide flight environmental data. The first operational launch of the three-stage Pegasus booster was scheduled for late last year.

The Bell-Boeing **V-22 Osprey tiltrotor aircraft passed several milestones last fall.** The number one Osprey achieved an equivalent airspeed of 250 knots (316 mph), which is the top airspeed of the initial government flight release. At the aircraft's 8,300-foot test altitude, that translates to a true speed of 280 knots. This speed is considerably faster than the 200+ mph top speed of the US military's fastest true helicopter, the Sikorsky MH-53J. Other Osprey milestones include completion of the first stage of stall tests, 2-G maneuvers, and single-engine flight. All six V-22 full-scale development aircraft are scheduled to be flying by the end of this year.

Last fall, the Canadair **CL-227 Sentinel** unmanned aerial vehicle **successfully completed a series of tests in conjunction with an aerostat while at sea.** Nine missions were flown from the Army-operated vessel *Jan Tide* near the Pacific Missile Test Center at Point Mugu, Calif., as part of an evaluation program for the US armed forces and other agencies. During the demonstrations, surface ships were acquired by the aerostat's AN/APG-66 radar while the airship was tethered above the *Jan Tide.* Using a real-time data link, the CL-227 was flown to find and intercept the target ship. Once over the target, the UAV's electro-optical sensors were used to provide visual identification and target classification. The six-foot-tall UAV will be evaluated by the Air Force at Fort Huachuca, Ariz., early this year to test the vehicle's utility in making air base battle-damage assessments.

★ **NEWS NOTES**—In four separate incidents during October and November, **Soviet ships may have directed laser beams at US patrol aircraft.** On

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October 17, a crewman on board an HC-130 suffered headaches, disruption of color vision, and other visual problems from possible laser illumination as the plane's crew was observing a Soviet ship 1,200 miles southwest of Hawaii, an impact area for Soviet ICBM warheads. On October 28, a Navy P-3 crew reported possible illumination by the same ship. On November 1, two Air Force aircraft hundreds of miles apart over the Pacific each reported possible illumination from nearby Soviet ships. It has not yet been determined that lasers were involved, and no protests have been filed. A US-Soviet agreement intended to avoid military encounters such as these went into effect on January 1, 1990.

In late October, the Air Force announced that **the Advanced Tactical Fighter's demonstration/validation phase will be extended by six months.** The extension will provide additional time for the contractors (Lockheed with Boeing and General Dynamics, Northrop with McDonnell Douglas, Pratt & Whitney, and General Electric) to generate data and will give the Air Force more time to analyze results. This will ensure that those results are fully incorporated into the final request for proposal, and it will help the Air Force meet the Defense Acquisition Board's documentation requirements.

The Air Force Reserve's **907th Tactical Airlift Group,** the Department of Defense's only unit capable of fixed-wing aerial spray operations, **was called on to fight mosquito infesta-**

January Anniversaries

- *January 18, 1905:* The Wright brothers open negotiations with the US government to build an airplane for the Army, but nothing comes of this first meeting.
- *January 19, 1910:* Signal Corps Lt. Paul Beck, flying as a passenger with Louis Paulhan in a Farman biplane, drops three two-pound sandbags in an effort to hit a target at the Los Angeles Flying Meet. This is the first bombing experiment by an Army officer.
- *January 19–20, 1915:* The Germans launch the first Zeppelin bombing raids on England. One airship, the L.6, turns back, but two others, the L.3 and L.4, drop their bombs on Great Yarmouth and King's Lynn.
- *January 24, 1925:* The Navy airship USS *Los Angeles* (ZR-3), with twenty-five scientists and astronomers on board as passengers, follows the path of a solar eclipse across the US.
- *January 20, 1945:* Army Air Forces Maj. Gen. Curtis LeMay succeeds Brig. Gen. Haywood "Possum" Hansell as Commander of XXI Bomber Command in the Mariana Islands.
- *January 15, 1950:* General of the Air Force Henry H. "Hap" Arnold, World War II Commander of the Army Air Forces and the leader in the fight for a separate Air Force, dies of a heart ailment in Sonoma, Calif.
- *January 23, 1950:* The Air Force establishes Air Research and Development Command, which in 1961 would be redesignated Air Force Systems Command.
- *January 31, 1950:* President Harry S. Truman announces that he has directed the Atomic Energy Commission "to continue its work on all forms of atomic-energy weapons, including the so-called hydrogen or super bomb." This is the first confirmation of US H-bomb work.
- *January 25, 1960:* In what is billed as the "first known kill of a ballistic missile," an Army MIM-23 HAWK antiaircraft missile downs an unarmed MGR-1 Honest John surface-to-surface unguided rocket.
- *January 13, 1975:* The General Dynamics YF-16 is announced as the winner of the Air Force's Lightweight Fighter technology evaluation program over the Northrop YF-17. The F-16 is also the leading candidate to become the Air Force's new Air Combat Fighter. The YF-17 is the predecessor of the Navy's F/A-18 Hornet.
- *January 26, 1975:* The Force Modernization program, a nine-year effort to replace all Boeing LGM-30B Minuteman I intercontinental ballistic missiles with either Minuteman IIs (LGM-30F) or Minuteman IIIs (LGM-30G), is completed as the last flight of ten LGM-30Gs is turned over to Strategic Air Command at F. E. Warren AFB, Wyo.
- *January 24–27, 1985:* The fifteenth space shuttle mission (51-C) is the first dedicated Department of Defense flight. The *Discovery* crew of Navy Capt. Thomas Mattingly (mission commander), Air Force Lt. Col. Loren Shriver (pilot), and Air Force mission specialists Lt. Col. Ellison Onizuka and Maj. Gary Payton, along with Marine Corps Lt. Col. James Buchli, deploy a classified payload, believed to be a signals intelligence satellite.

tion in South Carolina caused by Hurricane Hugo and unusually high tides. Crews on the 907th TAG's two C-130Es capable of dispensing pesticides began spraying ten counties in and around Charleston, Myrtle Beach, and Columbia on October 27 and completed operations in early November. The pesticide Dibrom, a commercially labeled aerial spray that poses no threat to humans or animals, was used. The missions were flown during the evenings at altitudes of approximately 150 feet.

The **fourth operational Navstar Global Positioning System satellite was successfully launched** on October 21. The Rockwell-built Block II GPS satellite was launched aboard a McDonnell Douglas Delta II booster that took off from Launch Complex 17 at Cape Canaveral AFS, Fla., at 5:31 a.m. When completed in 1992, the GPS constellation will consist of twenty-one operational satellites and three on-orbit spares. The satellites will provide navigational data accurate to within sixty feet anywhere in the world.

Air Force Logistics Command has started a warranty program on the work it performs on B-52 parts at the Oklahoma City Air Logistics Center at Tinker AFB, Okla. When an item is repaired by AFLC, the Command guarantees the part will meet or exceed a specified period before it fails. Unlike other warranty programs, customers will receive "credits" if an item fails during the guarantee period. The credits can then be cashed in for work over and above the programmed maintenance package—work the customers would often perform themselves at their home base. The program began with thirty B-52 parts that are regularly repaired at depots and will expand as experience grows.

The Air Force's **4450th Tactical Group,** the unit that flies the Lockheed F-117A Stealth fighter at the Tonopah Test Range Airfield in Nevada, **has been redesignated the 37th Tactical Fighter Wing.** The 4450th TG was deactivated on October 5 and was immediately reactivated as the 37th TFW. The 37th TFW designation was previously applied to the F-4 unit at George AFB, Calif., that was tasked with the Wild Weasel radar-suppression mission. That wing was deactivated, and its assets and squadrons were merged with the 35th TFW (also at George) in late September.

Air Force Recruiting Service met all of its goals for FY 1989, with the exception of accessions of physicians. Even though the Recruiting Service was fifty-two doctors short of its goal of 199, its FY 1989 recruit class was the largest overall since FY 1980. A total of 43,450 people with no prior military service were recruited, as were another 300 with prior service. Some 1,225 officer trainees attended Officer Training School, and recruiters were responsible for approximately 12,000 Reserve Officer Training Corps scholarship applications. Almost 1,300 health-care professionals entered the Air Force Medical Corps, and more than 300 people received scholarships to attend medical school. Ninety-nine percent of the nonprior service enlistees are high school graduates.

Air Force ROTC cadets are gaining valuable experience while advancing research for the Air Force Weapons Laboratory at Kirtland AFB, N. M., under a new program. The cadets, from Rensselaer Polytechnic Institute in Troy, N. Y., are performing experiments on the effects of radiation on components designed for use in space, where radiation can adversely affect microelectronic operation. The AFWL testing is done during special summer research programs as part of the cadets' required undergraduate research. The cadets who work at AFWL get on-the-job training and a firsthand look at the Weapons Lab as a possible duty location once they are commissioned.

The **Naval Aviation Museum Foundation** reports that it recently **passed the ninety percent mark in fund-raising for that museum's $8 million Phase III expansion.** Phase III, expected to be dedicated on Navy Day 1990, will consist of the west wing, a 110,000-square-foot, four-story complex dedicated to aircraft carrier technology, the Blue Angel Atrium, a 10,000-square-foot, seven-story glass atrium with four Blue Angel A-4F Skyhawks suspended from the ceiling in diamond formation, and an expansion to the gift shop. The museum, located at NAS Pensacola, Fla., recently changed its name to the National Museum of Naval Aviation, which reflects the museum's elevation to national status alongside the US Air Force Museum at Wright-Patterson AFB, Ohio, and the National Air and Space Museum in Washington, D. C.

People 1, Pigs 1. On June 7, 1988, Lt. Col. Sam Carter of the Florida Air National Guard was returning from a routine sortie and was preparing to touch down at Jacksonville Interna-

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—Photo by Paul Jackson

This vintage C-47, now preserved in the Imperial War Museum in Duxford, England, was saluted last fall by an RAF Tornado to commemorate the forty-fifth anniversary of Operation Market Garden, the airborne part of the ill-fated Arnhem landings. The C-47, then based at RAF Cottesmore (where the Tornado is now assigned), was used to drop troops on Day One (September 17, 1944) and as a tug for a Waco CG-4A glider on Day Two of the operation.

tional Airport when two wild pigs crossed the runway. Colonel Carter's F-16 struck the pigs at a speed of approximately 150 mph, and the impact sheared off the left main landing gear. The F-16 veered off the runway, crossed a ditch, became re-airborne, and headed for a stand of pine trees. Colonel Carter ejected and was uninjured, but the aircraft suffered major damage. The unit's 125th Consolidated Aircraft Maintenance Squadron, fearing they would hear cries of "Sooey!" anytime they went to another base, decided to rebuild the aircraft there at their home station. Just over a year later, the 125th CAMS, with an assist from the 2952d Combat Logistics Support Squadron at Hill AFB, Utah, had the F-16A (serial number 81-0713) back in the air. ■

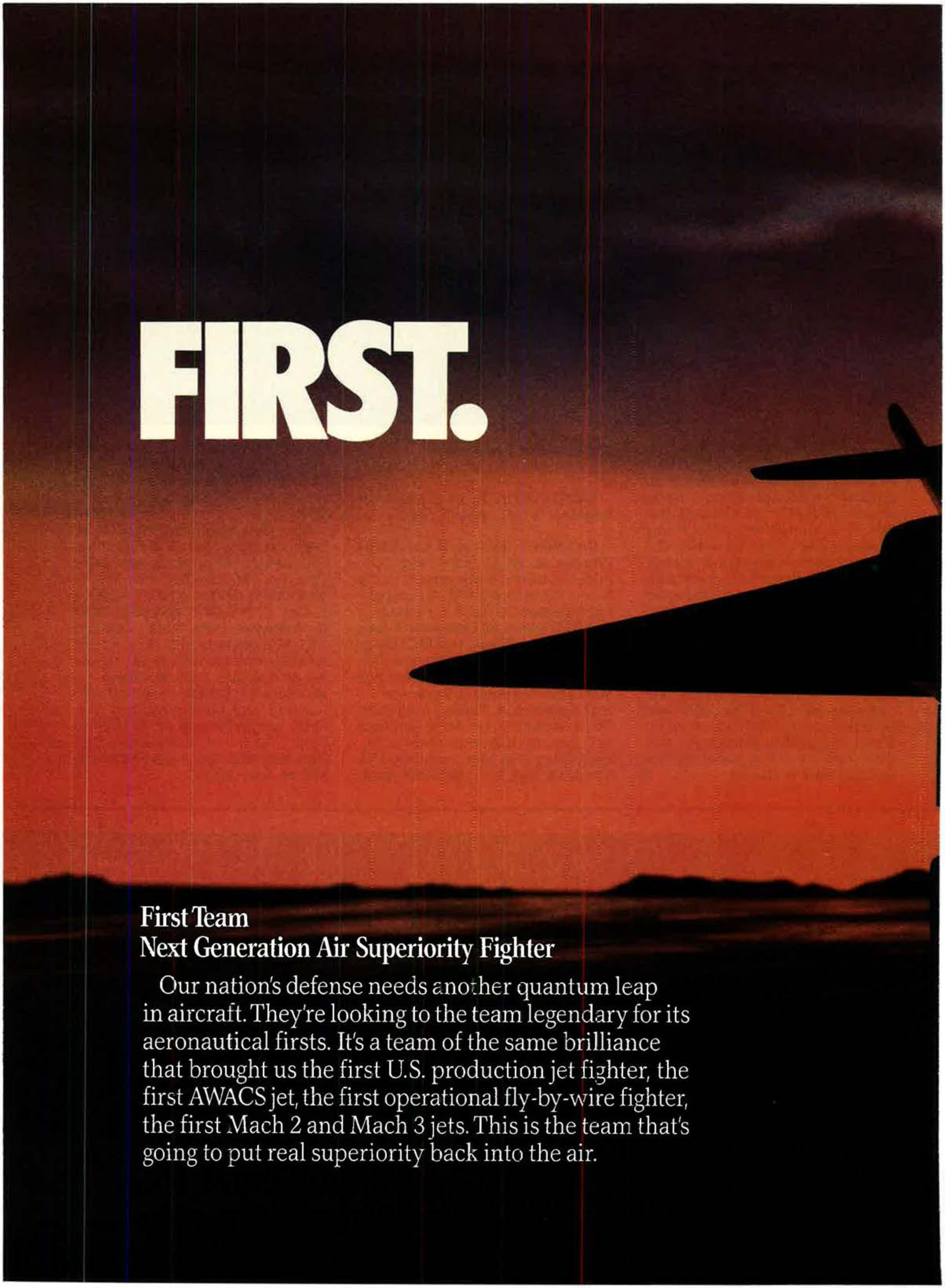
Senior Staff Changes

RETIREMENT: M/G M. Gary **Alkire.**

PROMOTION: To be **Lieutenant General:** M/G Charles G. **Boyd.**

CHANGES: M/G (L/G selectee) Charles G. Boyd, from Ass't DCS/P&O, Hq. USAF, Washington, D. C., to Cmdr., AU, Maxwell AFB, Ala., replacing deceased L/G Ralph E. Havens . . . **B/G (M/G selectee) Lawrence E. Day,** from Ass't DCS/Ops., Hq. TAC, Langley AFB, Va., to Cmdr., Chanute TTC, ATC, Chanute AFB, Ill., replacing B/G (M/G selectee) Peter D. Robinson . . . **M/G Frederick A. Fielder,** from DCS/Test & Resources, Hq. AFSC, Andrews AFB, Md., to DCS/Requirements, Hq. SAC, Offutt AFB, Neb., replacing M/G Charles A. May, Jr. . . . **M/G Charles A. May, Jr.,** from DCS/Requirements, Hq. SAC, Offutt AFB, Neb., to Ass't DCS/P&O, Hq. USAF, Washington, D. C., replacing M/G (L/G selectee) Charles G. Boyd.

Col. (B/G selectee) Everett H. Pratt, Jr., from Ass't DCS/Plans, Hq. TAC, Langley AFB, Va., to Ass't DCS/Ops., Hq. TAC, Langley AFB, Va., replacing B/G (M/G selectee) Lawrence E. Day . . . **B/G (M/G selectee) Peter D. Robinson,** from Cmdr., Chanute TTC, ATC, Chanute AFB, Ill., to Cmdr., AFOTEC, Kirtland AFB, N. M., replacing retiring M/G Cecil W. Powell . . . **M/G Robert F. Swarts,** from DCS/Contracting and Manufacturing, Hq. AFLC, Wright-Patterson AFB, Ohio, to Cmdr., Air Force Commissary Service, Kelly AFB, Tex., replacing retired M/G M. Gary Alkire. ■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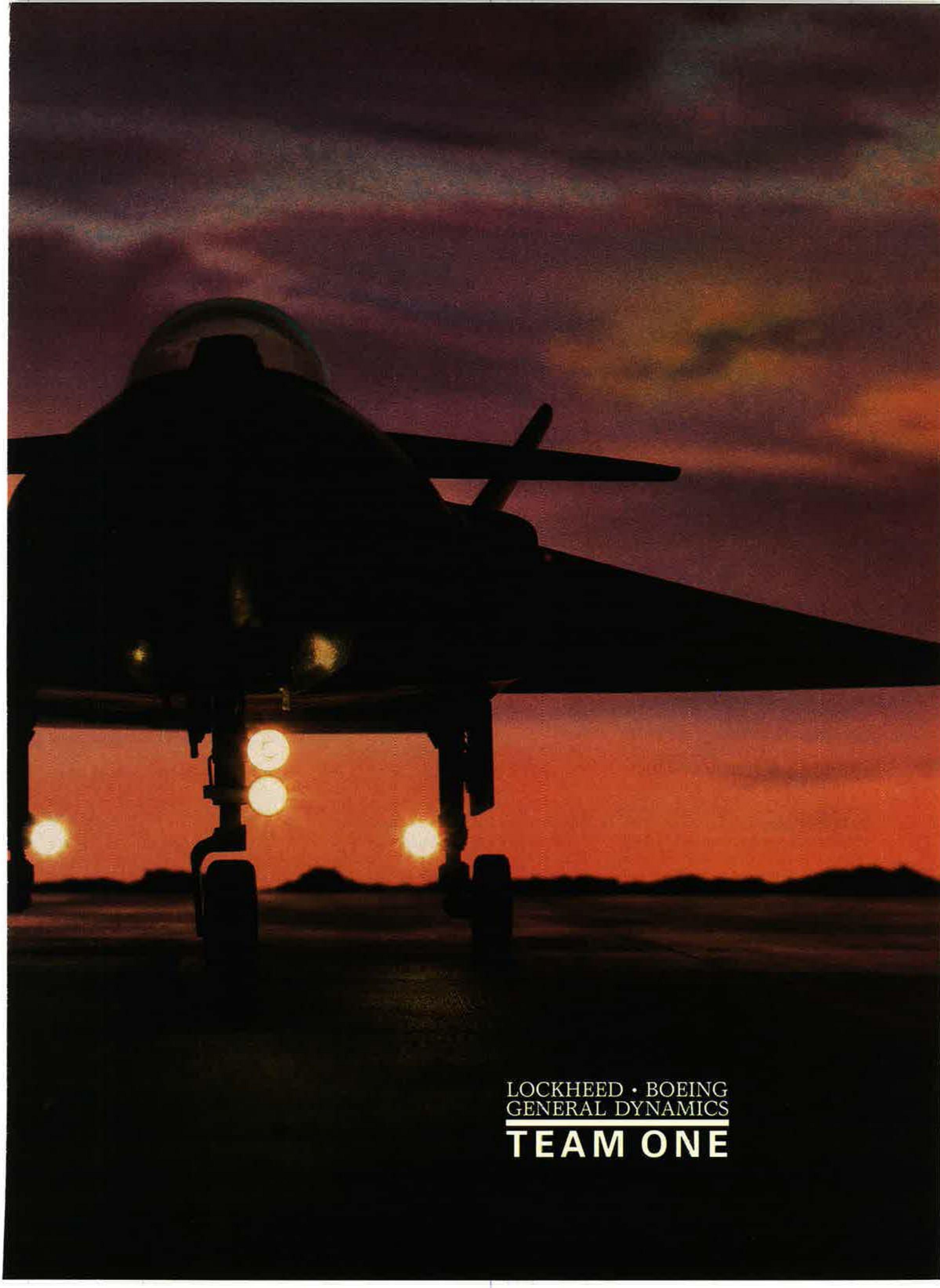
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The next twelve months will see a rare parade of prototypes, rollouts, and aeronautical modifications.

The Year of the Airplane

By Jeffrey P. Rhodes, Aeronautics Editor

FOR THE US Air Force, 1990 shapes up as the Year of the Airplane. Over the next twelve months, USAF Systems Command's Aeronautical Systems Division will deliver, fly, or purchase many of the combat aircraft that will carry the Air Force into the next century.

The schedule for both fiscal and calendar 1990 calls for debuts of no fewer than five Air Force aircraft, including the two Advanced Tactical Fighter prototypes. Assembly of the first C-17 transport will be completed. Two highly modified aircraft will fly for the first time. Several other airplanes will move into important development or test phases. Two more aircraft will be bought off the shelf, including the business jet to be used in the Tanker/Transport Training System (TTTS).

It promises to be a time of extraordinary activity for those at ASD headquarters at Wright-Patterson AFB, Ohio, which is pushing ahead with the development effort.

"We are operating at peak activity in a period of great change and turmoil because of reductions in the defense budget," maintains Lt. Gen. Mike Loh, ASD Commander. "There is a lot of activity, and there are a number of key programs that we have going into full-scale development or turning the corner from full-scale development into production."

One such major program is the Advanced Tactical Fighter (ATF). The secretive period of development is over, and it is time to fly airplanes in the ATF competition. Both competing teams, Lockheed with Boeing and General Dynamics, and Northrop with McDonnell Douglas, will roll out their prototype ATFs—the YF-22A and YF-23A, respectively—in the first quarter of 1990. A potential buy of 750 aircraft is at stake.

"The competition has been a real challenge so far," says Brig. Gen. James Fain, ATF Program Director. "We did not want to tell contractors what to do. We furnished the requirements, and we set goals. But the kinds of new technologies we are talking about take time to mature. It will be interesting to see how far the companies can go."

The ATF will replace the F-15 in the air-superiority role. The airframe must be highly maneuver-

The Air Force will buy, fly, or deliver more new aircraft types in the next twelve months than in almost any year since the 1950s. The new year gets off to a roaring start with the rollout of Advanced Tactical Fighter prototypes from Northrop/McDonnell Douglas (YF-23A) and Lockheed/Boeing/General Dynamics (YF-22A, shown here in an artist's concept). Both should be flying by spring.

able, have the capability for sustained supersonic cruise without afterburners, and have highly integrated avionics and weapon systems. The aircraft has a target weight of 50,000 pounds, with a unit flyaway cost (in FY 1985 dollars) of $35 million.

"During the dem/val [demonstration/validation, the current phase], we've defined points where we can say, 'This is what the user wants, and this is what technology says is achievable,' " says General Fain. "We'll look at the various combinations of low-observables, fuel economy, avionics capabilities, and speed and plot them on an S-curve. Then we'll take those S-curves and put them down on top of one another. The one point where the data meet, as we've interpreted it, is where we'll find the most cost-efficient combat machine."

The two aircraft that roll out will be measurably different from the full-scale development aircraft scheduled to start flight test in FY 1993. "The developed technology will evolve," notes General Fain. "What is made of aluminum in the prototype may be made of a metal or metal composite that for argument we'll call 'unobtainium' in the production aircraft."

All signs are that the contractors are eager to let the competition begin. "The ATF has been a new way of doing business for the contractors," concludes General Fain. "We have developed the specs and matured the technology at the same time. The contractors have had to participate in the process and have had to learn to work among themselves. We have finally convinced everybody that this is the way to go. It wasn't done overnight, and it wasn't done without its share of problems."

All of its parts and assemblies, like this upper cockpit section, are coming together, and the first McDonnell Douglas C-17A airlifter will be completed in Long Beach, Calif., late this year. The program has experienced some delays, and the plane's first flight is now expected to come in the middle of next year.

First C-17 to Be Finished

Nine years after McDonnell Douglas was selected as the winner of the C-X competition, assembly of the first C-17A is scheduled to be completed at Long Beach, Calif., in late 1990. Before that can happen, though, the C-17 must meet some tight deadlines in the next couple of months.

"There are no major technical difficulties with the program," says Brig. Gen. Michael Butchko, Director of the C-17 System Program Office. "It's taking longer than we thought it would to assemble the first aircraft, and writing some of the mission computer software has gone slower than planned. Neither of these is insurmountable, though."

A major assembly milestone will occur early this year when the C-17's wings and fuselage are joined, but fabrication of parts is slowing the assembly process. Douglas's capacity to fabricate parts is taxed to the limit right now, as the company has three other aircraft types in production.

The C-17 is being assembled with advanced numerically controlled tools that can even install rivets, but all of the parts that go into a particular subassembly must be loaded into the tool at the same time. If all of the parts aren't there, the automated assembly tool can't do its job. Because of the parts production load at Long Beach, the company has shifted a large portion of C-17 parts assembly to Air Force Plant 85 in Columbus, Ohio.

Douglas has assumed the software-writing task from Delco, and, as General Butchko says, "they seem to have a handle on that now. It's not of a highly technical nature, but it is a lot of lines of code. That software, though, is the long pole in the tent for first flight." The C-17's first flight is scheduled for mid-1991.

Controlling weight growth has been a constant challenge. A weight-reduction program has shaved 15,000 pounds so far. Projected weight of the C-17 is 270,000 pounds, or roughly 2,000 pounds over the plane's target weight. Even at this weight, the aircraft should meet maximum performance requirements.

The C-17 continues to enjoy strong congressional support. However, because money was allocated to buy only four C-17s, instead of the requested six in FY 1990, Military Airlift Command's date for initial operational capability has slipped. As a result of the combination of program slips and congressional action, IOC will slide from September 1992 to calendar year 1993. The first squadron will be activated at Charleston AFB, S. C., in mid-1992.

Tanker/Transport Training System

The Tanker/Transport Training System (TTTS) will be the largest buy of business jets in history—211 aircraft. TTTS will also be the first system for which the Air Force has procured a complete pilot training system. The winning contractor or contractor team not only has to provide aircraft, but also must provide an aircrew training system with simulators, part-task trainers, and courseware, plus a contractor-run logistics system. A $1.5 billion payoff is at stake.

TTTS is the first stage in Air Training Command's three-part trainer modernization, and it marks USAF's return to dual-track or Specialized Undergraduate Pilot Training. TTTS will be used to train tanker and transport pilots. Fifty-four percent of the students who make it to advanced training will undergo TTTS training. Use of TTTS will help to extend the life of the T-38 fleet, which will be used solely for fighter, bomber, and attack pilot training beyond the year 2006.

The major requirement for the TTTS aircraft is that it be an FAA-certified, twin-engine jet aircraft that can be bought off the shelf. Specific requirements include a Mach .7 speed at 35,000 feet, the ability to operate at 330 knots at 500 feet, a 250-nm divert capability, single-point refueling, a birdstrike-resistant windshield, a five-tube electronic flight instrument system that is commercially available, and a third crew seat.

The program is now in source selection, and the winner is scheduled to be announced in the next few months. "We can't focus on any one aspect of the proposals," notes Lt. Col. Stanley Yackel, the TTTS Program Manager. "We have to look at the total system. We have to look at the operational utility and the technical capability of the proposed system, life-cycle costs, program-management potential, adequacy of the logistics support, and even the past performance of the contractors."

The first aircraft is to be delivered for testing by October 1991. Simulators and other training devices must be in place at Reese AFB, Tex., the first of five student pilot training bases, by March 1992. TTTS instructor pilot transition training will begin at Randolph AFB, Tex., in June of that year. Student instruction will start in September 1992.

Wild Weasel Replacement Needed

One pressing need for the tactical air forces is a replacement for the F-4G "Wild Weasel" radar suppression aircraft. "The age of the F-4G airframe brought emphasis to what we want to do," says Lt. Col. Charles Court, ASD's Wild Weasel division chief. "The upgrade to the F-4G was taking too long, and the Air Force has opted instead for a replacement aircraft."

Contracts for the study phase of the Manned Lethal Suppression of Enemy Air Defenses program (also called Follow-on Wild Weasel, or F-WW) will continue, pending selection of the airframe, which is expected in 1990. A three-year demonstration/validation effort will follow, and one contractor will be chosen to begin full-scale development.

What the Air Force will be looking for in the next Wild Weasel is better range, more armament, and better avionics growth capability than the F-4G has. Other important considerations are improved visibility for the weapon system operator (to help the pilot look for air-to-air threats) and more automation in the mission equipment to ease the demanding work load that comes in playing cat-and-mouse with enemy radars. A radar receiver on par with the current AN/APR-38 and -47 will be critical.

—Staff photo by Guy Aceto

A pressing need for the tactical air forces is a replacement for the F-4G Wild Weasel radar suppression aircraft, shown here in the foreground with an F-4E, the "killer" element of a hunter/killer team. Contracts for the study phase of the Follow-on Wild Weasel program are expected to be let after the selection of an airframe, which is anticipated for this year.

The first LTV YA-7F flew late last year and will be joined by a second aircraft next month. The two YA-7Fs (greatly modified A-7Ds) will undergo a ten-month flight-test program to verify design and performance characteristics. This is the first YA-7F on its initial flight from the company's Dallas, Tex., facility last November.

Colonel Court believes that seven or eight contractors or teams of companies will respond to the formal request for proposal. At this juncture, the leading contenders for the F-WW airframe include the McDonnell Douglas F-15A/C/E and the Panavia Tornado.

The F-15A and C are older aircraft, and they would have to be greatly modified to include a second seat in order to perform the Weasel mission. They offer reduced costs, and their reliability and maintainability factors are known. The two-seat F-15B and D models are not seen as candidates, because there are not enough of them.

Both the F-15E and the Tornado already have a second seat, but both planes would be expensive. Some of the specialized F-15E equipment would have to be removed because there is no additional room for Weasel gear. The Electronic Combat and Reconnaissance version of Tornado is already in development and, if selected, would be built in the US by Rockwell.

YA-7F Demonstrator

The first LTV YA-7F demonstrator flew late in 1989, and it is scheduled to be joined by a second aircraft at the Air Force Flight Test Center at Edwards AFB, Calif., next month. This latest variant of the 1960s-era A-7 Corsair II ground-attack aircraft will take part in a ten-month developmental test and evaluation flight-test program to verify design and performance characteristics.

The YA-7Fs have been lengthened with the addition of a 29.5-inch plug fore of and an eighteen-inch addition aft of the wings. The jets also have aluminum wing strakes, a tail fin cap, augmented flaps, and lift-dump spoilers. These modifications have been undertaken to increase maneuverability and for aerodynamic compatibility with the main internal change, the installation of an afterburning Pratt & Whitney F100-PW-200 engine.

Other internal changes include the addition of an accessory mounted drive system for self-contained ground operations; a new environmental control system, mainly to cool the avionics; a 60-Kv generator, a molecular sieve oxygen generator; and improved airspeed and navigation systems.

The modifications will improve the aircraft's performance dramatically, decreasing takeoff roll by fifty percent, which will increase survivability. The engine will substantially increase both the aircraft's sustained speed while jinking (the A-7D loses nearly 200 knots of airspeed after two cycles) and its sustained G-loading.

Originally intended as a full-scale development effort, the YA-7F's test program will consist of airspeed, propulsion, performance, flying qualities, flutter, and avionics tests. Additionally, stores-separation tests will be conducted, and the number two aircraft will be put through a spin-test program.

All of the A-7s are now operated by the Air National Guard, and Guard pilots will conduct an early operational assessment of the YA-7F. There is currently no follow-on test program planned, and Tactical Air Command will make the decision on whether to modify the entire fleet to A-7F standard after the test flights are completed.

Special Operations Forces Projects

Two Special Operations Forces (SOF) projects will reach important milestones in 1990. The first MC-130H Combat Talon IIs will be delivered to operational users, and the first of the new-generation AC-130U Spectre gunships will be completed and start tests.

"We have a significant shortfall in SOF airlift capability right now," says Lt. Col. Dennis Boroczk, Director of the MC-130H Program. "These aircraft will fix that." The Combat Talon II, a much-improved version of the MC-130E Combat Talon I, is designed to provide specialized airdrop and airland capability for low-level missions at night and in adverse weather.

The new-build C-130Hs are modified both internally and externally. Lockheed Air Services adds the air-refueling receptacle, additional exterior lighting, explosive-suppressive fuel tanks, and a modified cargo ramp area for the High-Speed, Low-Level Aerial Delivery System. E-Systems installs the IBM-developed mission avionics and advanced cockpit. The pilot/copilot station has four multifunction displays, as does the navigator/electronic warfare officer station on the aft portion of the flight deck.

Other avionics include the Emerson AN/APQ-170 terrain-following/terrain-avoidance radar, dual radar altimeters, dual inertial navigation systems, and provision for a global positioning system receiver. The defensive electronics suite in the Talon II is significantly better than the one in the Talon I, and the equipment will eventually be retrofitted on the MC-130Es.

The test program for the MC-130H (which does not have the Fulton STAR recovery system) ends in June, and deliveries to the 1st Special Operations Wing's 8th Special Operations Squadron at Hurlburt Field, Fla., will begin later that month.

The AC-130U will roll out this summer at Rockwell's facility in Palmdale, Calif. One key to the improved capability of the new gunships is the main fire-control radar, the Hughes AN/APG-180. The APG-180, a derivative of the APG-70 in the F-15E, will allow the gunship crews to track and fire on targets even in adverse weather. The all-light-level TV is in a turret under the fuselage and has a 360-degree field of view. Sensor displays in the battle-management center are several generations ahead of the current gunship displays.

The crew of the new gunships will number only thirteen, as one of the gunners is no longer needed. Instead of two 20-mm Vulcan cannons, the AC-130Us will have a single trainable 25-mm cannon with an autonomous ammunition-handling and feed system. The gunship will carry an amount of ammunition for the one 25-mm gun equal to what the earlier Spectres carried for the two 20-mm guns. Both the 40-mm and 105-mm cannon are trainable and are tied in to the sensor suite.

The test program for the gunships will last until 1992, when the first gunships are delivered to the 1st SOW's 16th SOS. The Air Force plans to acquire twelve AC-130Us.

Other New Aircraft

Next year, the first Boeing VC-25A will arrive at Andrews AFB, Md., to begin service with the 89th Military Airlift Wing as the new Presidential aircraft. It is not one of ASD's largest acquisition efforts (only two aircraft), but the pair will be among the most recognizable aircraft on the planet.

The new "Air Force One" aircraft are specially configured 747-200B commercial airliners. The VC-25As will have a pair of self-contained airstairs on the left side and a built-in baggage-loader on the right side. This, and a second auxiliary power unit, will allow the aircraft to be practically self-sufficient and reduce the need for ground-support equipment on the President's travels.

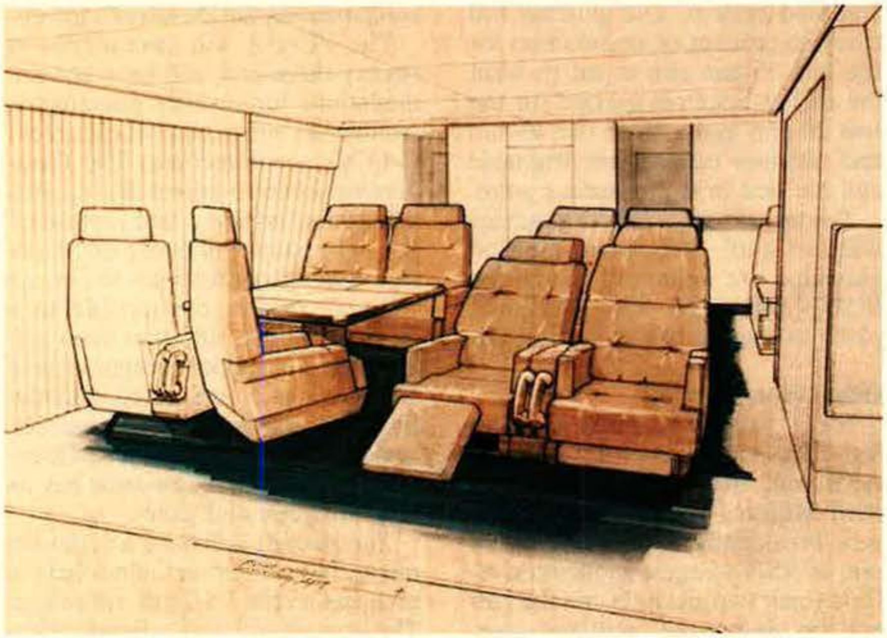
The VC-25A will have a crew of twenty-three and will have accommodations for seventy passengers, twenty-six more than the current C-137Cs accommodate. The President's executive suite will contain a stateroom, lavatory, and private office. The plane will have a combination dining/conference room, an "annex" that is convertible to a medical facility, and two main galleys that can support preparation of 100 meals at a time. Accommodations are also provided for guests, senior staff, Secret Service, security, and the media. The crew has its own rest area and galley.

The aircraft will have a 6,200-nm range, but will nevertheless have a receptacle for in-flight refueling. The cockpit will have a Bendix electronic flight-instrument system with multifunction displays and a fully automatic landing system.

The first VC-25A will be delivered considerably later than originally scheduled. The modification effort was a complex one, and with the extensive wiring needed and the FAA-mandated fire-suppression system, it simply took longer than anticipated.

—Staff photo by Guy Aceto

The first new-generation AC-130U gunship will be completed and will start tests this year. The twelve new gunships will be assigned to the 1st Special Operations Wing at Hurlburt Field, Fla. The 1st SOW's AC-130Hs (shown here) will then be transferred to the Air Force Reserve. The AC-130As used by AFRES, among the oldest C-130s in the Air Force, will be retired.



This is an artist's concept of the guest room on the Boeing VC-25A, a modified 747-200B commercial airliner that will be used as the new "Air Force One." Each of these leather chairs, which can recline and be used for sleeping, has a phone. The aircraft (there will be two) have accommodations for seventy passengers.

Last month, MAC was scheduled to take delivery of the first C-29As. These planes, with specialized flight-inspection equipment, allow crews to check and calibrate approach, traffic control, and ground-to-air communications equipment at military airfields in wartime or contingency situations. This mission gives MAC the ability to upgrade an airfield to an all-weather, twenty-four-hour operation.

The C-29As, military versions of the British Aerospace BAe 125-800 corporate jet, offer significant advantages over the C-140s and CT-39s they will replace. The new aircraft have a range of 2,400 nm (nearly twice that of the CT-39), which makes the aircraft easier to deploy because they won't need so many intermediate bases. The new jets are also less expensive to operate than the C-140 or CT-39. The C-29s were purchased off the shelf, with the only modifications being the addition of some military avionics, an upgraded electrical system, UHF radios, and an oxygen system.

The new automatic flight-inspection equipment, designed and integrated on the aircraft by LTV's Sierra Research Division, will allow the crew to conduct the entire process from the air. Under the old system, the crew had to land so one crew member could operate some equipment from the ground during the inspection.

The sixth and last C-29A will be delivered in May, and the two CT-39s and three C-140s will be retired. The C-29 pilots will be trained by FlightSafety International, and Sierra Research will train the initial cadre of ten flight-inspection system operators.

US Southern Command is pleased at the emergence of another new plane—the C-27A medium-lift transport. The program was eliminated from the FY 1988 budget, but reappeared this year. "The C-27 is the number one aviation priority for Southern Command," says Lt. Col. Robert Ziener, the head of the program. "They have a big need for an intratheater airlift [aircraft] that fits between the Army's CH-47 and the C-130.

"This is a very fast-track program to get the aircraft to SOUTHCOM by FY 1992," notes Colonel Ziener. After receiving industry comments on the draft request for proposal, ASD will send out the formal RFP early next year. If Congress approves C-27 funding, one contractor or team will be chosen in mid-1990. The aircraft contract will be worth $150 million, covering ten aircraft. A separate contract for the contractor-run logistics system (CLS) will be valued at approximately $9 million.

The primary requirement is that the C-27 be an off-the-shelf purchase. Other requirements are turbine propulsion (turboprops seem the likely choice), a short- and soft-field operating capability, provisions for cargo handling, and a limited airdrop capability. Foreign companies (such as CASA and ATR) have shown much interest. However, the Air Force's buying a foreign aircraft brings up "made in America" considerations. "The FY 1988 congressional language strongly encouraged that the aircraft be US-built," says Colonel Ziener.

One new research aircraft making a debut this year is the Variable-stability Inflight Simulator Test Aircraft, or VISTA. This highly modified F-16D will have reconfigurable flight controls that can be programmed to imitate characteristics of either a prototype or a production version of an aircraft that is not an F-16.

"VISTA is a step in the development process [from] analysis [to] ground simulator [to] aircraft," says Dave Frearson, VISTA Program Manager. "It is cheaper than bending metal on an actual aircraft and a lot safer."

Modified by General Dynamics under a $31.5 million contract, the VISTA NF-16D's external changes include a dorsal fairing for the variable stability system (VSS) avionics and maneuvering flaperons to give it direct-lift capability. Internal changes include extensive rewiring, a new hydraulic system with larger plumbing, and removal of 20-mm gun and ammunition drum.

The cockpit area will be completely redesigned. The rear cockpit will have the pilot-in-command functions, the VSS engage panel, and the VSS configuration keyboard. The front cockpit will be the simulation cockpit. It will have both a sidestick and a variable-feel center stick.

Although the modification will be completed in 1990, the NF-16D will not fly until ground tests are completed in early 1991. After functional check flights, it will be ferried to Edwards AFB, Calif., for a six-month flight-test program. The VISTA aircraft, which will replace the thirty-two-year-old NT-33, is expected to have a useful life of twenty-five to thirty years. ■

A Checklist of Major ASD Systems

Work in progress at the

Aeronautical Systems Division,

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:** GD, Williams, McDonnell Douglas. **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. 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. 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/McDonnell Douglas, Lockheed/Boeing/General Dynamics, GE, 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, advanced X-ray system. **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 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 vintage B-52 bombers and carry out SIOP and possibly conventional bomb missions. Program responsibility passed to AFLC in 1989. **Contractors:** Rockwell, Boeing, Eaton, GE. **Status:** PMRT.

B-2 System Program Office

B-2A Advanced Technology Bomber
Development of a four-engine, low-observable, flying-wing type of strategic penetrating bomber, designed specifically to be able to avoid enemy radar. Supplements and then supplants the B-1B in penetrating role. Plans call for construction of 132 of these two-place intercontinental aircraft. The 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/LRIP.

C-17 System Program Office

C-17A Aircraft
Development and production of USAF's latest airlifter, to augment C-5, C-141, and C-130. Will be used for (1) rapid intertheater deployment of Army and other units directly to overseas areas and (2) airlift of outsized cargo over both intertheater and intratheater ranges with the ability to take off and land at small, austere airfields. **Contractors:** McDonnell Douglas, P&W. **Status:** FSD, initial production.

EC/Reconnaissance System Program Office

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

Airborne Self-Protection Jammer F-16 Integration
Navy/Air Force program to develop internal ECM against radar missiles. **Contractors:** ITT, Westinghouse. **Status:** FSD.

Air Force Electronic Warfare Evaluation Simulator
Hybrid Digital/RF Simulator that provides a terminal engagement environment for testing electronic combat systems. **Contractor:** General Dynamics. **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:** FSD.

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:** FSD.

Real-time Electromagnetic Digitally Controlled Analyzer and Processor
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 provide compatibility of TEWS with F-15 radar, weapons, and avionics. **Contractor:** McDonnell Douglas. **Status:** Dem/val.

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. Will include advanced cockpit technology, LANTIRN, ring-laser gyro guidance, conformal fuel tanks, and reconfigured engine bay and upgraded tactical electronic warfare system. **Contractors:** McDonnell Douglas, 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:** McDonnell Douglas. **Status:** Production.

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

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

Tactical Electronic Warfare System P³I
Provides improvements to ALR-56C Radar Warning Receiver, ALQ-135 countermeasures set, and ALE-45 countermeasures dispenser on F-15. **Contractors:** Loral, Northrop, Tracor. **Status:** Production.

F-16 System Program Office

F-16 Multimission Fighter
The F-16 Multimission Fighter is a single-engine, lightweight, high-performance, tactical fighter aircraft 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 and 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.

Joint Tactical Autonomous Weapons System Program Office

Seek Spinner
Development of ground-launched, slow-moving UAV to locate and attack radar emitters. **Contractor:** Boeing. **Status:** Demonstration.

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.

Tacit Rainbow Ground Launch (BGM-136A)
USAF/Army program to develop a ground-launched variant of AGM-136A weapons. **Contractor:** Raytheon. **Status:** FSD.

LANTIRN System Program Office

LANTIRN System
Production of integrated navigation/targeting system for nighttime, under-the-weather ground-attack by F-15E and F-16 fighters. Navigation pod provides FLIR imagery and radar for obstacle avoidance. Targeting pod acquires and automatically tracks targets. **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. Usable by USAF, Army, and Navy platforms. **Contractor:** Bendix. **Status:** FSD.

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-220 Engine for F-15 and F-16
Evolutionary program to improve F100 durability and operability for the Alternate Fighter Engine competition. Increased durability to 4,000 TAC cycles, or nine years' operation, is sought. Includes digital electronic engine control. In production for F-16C/D, already installed in the F-15C/D and F-15E. **Contractor:** P&W. **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:** FSD.

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:** FSD.

F112 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.

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.

T406-AD-400 Engine for CV-22A
Acquisition of the Allison T406 engine for the CV-22 multimission VTOL aircraft. **Contractor:** Allison. **Status:** FSD.

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.

Joint Vertical Lift Airlift (JVX) (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:** Pre-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:** Prototyping.

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:** Modification.

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

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 in the standard Maverick. **Contractors:** Hughes, Raytheon. **Status:** Production.

Air Force One (VC-25A)
Replacement of two aging VC-137 Presidential aircraft with two new wide-body 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-5A Aircraft
Space Cargo Modification (C-5A SCM) modifies two C-5As to carry outsize space cargo by enlarging the cargo bay and modifying the aft doors. **Contractor:** Lockheed. **Status:** Modification complete.

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

C-22B Air National Guard Support Aircraft
Modification of four Boeing 727s for ANG use as operational support airlift aircraft. **Contractor:** 4950th Test Wing. **Status:** Modification.

C-26A Aircraft
Acquisition and support of 13 Fairchild aircraft to replace the ANG C-131 fleet. **Contractor:** Fairchild Aircraft. **Status:** Production.

C-27A Aircraft
Acquisition of ten commercially available STOL aircraft to provide intratheater airlift for USSOUTHCOM. **Contractor:** None. **Status:** RFP preparation.

C-29A Aircraft
Acquisition of six commercially available, FAA-certified, business-jet-type aircraft equipped with state-of-the-art flight-inspection systems. The flight-inspection mission provides worldwide, all-weather, certified instrument approaches; traffic control and landing systems equipment; and air-to-ground communications during contingency or wartime operations. The six C-29As will replace the aging Lockheed C-140s and Rockwell T-39As currently accomplishing the mission. The C-29A provides a fuel-efficient, low-maintenance, longer-range system. **Contractor:** LTV Aerospace. **Status:** Production.

KC-10 Integral On-Board Loader
Modification of KC-10A aircraft to provide a dual-pallet, self-loading capability. **Contractor:** McDonnell Douglas. **Status:** Development.

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:** McDonnell Douglas. **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.

Peace Pearl
FMS program to design, develop, and produce a new fire-control system for China's F-8II aircraft. Avionics will be used to help upgrade air-to-air capabilities. **Contractor:** Grumman. **Status:** FSD.

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

Tanker/Transport Training System
Acquisition of 211 business jets to support Specialized Undergraduate Pilot Training. **Contractor:** None. **Status:** Source selection.

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

Transport Advanced Avionics and Cockpit Enhancement
Upgrade of C-135 avionics test-bed. The program includes the integration of updated flight-deck avionics and digital flight management systems to facilitate testing of new/advanced subsystems. **Contractor:** Boeing Military Airplane. **Status:** Design/modification.

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/McDonnell Douglas, 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:** Development, acquisition.

B-52 Offensive Avionics System Block II
Development and production of mod kits for nine B-52 Weapon System Trainers and four Offensive Station Mission Trainers. **Contractor:** Singer-Link. **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:** Development, acquisition.

C-17 Aircrew Training System
Development and production of a total aircrew training system for C-17A aircrews. **Contractor:** McDonnell Douglas Training Systems, Inc. **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 F-15E WST. **Contractor:** Loral. **Status:** Production.

F-16 Weapon System Trainer
Procurement of Operational Fighter Trainers, improved Digital Radar Landmass simulators, improved Electronic Warfare Training Devices, visual systems, and various LANTIRN simulators. **Contractors:** Link-CAE, GE, AAI, E&S. **Status:** Acquisition.

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

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

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 CV-22 crew members. **Contractors:** Loral, Logicon, GE. **Status:** Development, acquisition.

Standard DoD Simulator Digital Data Base (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. **Prime Contractor:** Planning Research Corp. **Status:** Development.

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 nonflammable hydraulic system, power electronics, advanced battery, and highly reliable electrical power systems for electric 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.

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.

Integrated High-Performance Turbine Engine Technology Initiative
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
Development of a demonstrator engine 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 demonstrator engines combining advanced high-pressure core components with advanced low-pressure and adaptive components. **Contractors:** Garrett, GE, P&W. **Status:** Advanced development.

Joint Turbine Advanced Gas Generation
Interservice program to assess new core engine components, advanced structures, and material technologies in a true, small-to-medium thrust class engine environment. **Contractor:** To be determined. **Status:** Advanced 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.

Avionics Laboratory

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:** None. **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:** General Dynamics. **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:** In-flight test.

Cruise Missile Advanced Guidance
Development and demonstration of advanced guidance concepts, such as CO_2 laser radar measurements and pattern recognition, that may provide precise, autonomous, terminal guidance for standoff missiles. **Contractors:** GD, McDonnell Douglas. **Status:** Completed.

Electronic-Combat Multifunction Radar Technology (EMR-T)
The overall objective of EMR-T is to develop the technology required for robust airborne radar ECCM performance in post-1995 threat environments, achieved through wide tunable bandwidth and adaptive waveforms. This effort, through design, development, and fabrication of critical laboratory breadboard demonstration hardware, will demonstrate the critical technology required to successfully pursue further development and airborne demonstration of the EMR concept in a future phase. **Contractors:** Hughes Aircraft, Raytheon. **Status:** Development.

Embedded Computer Resources Support Improvement Program
Development of software support technologies to reduce costs, improve the software turnaround capability, and provide for software supportability of new technology insertion for Air Logistics Centers. **Contractors:** ITT, Hughes, TRW, Booz-Allen & Hamilton. **Status:** Development.

EW Reliability Improvement Program
Effort to increase mean time between failures of candidate EW systems by two orders of magnitude. Envisions integration of MMIC technology into active, phased-array apertures. **Contractors:** TRW, Northrop, Westinghouse, TI, Raytheon. **Status:** Development.

Expert Avionics Code Modifier
Program to provide technologies for rapid and efficient maintenance and modification of avionics application software. **Contractor:** General Research. **Status:** Development.

Full-Spectrum FLIR
Effort to develop an electro-optical, thermal-imaging, air-to-ground sensor capable of operating over the future battlefield while enabling the launching aircraft to avoid detection. **Contractor:** None. **Status:** Development.

Generic Algorithms for Vision Learning
Establishment of a test-bed for development of vision experiments that combine advanced learning mechanisms with earlier image operations to form new symbolic representations. **Contractor:** None. **Status:** Development.

Have Glance
Program to develop advanced concepts to counter infrared surface-to-air and air-to-air missiles. **Contractor:** Loral. **Status:** Design.

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:** Concept demonstration.

Integrated Communication Navigation Identification Avionics System
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 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.

Integrated Terrain Access and Retrieval System
Program to develop and demonstrate a digital database management system for instantaneous display of terrain data that can be integrated with navigation systems for terrain following and terrain avoidance. **Contractor:** Hughes. **Status:** In-house evaluation.

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
Design and development of an integrated diagnostics concept to address maintenance issues in Pave-Pillar-type avionics. **Contractor:** None. **Status:** Development.

Pave Pace
Design and demonstration of key elements of an advanced avionics architecture for the 21st century. Exploits potential of emerging technologies in parallel processing, optoelectronics, and artificial intelligence. **Contractor:** None. **Status:** Concept definition.

Resonant Fiber-Optic Gyro
Program to develop and demonstrate feasibility of an inertia 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, Honeywell, TI. **Status:** Development.

Strategic Targeting Laser Radar Technology
Development and demonstration of critical technologies and components needed to produce a CO_2 laser radar sensor that can permit manned bombers to recognize and attack relocatable targets. **Contractor:** None. **Status:** Development.

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.

VHSIC Avionics Modular Processors
Investigation of an expandable, modular computer system, consisting of the MIL-STD-1750A processor module and external input/output modules. Aims for improvement in throughput and

smaller size of equipment. **Contractor:** Westinghouse. **Status:** In-house evaluation.

Electronics Technology Laboratory

Device Research
In-house III-V semiconductor basic research using state-of-the-art molecular beam epitaxy, electron-beam lithography, and reactive ion etching (RIE) technologies for developing new microelectronic and electro-optic device designs and processes. **Contractor:** N/A. **Status:** Ongoing.

Microelectronics Manufacturing Science and Technology
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 deposition (PECVD), and *in-situ* sensors with expert system process control for low-volume, military, semiconductor products. **Contractors:** TI with Stanford University subcontract. **Status:** Development.

Microwave/Millimeter Wave Monolithic Integrated Circuits
This DARPA/Triservice program is to develop affordable gallium arsenide MIMICs for advanced DoD systems. MIMIC development areas, such as computer-aided design, chip fabrication, testing procedures, packaging, and manufacturing, are emphasized. Brassboard chip and module demonstrations are being conducted to support radar, electronic warfare, communications, and smart weapons applications. **Contractors:** Phase I: Hughes Aircraft/GE. Phase II: Contract not awarded. Phase III: AT&T, Varian, Gateway Modeling, M/A-COM. **Status:** Ongoing.

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

Flight Dynamics Laboratory

Advanced Fighter Technology Integration F-16
Program to develop, integrate, and validate 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, and voice-interactive avionics. **Contractor:** GD. **Status:** Final reports being completed.

AFTI/F-111 Mission Adaptive Wing
Development and flight-test of a wing that increases range, maneuverability, survivability, flexibility, and agility by automatically changing shape in flight in response to pilot commands, flight conditions, and configuration. **Contractor:** Boeing. **Status:** Final reports being completed.

Aircraft Windshield System Development
Integration of emerging technologies into operationally acceptable transparency systems compatible with evolving military missions and having supportability as a measurable, deliverable feature. **Contractor:** In-house. **Status:** Continuing.

Carbon-Carbon 2D Exhaust Nozzle Structures
Program to develop the technologies required to design and manufacture advanced engine thrust-vectoring/thrust-reversing nozzle components of oxidation-protected carbon-carbon composites. **Contractor:** General Electric. **Status:** Materials testing on F110 engine. Designing components for ATF engine tests.

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:** McDonnell Douglas. **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 Aerospace. **Status:** Final design, fabrication, and 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:** McDonnell Douglas. **Status:** Flight test.

STOL and Maneuver Technology
Program to develop and flight-test, on an F-15 test-bed, advanced technologies to provide STOL capability for supersonic fighters while enhancing cruise performance and maneuverability. Technologies include two-dimensional thrust-vectoring/reversing nozzles, integrated flight and propulsion control system, rough field landing gear, and advanced pilot/vehicle interface. **Contractor:** McDonnell Douglas. **Status:** Flight test.

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:** Continuing.

Structural Improvement of Operational Aircraft
Investigation of how to achieve improved durability and reduced cost through design, fabrication, and installation of advanced secondary components in operational aircraft. **Contractor:** LTV. **Status:** Complete. F-111 spoiler preferred spares buy in progress.

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:** Complete. Detail design under way.

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 test.

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, and missiles. **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 optoelectronic devices, and high-speed missiles and aircraft. **Contractors:** AT&T, GE, Hughes, Rockwell, U. of Dayton Research

Institute, Westinghouse, others. **Status:** Research and exploratory development.

Hardened Materials/Airborne and Space Subsystems
Development of 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, McDonnell Douglas, 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 structures. **Contractors:** Many. **Status:** Research and exploratory development.

Manufacturing Research
Provide the technology base for early introduction of advanced materials and processes into manufacturing; for significantly reduced new product cycle time, acquisition, and life-cycle cost; and for flexible, low-volume, high-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 attain 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 utilize 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 Research and Development
Exploratory and advanced development of new, more accurate, more reliable, nondestructive/inspection (NDE/I) capabilities to support weapon systems quality assurance and reliability and maintenance programs within the Air Force. These methodologies are used to characterize hidden, minute defects; other failure-causing conditions (cracks, delaminations, corrosion, etc.); and materials conditions/properties in both advanced structural materials and fabricated/assembled components in both the manufacturing and in-service NDE/I operational settings. **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:** McDonnell Douglas, 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. Provide 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.

Laboratory Directorates

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, McDonnell Douglas. **Status:** Manufacturing technology.

Assault Transport Crew Systems Development
Effort to define and develop crew system concepts for an advanced assault transport to support SOF missions. **Contractor:** None. **Status:** Proposal evaluation.

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 transition from existing factory systems to advanced-technology solutions. **Contractors:** Northrop and its subcontractors. **Status:** Manufacturing technology.

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. **Status:** Development.

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

Information Management Technologies
Initiative to advance the state of the art in certain key technology areas that have been determined to be critical to enterprise integration. **Contractor:** None. **Status:** RFP preparation.

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

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 RSG, TI/Westinghouse Joint Venture. **Status:** Manufacturing technology.

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 domestic source for same. **Contractor:** TI. **Status:** Manufacturing technology.

Microelectronics Manufacturing Science and Technology
See description of this program under Electronics Technology Laboratory, page 50.

Panoramic Cockpit Control and Display System
Demonstration of advanced control and display techniques in a full-cockpit simulation. Possible application to F-15 in the mid-1990s. **Contractor:** McDonnell Douglas. **Status:** Development.

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

Product Data Technology
Initiative for tackling technology and standards issues relative to the generation, use, transfer, and storage of the digital information required to define a product completely. **Contractors:** Northrop, P&W, McDonnell Douglas, ICAD, others. **Status:** Manufacturing technology.

Technology Exploitation
This management thrust is embodied in the Technology Exploitation Directorate. It oversees the strategic management of WRDC's 6.3 and 6.2 programs and makes their transition into weapon system acquisition programs. The program includes management of key high-emphasis multidisciplinary activities, assessment of competing technology alternatives, and Center-wide investment strategy. **Contractor:** None. **Status:** Continuing.

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:** FMC Perceptronics. **Status:** Development.

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.

Allied Standard Avionics Architecture Council
International avionics technology-sharing forum established to promote allied cooperation in the design, development, and acquisition of avionics systems. **Contractor:** None. **Status:** Continuing.

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

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:** Air Force coordination.

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 (*e.g.*, compilers, linkers, debuggers) 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 Labs, Charles Stark 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:** The Analytic Sciences Corp., Information Spectrum Inc. **Status:** Continuing development.

Deputate/Development Planning

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's definition of characteristics for a next-generation theater airlifter and to identify system options and critical technologies. **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
Develop concepts that consider the interaction of avionics with the airframe and armament to ensure a balanced, effective design. **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. Concepts spanning the range of velocities from Mach 4 to orbital speeds will be assessed. **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.

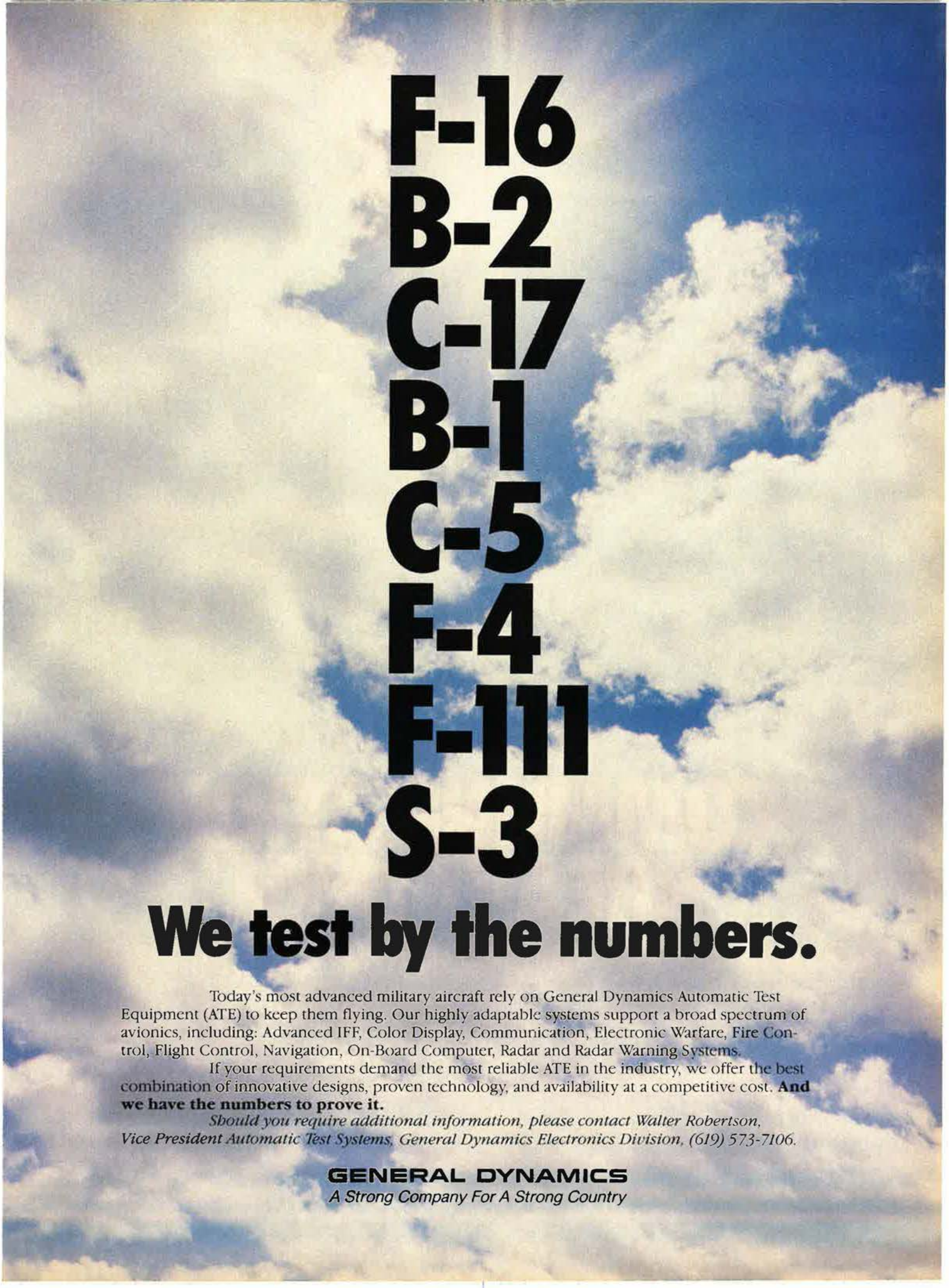
Infrared/Electro-Optical Sensor Trends and Requirements
Investigation to provide an assessment of performance capability and availability of specific IR and EO technology. Focus will be on next-generation aircraft and future-generation aircraft. **Contractor:** MacAulay-Brown, Inc. **Status:** Continuing.

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

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; their related environmental impacts; and communication infrastructure issues associated with mission planning. **Contractor:** Science and Engineering Associates, Inc. **Status:** Continuing.

Mission/Flight Systems Integration
Development of Functional Capability Requirements for future aircraft electronic/avionics systems for a variety of emerging vehicles and missions. Assessment of conceptual approaches to functional integration of avionics and flight systems. **Contractors:** Illinois Institute of Technology Research Institute; Frontier Technology, Inc.; McDonnell Aircraft Co. **Status:** Continuing.

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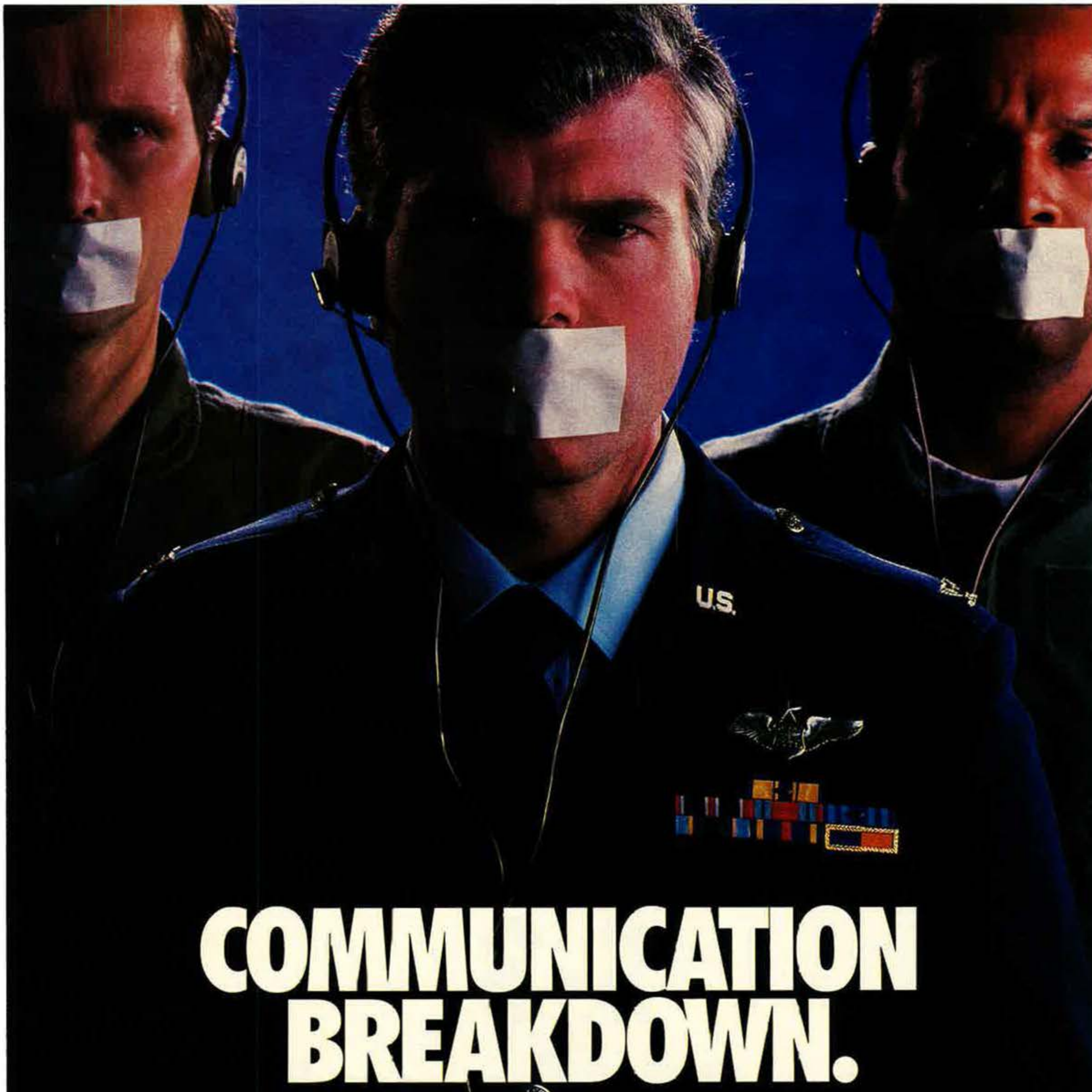

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Special Operations Aircraft
Definition of long-range survivable system concepts and needed capabilities for a new special-operations airlift vehicle. **Contractors:** In-house, Boeing, Douglas Aircraft, Lockheed. **Status:** Preconcept definition.

Specialized Undergraduate Pilot Training (SUPT) 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.

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.

Deputate/Engineering

Aircraft Structural Integrity Program
Program to tie together 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
Structured design process to ensure that development of avionics systems meets reliability and safety requirements. **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, Marcon, Rockwell, TRW. **Status:** Continuing.

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 specs and standards placed on contract and to eliminate overspecification of programs. **Contractor:** None. **Status:** Continuing.

R&M 2000
Enhanced systems-engineering process promulgated 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
This program is 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 University), 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 Aircraft. **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, and 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 module, a real-time test data monitoring module, and a module for improved data computation and analysis. The GBL 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:** Various. **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.

Milstar
A C-18 aircraft has been modified to test and to prove the feasibility of the EHF/UHF Airborne Command Post Milstar communications terminal. An NKC-135 will be flight-tested to collect data that will be used in the airworthiness certification of the radome installation on the SAC EC-135. **Contractor:** Electrospace Systems Inc. **Status:** Flight test.

Testing Off-the-Shelf Aircraft
This program provides evaluation of civil aircraft against specific military requirements. Areas of evaluation include ground handling, maintenance, flying qualities, performance, and human factors. Recent evaluations of off-the-shelf aircraft have resulted in the selection and procurement of the C-12, C-18, C-20, C-21, C-22, C-23, and the Air Force One replacement aircraft. **Contractors:** Various. **Status:** Continuing. ■

Political transformation is intensifying, not diminishing, the importance of quality in military aeronautics.

—Staff photo by Jeffrey P. Rhodes

Change on the Wing

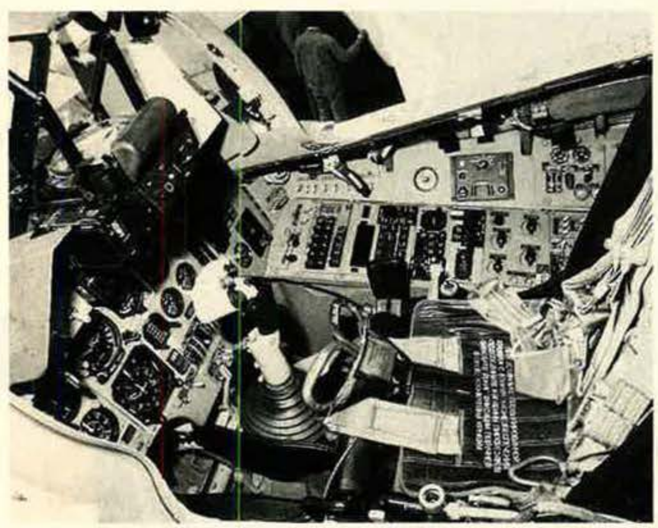
By John W. R. Taylor

FOR some time, Western analysts had been puzzled by pictures taken by their military reconnaissance satellites over the Soviet experimental flight test center at Ramenskoye, near Moscow. It has been routine for years to monitor the progress of new aircraft prototypes under development there and at other airfields near Soviet Experimental Design Bureaus (OKBs) and manufacturing facilities.

In 1989, however, Ramenskoye was strangely barren of such aircraft. The big question is whether or not this reflects another of President Gorbachev's much-heralded policies, *konversiya,* under which military expenditure and production are being cut back in favor of civilian and consumer commodities.

It would be foolish to imagine that the Soviet Union, any more than the US, is ready to end development of more advanced combat aircraft and switch primarily to work on commercial programs. It cannot have escaped the Kremlin's notice that the UK government, watching with some dismay the deactivation of USAF ground-launched cruise missile installations at RAF Greenham Common and RAF Molesworth in England, is reportedly eager to welcome nuclear-armed F-15Es in their stead. On the other side, it is likely that the availability of fighters as good as the Su-27 "Flanker" has enabled Soviet air forces to forgo the successors that would normally have followed within ten years and progress directly toward an equivalent of USAF's Advanced Tactical Fighter (ATF).

Support for this view came from Sukhoi's General Designer Mikhail P. Simonov and Deputy Chief Designer Nikolai F. Nikitin at the Paris Air Show in June. They



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Instrumentation in the cockpit (above) of the Sukhoi Su-27 "Flanker," seen at the Paris Air Show last summer, is of 1960s vintage, and the airframe (right) contains little composite material. Still, the high quality of today's Su-27 and plans to build improved versions permit the USSR to move directly into development of a Soviet equivalent of USAF's Advanced Tactical Fighter.

emphasized that the present Su-27 has the characteristics to be expected in an early 1970s design (the prototype, known as Model 1021, flew on May 20, 1977). There is a great deal of titanium in the airframe, but little composite material. Instrumentation in the cockpit is of 1960s vintage, except for an interesting vertical-readout fuel gauge. Improved versions of the Su-27 are promised, and an example displayed at the next Paris Air Show in 1991 will have a more up-to-date "glass" cockpit featuring CRT displays. A retractable in-flight refueling probe is also likely, in front of the cockpit on the port side. The current standard version of the fighter can fly 2,500 miles on internal fuel, which eliminated the requirement for even external tanks until a probe was added to the Su-24 "Fencer" attack aircraft, which "Flanker" is intended to escort on deep penetration missions. With in-flight refueling from an Il-78 "Midas" tanker and an Su-24 carrying a buddy pack, an endurance of sixteen hours has since been demonstrated.

A film screened openly at Paris showed other techniques and equipment that have been tested on experimental variants of the Su-27. One aircraft was seen making repeated ski-jump takeoffs and arrested landings during the trials program associated with imminent commissioning of the Soviet Navy's first 65,000-ton carrier. Another, designated Model 1024, had canard control surfaces on the forward fuselage and vectoring jet nozzles, like those of the McDonnell Douglas F-15 S/MTD (Short Takeoff and Landing/Maneuvering Technology Demonstrator), which flew for the first time on September 7, 1988.

Mr. Simonov said that the resulting improvement in takeoff performance was so small that similar modification of the production Su-27 was not worthwhile. However, foreplanes and vectoring nozzles also offer enhanced maneuverability in combat. In light of the already impressive tight turning circle of the Su-27, the Soviet air forces' "ATF" could well embody foreplanes and vectoring nozzles as well as in-flight refueling capability.

Sights, Servicing, and Survivability

In some areas, the Soviet air forces already insist on features that could give their aircraft an operational edge over NATO. Infrared search and track (IRST) sensors, abandoned years ago by USAF as being unaffordable, are standard on all three types of present-generation Soviet air combat fighters. Integrated fire-control systems enable the coherent pulse-Doppler radar, IRST, and laser rangefinder of the Su-27 and MiG-29 to be slaved to the pilot's helmet-mounted aiming device and displayed on the wide-angle HUD.

Ease of servicing under extreme climatic conditions has received special attention. A requirement for the Su-27 was that between-flights servicing be practicable for personnel wearing thick gloves under Arctic conditions. There are no access panels in the top of the center fuselage. Instead, all "black boxes" are withdrawn downward from inside the large nosewheel bay, so that neither ground crew nor avionics is exposed to rain or snow.

It is less easy to enthuse over the Su-25 "Frogfoot," the 1980s Soviet counterpart of the wartime Il-2 Shturmovik that Joseph Stalin claimed was "as essential to the Red Army as air and bread." It has the same kind of massive wings, is highly maneuverable, and can operate from rough unpaved strips of less than 4,000 feet while carrying four tons of weapons. The pilot sits in an all-welded cockpit of titanium armor, which, with other carefully conceived survivability features against small antiaircraft missiles and cannon shells of up to 30-mm caliber, accounts for 7.5 percent of the aircraft's normal takeoff weight. Containers for a total of 256 infrared countermeasures flares, sufficient to provide protection during eight attack runs, extend down the spine of each engine nacelle and above the tailcone. However, even a maximum speed of Mach 0.8 (608 mph) at sea level makes the Su-25 little more attractive than an A-10 for a pilot in a modern front-line environment.

The Su-25 does have some features that reflect the same thoughtful design that produced the Su-27. Its

—Mike Keep/Jane's Information Group

This artist's concept shows an advanced Su-27 warplane fitted with canards and thrust-vectoring engine nozzles—already tested on an experimental "Flanker." Even though such devices probably won't be found on any new production Su-27s, advanced foreplanes and nozzles could well be installed on the next-generation Soviet "ATF," making it more agile than even the Su-27.

—Photo by Mike Jerram

Flare containers on the engine nacelle of a Sukhoi Su-25 "Frogfoot," shown in Paris. The Su-25 has massive wings, is highly maneuverable, and can operate from short, rough, unpaved air strips.

Tumansky R-195 nonafterburning turbojets, based on the well-proven engine of the MiG-21, can operate on any fuel likely to be found in a combat area, including MT gasoline and diesel oil. It can carry on its underwing pylons a four-pod servicing kit adequate for all routine needs during a twelve-day deployment to a forward base, independent of on-site ground equipment. This kind of thinking keeps airplanes flying and wins battles, as well as making ground crews feel that somebody understands their problems.

The Mi-28 "Havoc," the Eastern counterpart of the US Army's AH-64A Apache, displays similar attention to front-line needs. Its 30-mm gun is identical with that used on Soviet Army BMP-2 armored personnel carriers. This means that if it runs out of ammunition, the pilot need only land near the army unit he is supporting and replenish his twin ammunition boxes from its supply. The boxes are attached to the gun mounting. They rotate with the gun through 110 degrees to each side, elevate thirteen degrees, and depress forty-five degrees with it, thus preventing the gun jamming that has been experienced with some Western helicopter armament.

Parachutes are mandatory for Soviet military helicopter aircrew. If the crew of an Mi-28 had to use them, an emergency system would blast away the rearward-opening doors and the stub-wings and inflate a bladder beneath each doorway. As the pilot and gunner left the aircraft, the bladders would ensure that they bounced clear of the landing-gear mainwheels. Perhaps by good fortune rather than original intent, a compartment in the center fuselage of the Mi-28 is large enough to enable the pilot to land, retrieve two colleagues stranded in hostile territory, and fly them to safety. The advantages compared with calling up a dedicated search and rescue helicopter are obvious.

A tiedown point in the tip of each stub-wing might prevent the kind of damage that made 120 Apaches unserviceable when hurricane-force winds overturned them in Texas and South Carolina last year. By inserting a handcrank into each wingtip, weapons can be mounted on the pylons without need for a hoist or other ground equipment.

Flyby over Tushino

Two months after the Paris Show, on August 20, the Kremlin staged its first major public air display in twenty-two years. Aviation Day flybys in the 1950s and 1960s always included hitherto-unknown prototypes that set the popular press conjecturing for months afterward about imminent Soviet leadership in the air. Things were different in 1989. As at Ramenskoye, nothing flew over the airport of Tushino, near Moscow, that was not already known and reported in the March 1989 Air Force Magazine Soviet Gallery.

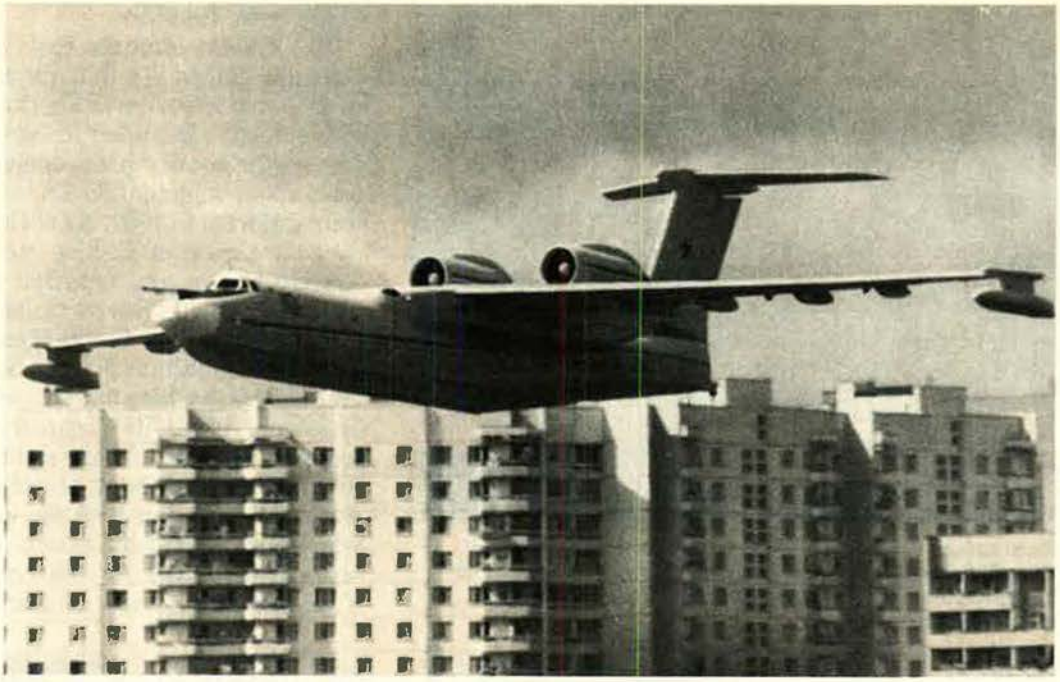
Admittedly, the C-130-sized A-40 Albatross twin-turbofan amphibian had not previously been photographed by anything but Western satellites orbiting over Taganrog. At last, its elegant form could be admired, the length of its weapons bay estimated at twenty feet, and its usefulness assessed. Maritime patrol and ASW roles were not highlighted by the commentator at Tushino, who concentrated on search and rescue capability. It was suggested that the A-40 could alight on the open sea if another Soviet Navy nuclear submarine ran into trouble and could assist or pick up the crew. Sturdy as the A-40 appears to be, this would surely call for an unusually calm sea.

—Photo by Brian M. Service

The Soviet Mi-28 "Havoc" is the Soviet counterpart to the US AH-64 Apache attack helicopter, and it is designed with front-line needs in mind. The undernose gun on the Mi-28 is also a standard weapon on many Soviet ground vehicles.

Apart from a Tu-160 "Blackjack" supersonic strategic bomber that traversed the airfield in high-speed, low-level flight, all else had been seen before in public. A static display at Moscow's Khodinka Airport added to the list a "Helix-B" shipborne assault helicopter, which proved to be designated Ka-29, but an example of this had been identified and photographed from a French Navy aircraft, on board the landing ship *Ivan Rogov* in the Mediterranean, as early as 1987.

As a result, interest for Western observers at Khodinka focused largely on an array of air-to-air and air-to-surface missiles, with a first opportunity to see at close quarters such weapons as the highly maneuverable AA-11 "Archer," which might be regarded as being in the class of the still-awaited Western AIM-132 ASRAAM. It was shown on the wingtip launcher of an



—AP LaserPhoto

The A-40 "Albatross," the Soviet Union's elegant new amphibian craft, made its public debut last August in a flyby at the Moscow Air Show. Soviet officials describe the A-40, which might be able to land on open ocean, principally as a sea search and rescue plane. However, the plane has a clear capability to carry out naval missions such as maritime patrol and antisubmarine warfare.

Su-27 and on the center underwing pylon of a MiG-29. Underneath an Su-24 was an antiradiation missile assumed to be either an AS-12 "Kegler" or, possibly, an AS-11 "Kilter."

Not exhibited were the MiG-31 "Foxhound," the Kamov combat helicopter known to NATO as "Hokum," the Soviet counterpart of the US Lockheed U-2/TR-1 illustrated for the first time in the 1989–90 edition of *Jane's All the World's Aircraft*, and the new Yak-41 supersonic V/STOL carrier-based combat aircraft, of which an artist's impression appears in the 1989 edition of DoD's *Soviet Military Power*. Thus it cannot yet be determined whether the Yak-41 retains the dual liftjet/propulsive jet primary powerplant configuration of the Yak-38 "Forger" or has progressed to a single integrated lift/thrust engine like the Harrier's Rolls-Royce Pegasus. What is virtually certain is that it will serve on the Soviet Navy's large carriers, with navalized versions of the Su-25, Su-27, and Kamov "Hokum" all lined up as further candidates for the naval air wings.

Stealth and STOVL

There is little need to remind AIR FORCE readers of the dozens of diverse fixed-wing V/STOL concepts that have been projected, built, tested, and discarded in the US, Europe, the USSR, and elsewhere since the Second World War. Only the vectored-thrust system of the Harrier has proved entirely satisfactory in first-line service, although the Soviet Yak-38/41 formula has, at least, justified operational deployment.

It is difficult to understand how the Anglo-US government team, sitting in solemn judgment on where we might go in supersonic STOVL configurations in the 1990s, came to the conclusion that vectored thrust is insufficiently promising. Work in the US and UK is to be concentrated on an augmented flow system (which failed to work in the Lockheed XV-4A of the 1960s and the Rockwell XFV-12A of the late 1970s) and a device termed the remote augmented lift system, which fills the fighter with hot ducting.

Much the same thinking afflicts Western supersonic/hypersonic transportation programs. Because development of the Concorde cost the UK and France a great deal of money, and because it costs more to cross the Atlantic by Concorde than by 747, everyone associates supersonic air transportation with generally unaffordable expense. Speed has always been the number one benefit offered by air travel, and the best way to cut costs is to increase the number of seats in each aircraft. A 250-seat SST with modern engines would reduce fares to a level that would encourage airlines with long overwater routes to invest in initially modest fleets. Development costs should be relatively lower, on the basis of experience with Concorde, provided a cruising speed of around Mach 2.2 were considered acceptable. Sales of 500 to 1,000 aircraft would then make the entire program viable.

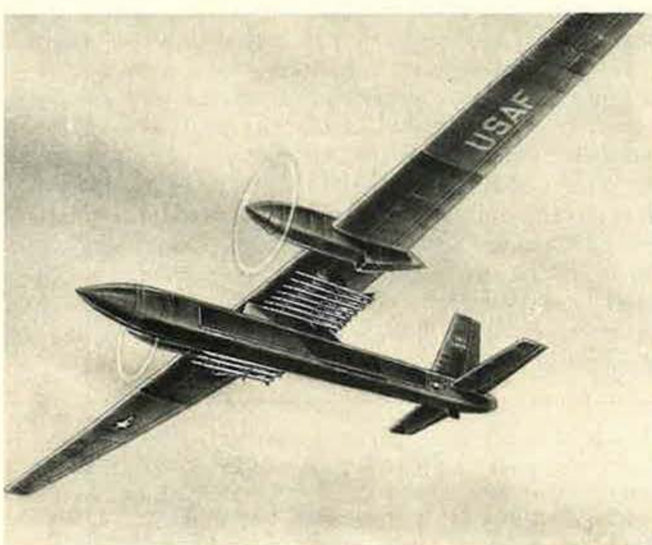
Japan plans first flight in 1992 of the Ishida TW-68, a tilt-wing transport similar to the V-22 Osprey. Less complex than the V-22, it will have maximum VTOL takeoff weight of only 12,500 pounds and seating for up to sixteen passengers.

Designs for such aircraft are under way, or about to be started, in Japan and France, but the Soviet Union might well set the pace this time, having shrugged off the disappointment of its original Tu-144 SST. At that period, available engines lacked the fuel economy essential for such an aircraft. Today, the Lotarev and Soloviev OKBs offer modern turbofans producing up to 51,590 pounds static thrust, with specific fuel consumptions comparable with large Western engines. Added to experience gained with such aircraft as the Tu-26 "Backfire" and Tu-160 supersonic strategic bombers, there is little reason to doubt that Soviet engine OKBs could now provide the powerplant for a thoroughly acceptable SST. In any case, airlines in the East are already being supplied with Boeing and Airbus transports powered by the best available Western commercial engines. We may well see Soviet airliners like the new Il-96-300 and Tu-204 flying with Rolls-Royce turbofans before long.

Is Leadership Passing?

Models of supersonic aircraft able to carry from twelve to several hundred passengers have been exhibited on Aviaexport and Soviet research center stands at Western air shows, and Soviet OKBs seldom fail to translate such models into full-scale aircraft. The current pacesetter is the Sukhoi bureau, which has emphasized its commitment to *konversiya* by revealing models of everything from a four-seat piston-engined general aviation aircraft with foreplanes to an eighteen- to nineteen-seat tandem-wing multirole transport powered by twin turboprops to SSTs of various sizes.

Best-publicized of these has been the supersonic business transport that may form the basis of a joint program between Sukhoi and America's Gulfstream Aerospace Corp. A memorandum of understanding covering joint studies was signed after negotiations began at the 1989 Paris Air Show. Gulfstream's CEO, Allen Paulson, stated that Sukhoi "appears to be years ahead of the rest of the world in the design and development of supersonic aircraft which can be used for business flying." He added his belief that this Soviet OKB could have a



—Mike Keep/Jane's Information Group

This artist's concept of a new, more survivable airborne warning and control system aircraft includes features of the Boeing Condor unmanned air vehicle. A survivable AWACS is urgently needed by air forces worldwide.

The US-built V-22 Osprey is much larger than Japan's VTOL transport entry, the TW-68. The Osprey has a maximum VTOL takeoff weight of 47,500 pounds and seats twenty-four passengers. Its pivoting wings and tilting rotor pods enable it to meet shipboard stowage requirements.

twelve- to twenty-one-passenger SST prototype flying within three years and in production in five.

The vast distances that separate major cities in the USSR clearly provide an incentive for the use of such aircraft. Nor do environmental issues such as sonic booms represent a major deterrent where so much of the terrain is sparsely populated and where people retain an old-fashioned pride in national technological achievement. Beyond the SSTs of this generation are the HSTs (hypersonic transports) and TAVs (transatmospheric vehicles) of the first half of the twenty-first century. Now that even subsonic bombers already cost more than half a billion dollars each, an age in which world peace could be maintained by a handful of TAVs, able to drop down out of orbit on reconnaissance or pinpoint attack missions and then return to orbit, as units of a truly international policing force, has great attraction.

Leadership in some of the most challenging and worthwhile aviation technologies for the next century could pass from West to East. As well as launching studies for supersonic and hypersonic transports, Japan intends to develop for first flight in 1992 a tilt-wing transport known as the Ishida TW-68. It will be less complex than the V-22 Osprey, which needs pivoting wings as well as tilting rotor pods to meet requirements for shipboard stowage. Ironically, although Japanese-funded, the TW-68 is being designed by DMAV (Dual Mode Air Vehicle) Inc., a Texas company that includes former Bell employees in its work force.

The TW-68 is considerably smaller than the Osprey, with a maximum VTOL takeoff weight of only 12,500 lb (against 47,500 lb) and seating for up to sixteen, rather than twenty-four, passengers. It will be large enough for many tasks, such as support for offshore oil rigs, where a cruising speed of 215 to 308 mph would offer major time savings over helicopters currently in use.

Get the Act Together

Quality control has become a major concern on the assembly lines of new airliners as much as for those

Possible development of new supersonic civilian transport planes is being studied in France, Japan, and the Soviet Union. The latest French concept to emerge is Aérospatiale's ATSF, or "Avion de Transport Supersonique du Futur," shown here in model form. The ATSF would be a 200-passenger successor to the Anglo-French Concorde, built in the 1970s.

operators whose fleets include a high proportion of aging aircraft. After years of outstanding improvement, safety records have begun to take a beating. Acceptable levels depend almost entirely on the dedication of highly trained engineers in factories and on maintenance bases. Nothing could be more alarming than the editorial "Unskilled and Unprepared" in the October 1989 issue of Air Force. The situation it describes threatens the high-tech industries of the UK and western Europe as much as it threatens the US, and the time has come for the West to begin putting matters to right.

In the century of the X-30 National Aerospace Plane, it will not be good enough if "the *average* Japanese high school student consistently does better at math than the top five percent of American students do" and that in a sixteen-nation comparison of science achievement, US ninth-graders continue to be next to last. The prospect of US companies, by the year 2000, having to hire 1,000,000 new people a year who cannot read, write, or count is frightening.

Even in commercial aviation, where Europe and the US have set the pace for seventy years, the pendulum is swinging eastward. The Director General of IATA (International Air Transport Association) said recently that "the Asia/Pacific share of international scheduled passenger traffic will increase to almost forty percent by the year 2000—the highest percentage for any of the world regions."

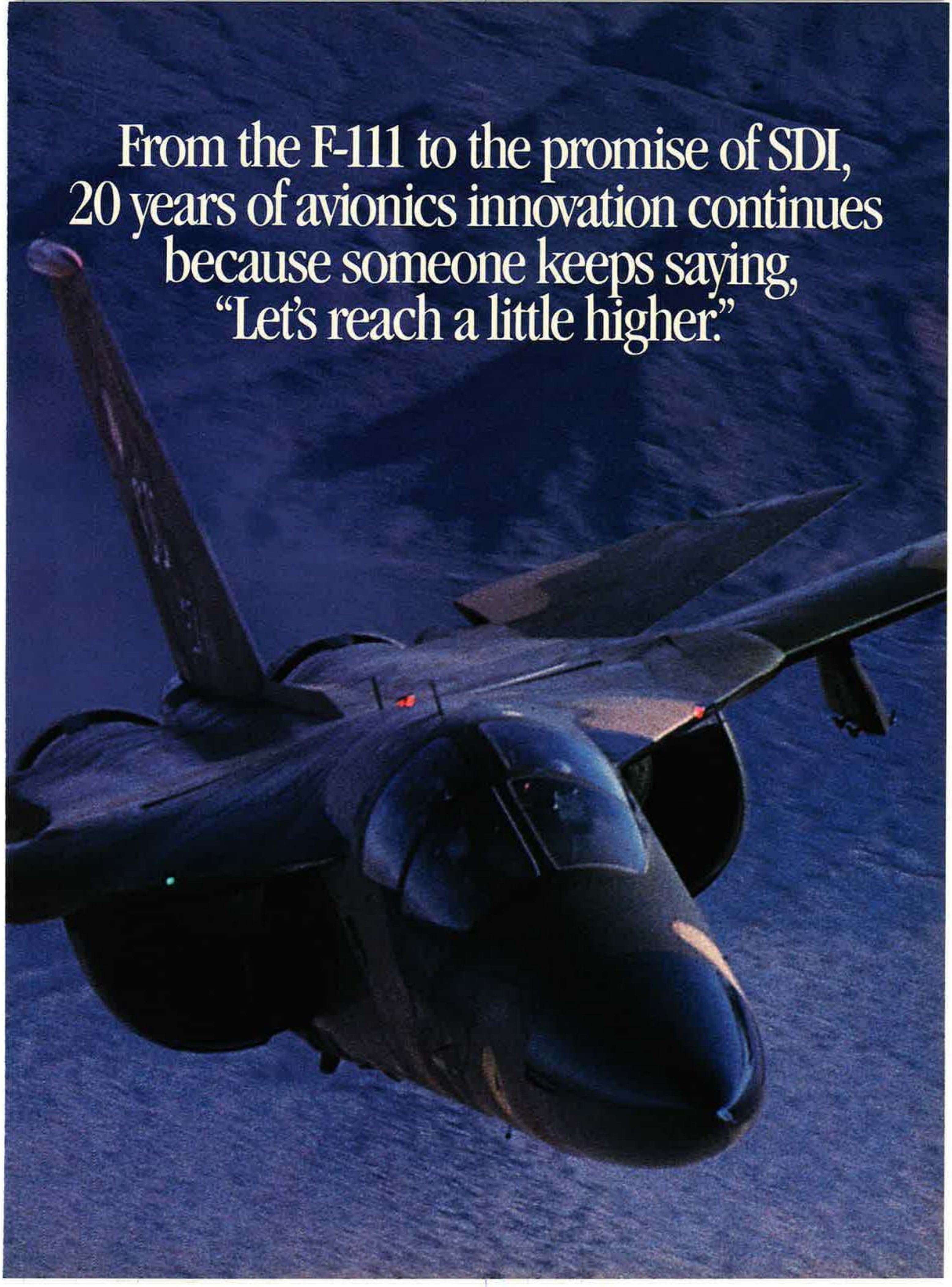
Whether or not we like it, further consolidation of the US aerospace industry through mergers and sales seems inevitable in the 1990s. In Europe, aerospace will thrive only by concentrating on the kinds of international joint programs that produced Concorde, Tornado, and the Airbus family. Whatever the profitability of such ventures might be in financial terms, their real importance to the West is that they have kept much of western Europe's aircraft industry alive, busy, and in the forefront of technology.

If this appears in any way to conflict with US interests, it is worth remembering that all Airbuses yet flown have either US engines or engines built in partnership with the US, whereas a sizable proportion of Boeing jetliners have British-built Rolls-Royce engines. The safety record of the Airbus family, like that of Concorde, must have helped to keep all other airliner manufacturers on their toes. In the military field, it is not the fault of Europe's engineers that the V/STOL Harrier lacks a supersonic successor.

Europe's national aerospace industries must now get their act together—literally. At present, good, but not really good enough, competitive fighters are being developed at high cost in France and by a UK/German/Italian/Spanish consortium, not to mention the Gripen of neutral Sweden and Novi Avion of nonaligned Yugoslavia. There are programs for at least three competing European attack helicopters, not quite in the class of the Apache and Mi-28, and a variety of trainers, transports, and other aircraft all battling against each other in the marketplace, a ridiculous state of affairs.

What is needed is an industrial—not governmental—committee, whose professional advice governments would respect, capable of identifying future requirements for military and civil aircraft and of coordinating the efforts of Europe's individual national industries to develop and build them. Without action of this kind, in a period when the aerospace industries of such nations as Japan, China, India, and Indonesia are growing rapidly in size, experience, energy, and success, the odds against continuing US/European leadership in the air must lengthen daily. ■

John W. R. Taylor, a longtime Contributing Editor to Air Force *Magazine, is Editor Emeritus of the world-renowned* Jane's All the World's Aircraft. *A Fellow of the Royal Aeronautical Society and the Royal Historical Society, Mr. Taylor compiles or edits for us the galleries of aerospace weapons that appear in the USAF Almanac and Soviet Aerospace Almanac issues of this magazine, the "Gallery of West European Airpower," and last month's "World Gallery of Trainers."*


From the F-111 to the promise of SDI,
20 years of avionics innovation continues
because someone keeps saying,
"Let's reach a little higher."

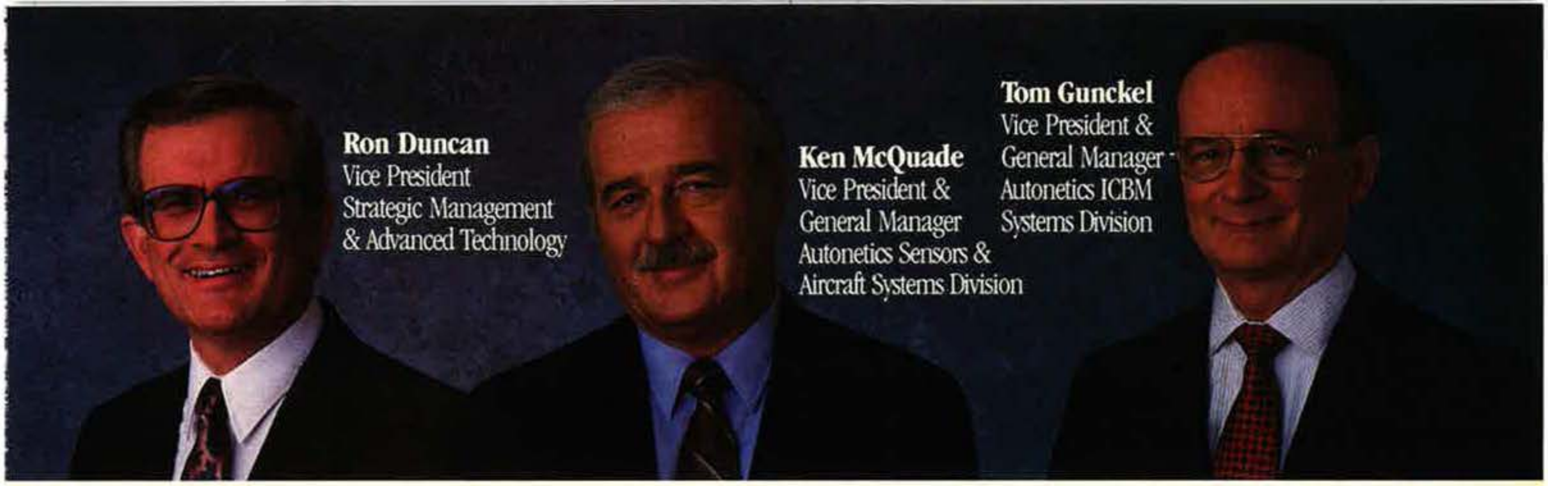
From equipping the nation's ICBM and nuclear submarine fleets with state-of-the-art electronics and software systems, to delivering tactical superiority with HELLFIRE, the Autonetics people of Rockwell International have established a legacy of performance. This heritage of quality and technology continues today—with strategic and tactical systems for land, sea, air and space. Here's the story from the people who help make it happen.

Mid 50's
G6 gas spin bearing gyro rotor.

Early 60's
Minuteman I inertial guidance system.

Late 60's
F-111D navigation set and attack radar.

Mid 70's
Laser seeker development sets stage for HELLFIRE.



Washington: Autonetics has been contributing a variety of technologies to the national defense for a very, very long period of time.

McLuckey: Starting with programs as far back as the mid-50's, teamwork and pride in quality workmanship have been driving the organization's progress.

Gunckel: In the guidance area, you can see the steady evolution of state-of-the-art technology to meet customer requirements with equipment that's smaller, lighter, more reliable and much less expensive than the prior generation.

McQuade: And there's been similar progress in the areas of processing and software.

Washington: For example in data multiplexing activities for the Navy, our system is in effect a Local Area Network. We have to interface with all the major weapon systems, command and control media and displays on board ship.

McLuckey: We've also built upon our knowledge of avionics and avionics system integration by applying research and development monies towards solving the customer's future needs in the areas of terrain following and obstacle avoidance.

Duncan: That's a characteristic of what we do. We take on these challenges to develop new products, in anticipation of the market.

McQuade: That's the case with a lot of the technology that applies to SDI. We see derivatives being very important to the tactical world. Miniature sensors. Miniature seekers. We are doing front-end work in support of both of those.

Duncan: The same can be said for our investment in IR technology, where today we're being approached by every major weapon-system supplier that uses electro-optic devices.

McLuckey: We've become one of the two preeminent suppliers of focal planes in the United States. We've won major producibility contracts that will allow us to get the cost per pixel down, which is a necessary prerequisite to sell and incorporate focal planes into numerous tactical weapons.

Smith: But success takes more than technology. We're also committed to employee involvement, communication and continuous improvement.

Gunckel: We've always been willing to adapt and change to meet the changing requirements of the customer. Both in terms of technology, and the way we do business. This approach allows us to focus not just on the lowest cost, but on the most cost-effective solution—the best-value solution.

Smith: Our customers see it. They've said that of all the businesses they work with, we're one of the best hands-on examples of real Total Quality Management at work.

Let's reach a little higher.

Autonetics is part of the worldwide Rockwell International team of more than 100,000 people. Working together and with our customers, we apply science and technology to reach a little higher in developing advanced systems for strategic and tactical defense. For more information, please call: Science and Technology, Rockwell International, Autonetics, (714) 762-7775.

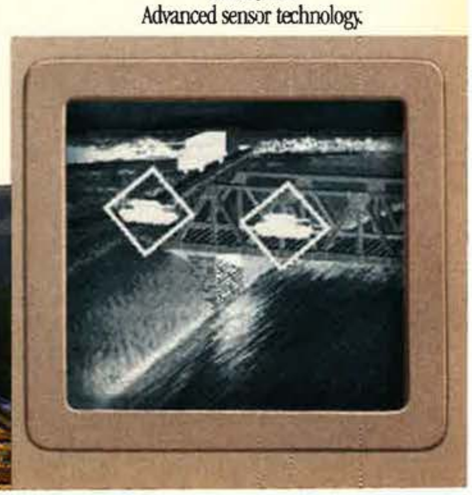
Rockwell International

...where science gets down to business

Mid 80's
Royal Australian Navy Submarine systems integration.

Late 80's
Peacekeeper Rail Garrison launch control system.

Mid 90's
Advanced sensor technology.



Pave Pace architecture will put at least eight new technologies into the air.

The Next Generation of Avionics

By John Rhea

EVER since the Digital Avionics Information System (DAIS) program in the 1970s, USAF has taken the lead among the services in working out system architectures for new-generation aircraft. The purpose has been to create mechanisms to integrate almost-predictable advances in computers, sensors, and data links into operational avionics.

As the pace of advances quickened during the 1980s, DAIS evolved into a new program known as Pave Pillar. Among the significant technologies gathered by Pave Pillar were standard electronic modules (SEMs) built out of high-performance chips developed under the Defense Department's Very-High-Speed Integrated Circuit program, fault-tolerant operating systems based on the DoD-mandated Ada programming language, and a fiber optic data bus with an information transfer rate of fifty megabits per second.

Now, under a new program known as Pave Pace, Air Force technologists are at work on the system architecture of the 1990s and beyond. DAIS marked a revolutionary departure from the analog past to the digital future. Pave Pillar and, to a greater extent, Pave Pace will bring evolutionary steps toward greater levels of avionics integration—and thus toward improved combat effectiveness.

In the view of senior researchers at USAF's Avionics Laboratory, Wright-Patterson AFB, Ohio, Pave Pace shapes up to be the prime mechanism for introducing into new aerospace vehicles at least eight leading-edge technologies.

They are wafer scale integration (WSI) of functions now performed by individual chips, photonic devices, artificial intelligence, parallel processing techniques, neural networks, VHSIC chips, computer-aided software engineering, and radar and other analog functions performed by gallium arsenide (GaAs) chips derived from Microwave/Millimeter Wave Monolithic Wave Integrated Circuit (MIMIC) programs.

In the current round of Pave Pace studies—for which the Avionics Lab is now starting to award contracts—the baseline air vehicle is a proposed multirole combat aircraft (MRCA). This "paper" airplane

combines air-to-air and air-to-ground capabilities currently under study by the Aeronautical Systems Division at Wright-Patterson AFB for initial operational capability in 2005. The ASD study will also cover the avionics architecture needs of hypervelocity vehicles to be derived from the X-30 National Aerospace Plane (NASP) joint program with NASA and a new class of unmanned vehicles.

System Architecture

System architecture is a difficult concept to comprehend. It is not hardware, and it is not exactly software either. It is the glue that holds the two together. It is a logical way of organizing aviation electronics, or avionics, functions within an aircraft to improve performance and reliability and perhaps to reduce avionics cost.

A helpful way to look at system architecture is to compare it to the game of chess, which also has a logical organization. The individual pieces have different values and different functions, and at the start of the game they are distributed on the board in a prearranged order. A skillful player uses his positions and capabilities to win.

System architecture is like the chessboard, and avionics subsystems are like chessmen. The goal is to integrate functions to achieve another kind of victory. Further, as system architectures evolve, more powerful pieces can be substituted—queens for pawns that reach the eighth rank in the case of chess, 100-megabit optical fibers for copper cables in the case of aircraft. The goal is to put fewer—but more capable—pieces on the board.

Pave Pillar, for example, is intended to reduce the total number of avionics modules per aircraft to about 300, of which there would only be thirty or forty different types. Pave Pace should do better. These modules have been standardized for more than twenty years, ever since the Navy's original Standard Electronics Module program defined the SEM-E package as a card measuring 5.8 by 6.7 by 0.6 inches. These cards, once filled with transistors, just as easily accommodate the VHSIC chips of today.

During the precomputer days of World War II, there was no need for avionics system architecture because there wasn't much avionics to integrate. Radios, navigation aids, radars, and all the other pieces of first-generation electronic equipment were hung on the airplane anywhere they would fit. Unfortunately, these black boxes, most of them low-reliability electromechanical and analog systems, tended to proliferate and hog aircraft weight, space, and electrical power.

The military lagged far behind the commercial airlines, which much earlier realized the value of standardizing the black boxes on the basis of form, fit, and function so they would be interchangeable among airlines and readily available at scattered maintenance facilities.

DAIS began to do the same for military aviation and, since the rest of the electronics industry was upgrading to digital systems, threw in high-performance digital avionics for good measure. The result was the second generation of avionics, in which interchangeable subsystems known as Line Replaceable Units (LRUs) could be produced in volume by more than one vendor for more than one type of aircraft, thus reducing hardware costs and simplifying maintenance. Notable examples are the 1750A standard airborne computer and 1553 one-megabit data bus. DAIS defined the system architecture of the current generation of USAF aircraft, the F-15 and F-16 fighters and the B-1B bomber.

With Pave Pillar, in the 1980s the avionics business moved into its third generation of technologies, capped by the retirement of the original DAIS cockpit to the Air Force Museum in March 1988 and its replacement by a new research simulator known as Generalized Avionics Simulation/Integration System (GENASIS).

Technologies in Search of an Airplane

These technologies were in search of an airplane, and the Air Force found one in the Advanced Tactical Fighter (ATF). It is only a slight exaggeration to say that the ATF is an airplane built around an avionics architecture. Today's ATF contractors were the Pave Pillar study contractors. Technologies feeding into the ATF were flight-tested at Wright-Patterson under the Advanced Fighter Technology Integration (AFTI) program, using F-16 and F-111 aircraft to simulate the environments the ATF would encounter—all before the first pieces of metal were cut or even designed for the ATF.

There is some hope that this third generation, unlike previous generations, will see interservice cooperation in tactical aircraft. Results of Pave Pillar and other USAF-sponsored research are being shared with the other services through a DoD-level organization known as the Joint Integrated Avionics Working Group under a memorandum of agreement signed by the three services in March 1987.

The program is designated Advanced Avionics Architecture (A^3), and it is aimed at achieving some measure of commonality at the avionics-system level among the Air Force's ATF, the Navy's A-12 Advanced Tactical Aircraft (ATA), and the Army's proposed Light Helicopter Experimental (LHX).

After the disastrous experience with the F-111, or TFX, during the McNamara era at the Pentagon (1961–68), the Air Force and Navy have gone separate ways on each round of follow-on aircraft: first the F-14 and F-15 and then the F-16 and F/A-18. Economies of scale were lost by producing separate airframes each time, and even the strongest military supporters in Congress, such as Sen. Barry Goldwater, voiced strong criticism.

As avionics accounts for a greater percentage of each aircraft's cost, it becomes less urgent to standardize the airframe (which has to be tailored to specific missions anyhow, particularly the Navy's carrier-based operations) and more compelling to find common ground on avionics. The avionics share of cost is up to thirty percent with the ATF-ATA-LHX generation, and some expect it to rise to forty percent in future generations—particularly with the introduction of Stealth and counter-Stealth technologies.

Some of this cost growth is justifiable. "We feel that avionics still constitutes a bargain, given that the cost per function has actually gone down," comments D. Reed Morgan, Pave Pace Program Manager at the Avionics Lab. "However, our appetite for adding additional functions and new capabilities through avionics is resulting in avionics capturing a bigger piece of the pie. . . . The total cost to field avionics is growing very rapidly, and [the price per pound of avionics] will soon approach the price per pound of gold."

A Serious Software Problem

One indicator of increased avionics costs is software. Software for the ATF is projected to require creation of 6,000,000 lines of code. The B-1B required less than 1,000,000.

The software problem is serious. Total Air Force expenditures on software development and support doubled between 1985 and 1989—from $4 billion to $8 billion—and are projected to exceed $12 billion by the end of this decade. To put it another way, a ten percent savings in Air Force software costs in 1986 would have bought twenty-six additional F-16s.

This problem isn't likely to go away anytime soon, according to Mr. Morgan, who cites threat escalation, mission-time compression, automation needs, mission flexibility, and the need to have capable aircraft to overcome numerically superior forces as the big drivers of software costs.

Yet software productivity is increasing at a rate of only three to four percent a year, measured in terms of validated lines of code produced per day, while the total amount of real-time embedded software in weapon systems doubles every four or five years. Meanwhile, the demand for trained software personnel is increasing by twelve percent a year.

"We must effect dramatic, even cultural changes in the way we specify, develop, support, and manage software," Mr. Morgan concludes. "New automation tools and the system-tailoring of reusable software application modules appear to hold the key."

That's the purpose of the Computer Aided Software Engineering effort: developing reusable generic software that can be system-tailored as applications modules. The initial effort is aimed at graphics software for signal processing and involves work at both the USAF Avionics and USAF Armament Laboratories. Other tools are being

developed at the Rome Air Development Center (RADC) at Griffiss AFB, N. Y., and under the triservice Software Technology for Adaptable, Reliable Systems program, the Strategic Computer Initiative of the Defense Advanced Research Projects Agency, and SDI. The Software Engineering Institute is developing a roadmap for Pave Pace software.

The post-ATF generation of vehicles will require not just supercomputers, but *networks* of supercomputers with estimated total processing requirements for each vehicle in excess of 200 billion operations per second (BOPS). At least fifteen supercomputer applications per vehicle are expected for such functions as real-time decision aids for the aircrew using knowledge bases (the so-called Pilot's Associate), high-speed image processing for automatic target recognition, high-speed signal processors to support low-observable sensor operation (multifunctional integrated apertures), and missile warning.

What was once conceived as the "supercomputer in a coffee can" for SDI is evolving into a "supercomputer in a soup can," according to Mr. Morgan. The Hughes Research Laboratories, for example, are working on a six-BOPS machine built out of fifteen four-inch-diameter wafers.

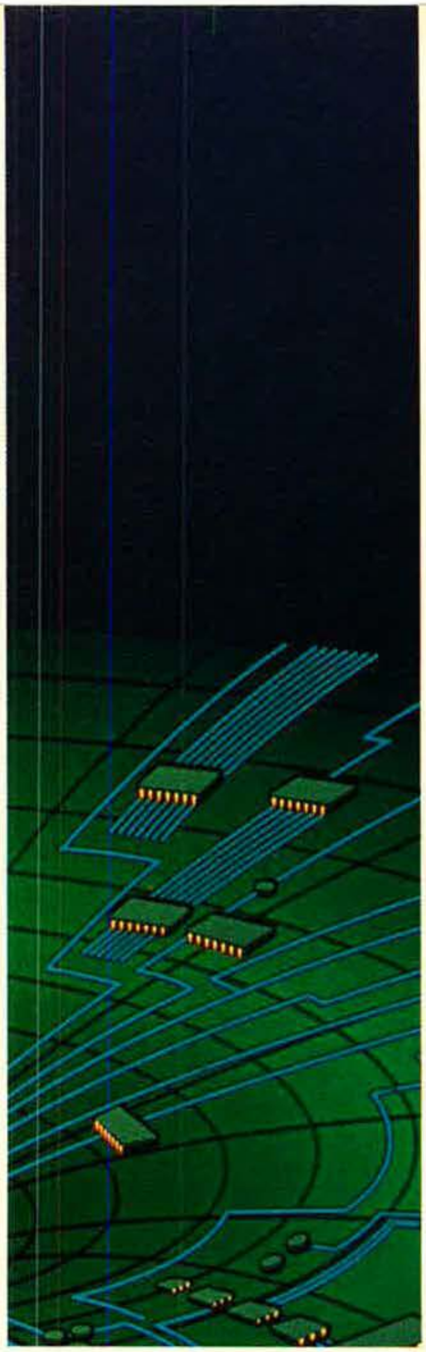
Another supporting effort is RADC's development of the RH-32, a radiation-hardened, thirty-two-bit triservice avionics processor capable of floating point operations. Among those participating in this program are IBM, Honeywell, TRW, and Unisys. This would use reduced instruction set computing software for greater efficiency and (probably) digital GaAs circuits for greater raw processing power.

Greater Precision

Airborne computers of the future will evolve from today's sixteen-bit versions because greater precision is available from thirty-two-bit, floating point processing. This is particularly important for rule-based expert systems such as Pilot's Associate. This is known as pipeline architecture, in which multiple arithmetic units are simultaneously working on a given processing problem as it goes through the pipeline.

An even more advanced computer architecture than pipeline, or parallel, processing is a concept known as neural networks. This attempts to simulate the organization of the human brain. Like electronic computers, the human brain is a digital information-processing system with about 100 trillion neurons performing the logic and memory functions. That is equivalent to about a billion of the most powerful VHSIC-class chips available today. Photonics could close the gap between man and machine in a few decades.

Where the human brain (and, by extension, neural networks) radically differs from conventional computers is its ability to operate at a variable speed and thus focus pro-



cessing power on the most important task at hand. Computers are confined to a fixed operating speed, known as the clock rate, and today's most powerful supercomputers have clock rates of 100 Megahertz (million cycles per second) or more. A neural network system architecture would theoretically be much more efficient, but it would be extremely difficult to implement with today's hardware and software.

The attempt to stuff all this increased computing power into the confined space of an aircraft runs head-on into the chief problem of all electronics: heat and power dissipation. There is a long-term and a short-term solution to this problem. The long-term solution is to replace today's electronic circuits with the photonic and optoelectronic devices now in development at the Air Force's Photonics Center at RADC, but that could be risky, given the uncertainties of the basic research. The short-term solution, improved packaging and cooling methods, reduces that risk, but it has finite limits. However, the advantage here is that there is a good technology base to build on. The use of VHSIC components has already reduced the excess heat from an LRU like the 1750A from eighty watts to twenty-seven watts.

Another straightforward approach is to reduce the number of solders, which are susceptible to thermal expansion and contraction and account for half of all electronic problems. The 1750A, for example, has 2,500 solders. Wafer-scale integration should help here. However, this may increase the number of pins connecting the devices to the outside world, raising problems of a different nature.

Cooling technology is also well advanced, notably with the top-of-the-line Cray supercomputers, which operate while immersed in a chlorofluorocarbon liquid. A similar heat-dissipating fluid known as Coolanol, similar to automobile antifreeze, is used as the coolant in the 1750A rack.

Increased Aircraft Availability

The purpose of all these efforts is to increase the availability of combat aircraft, as measured in mean time between mission-critical failures (MTBMCF). Don Marth, Director of Common Module Development at the Unisys Computer Systems Division in Minneapolis, puts it this way: "The users don't want to see a lot of 'yellow' [maintenance equipment] around their aircraft; they want to see armament and fuel."

The current champion is the F-16, which has an availability level of about eighty-five percent. That translates into an MTBMCF of 11.5 hours, or a tenfold improvement over such 1960s aircraft as the F-4 and F-111. The F-15E's MTBMCF is projected at around thirty hours; the ATF's, using the innovations derived from Pave Pillar, at seventy hours.

Even that's not good enough to meet standards set by the recent USAF Reliability and Maintainability 2000 initiative. R&M 2000 calls for the ability to fly four sorties a day from an austere base with a sixty percent probability of deferring maintenance for thirty days. That demands a 500-hour MTBMCF, which Mr. Morgan believes can be met with "throwaway" modules created by Pave Pace that eliminate the need for intermediate-level maintenance.

Another goal of Pave Pace is to reduce the cost of the sensors, such as the radars, which represent more than sixty percent of avionics hardware costs and which have resisted conversion from analog operations to more economical and efficient digital methods. These analog sensors operate in the radio frequency (RF) domain, and their outputs must be converted to an intermediate frequency (IF) for eventual digital signal processing. Through the use of advanced components, particularly optoelectronics, RF signals can be digitized at the front end to increase the data flow rate and reduce the need for costly IF devices.

Pave Pace is an architecture without a tangible structure. It exists on paper and computer disks. Following the route of progression taken by DAIS and Pave Pillar, the next step is to begin validating real-time operation of the fourth-generation hardware and software in an integrated test-bed built at the Avionics Simulation Analysis Integration Laboratory. This is planned for the coming year, followed by development of the first individual modules in 1992.

There are no plans now for a flight demonstrator like AFTI, but the goal is to get this technology into operational vehicles. The leading candidates are the ATF-ATA-LHX generation, NASP-derived vehicles, and the B-2 Stealth bomber—all of which have increasingly complex functions that demand a logical form like Pave Pace. ■

John Rhea is a free-lance writer who specializes in military technology issues and is a frequent contributor to AIR FORCE *Magazine. His most recent article, "The Simulator Revolution," appeared in the December 1989 issue.*

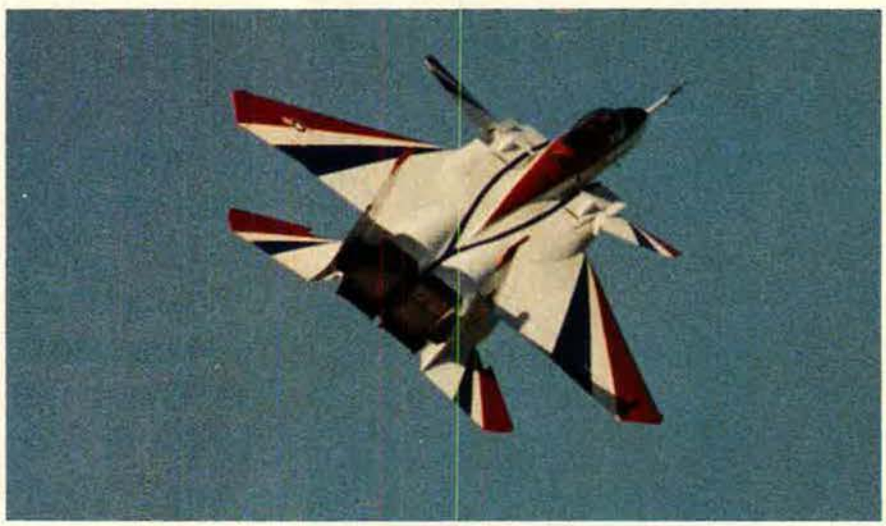
USAF must improve its current engines, develop better ones for ATF, and explore advanced technologies for the twenty-first century.

The Push for Fighter Engines

By F. Clifton Berry, Jr.

In the Air Force's quest for better performance from its fighter aircraft, improving engines gets high priority. Engine performance governs much of what airframe designers can achieve. The propulsion system is the great enabler of, and the toughest barrier to, improved performance. Advanced weaponry, avionics, and navigation aids are of little use if the powerplants don't deliver performance as good as or better than an adversary's.

To understand development of Air Force fighter engines in the short run and well into the 1990s, one should break the process into distinct steps. First comes improvement to engines in current-generation F-15 and F-16 fighters, where advances in technology will enhance performance characteristics. Second, the Air Force will exploit more advanced technologies to meet engine requirements for the next-generation Advanced Tactical Fighter (ATF). Finally, USAF will aggressively push exotic engine technology developments in all categories, so that they will be ready when needed in the mid-1990s and into the twenty-first century.



The integration that was required and the testing now going on with two-dimensional vectored-thrust nozzles on the Pratt & Whitney F100-PW-220 engines on the F-15 STOL/Maneuvering Technology Demonstrator (above) will have a direct impact on the YF119-PW-100 engine, a contender for the Advanced Tactical Fighter powerplant (right). The YF119 is undergoing sea-level testing at the company's plant in West Palm Beach, Fla.


XF-119

Several factors that play important roles in USAF propulsion development are highlighted in current F-15 and F-16 programs.

One is that the Air Force wants, and the engine companies are successfully delivering, growth potential in a new engine; as technology advances, the manufacturers can apply improvements to existing engines. Second, competition can bring big benefits when applied properly. Third, the Air Force is serious about building greater reliability and expanded service life into its engines.

When the F-15 and F-16 fighters went into service in the late 1970s, both were powered by the Pratt & Whitney F100-PW-100 engine. It was a turbofan with afterburner for pushing the aircraft along at speeds in excess of Mach 2. Rated power was about 24,000 pounds of thrust in an afterburner takeoff. The F100 was the first engine to exceed an eight-to-one thrust ratio.

The "Great Engine War"

After the F100 engine was in service for a time, the Air Force invited General Electric to compete against Pratt & Whitney for a part of its fighter engine buy each year. With its invitation to GE, the Air Force touched off what became known as the "Great Engine War." General Electric was ready with its F110 augmented turbofan, which delivered more thrust than the P&W F100, to be fitted into the F-16.

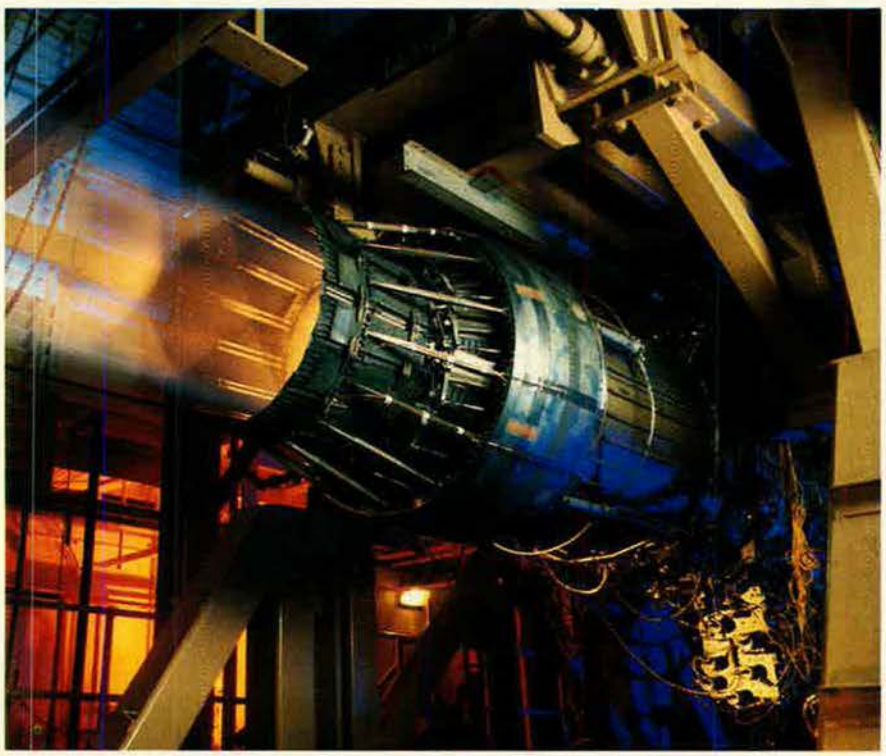
Beginning in February 1984, and for several years thereafter, the Air Force awarded most of its annual F-16 fighter engine buy to GE, and all F-15 engines to P&W. The inspection interval required by USAF for both engines was more than 4,000 tactical cycles. (A tac cycle is roughly equivalent to the length of a single mission.) The P&W F100-PW-220, an improved version of the original F100, sustained a readiness rate of 99.5 percent in USAF service. Today, 4,000 tac cycles is the standard life expectancy of current engines.

In the mid-1980s, the Air Force awarded contracts to both of the major engine houses under its Increased Performance Engine (IPE) program. The goal was to develop greater performance and reliability in the basic P&W F100 and GE F110 engines. By 1988, both manufacturers had their new IPEs flying in test aircraft. By the end of 1989, both engines had completed flight tests in both the F-15 and F-16 aircraft.

The GE IPE is the F110-GE-129; P&W's is the F100-PW-229. Both engines are in the 29,000-pound-thrust class, and the engines and parts are warranted to the Air Force for three years. Thrust and fuel consumption are warranted for 4,000 tac cycles. That number of cycles approximates nine years of tactical mission flying. That means the engine can go for seven years with routine maintenance before the engine must be removed for overhaul.

For contrast, consider the J79 engine installed in the earlier-generation F-104 and F-4 fighters. Its service life, 200 tac cycles in the beginning, eventually improved to 1,200 in later versions, but could go no further. The service life of the Tumansky R-13-300 powerplant in the ubiquitous MiG-21 was around 200 cycles.

Now, with two IPEs proven in flight, USAF has achieved several desirable goals. Its IPEs have higher thrust, are more reliable, and are far easier to maintain. Because of those factors and comprehensive warranties from the manufacturers, the Air Force can count on its having engines with significantly longer service life to power its F-16s and F-15s.



The Increased Performance Engine program challenged both Pratt & Whitney and General Electric to develop greater performance and reliability in the basic F100 and F110 engines used to power F-15s and F-16s. Flight tests with both the F100-PW-229 (here, at full afterburner on a test stand) and the F100-GE-129 were completed last year. Both engines will be in the field this year.

Billions in Potential Savings

USAF also has a choice of engine producers and can continue to require P&W and GE to compete annually for its engine purchases. As a result of such competition, USAF expects to save up to $4 billion over the life of the engine program.

In addition to launching the IPE initiative, the Air Force began another program to achieve more versatile performance from its fighters. This program has the unwieldy name of "F-15 Short Takeoff and Landing/Maneuvering Technology Demonstrator" (S/MTD). It is sponsored by the Flight Dynamics Laboratory at Wright Research and Development Center at Wright-Patterson AFB, Ohio. S/MTD is a test program involving an F-15 with an airframe modified by the addition of movable canards and an advanced, four-channel, digital, fly-by-wire control system for both propulsion and flight controls.

The extraordinary maneuvering capabilities of the S/MTD are the key to the thrust-vectoring capability of its two P&W F100-PW-220 engines. Until now, jet engine nozzles have been circular and fixed in position. The S/MTD's engines have two-dimensional rectangular nozzles that can be moved to vector or reverse the thrust as the pilot requires.

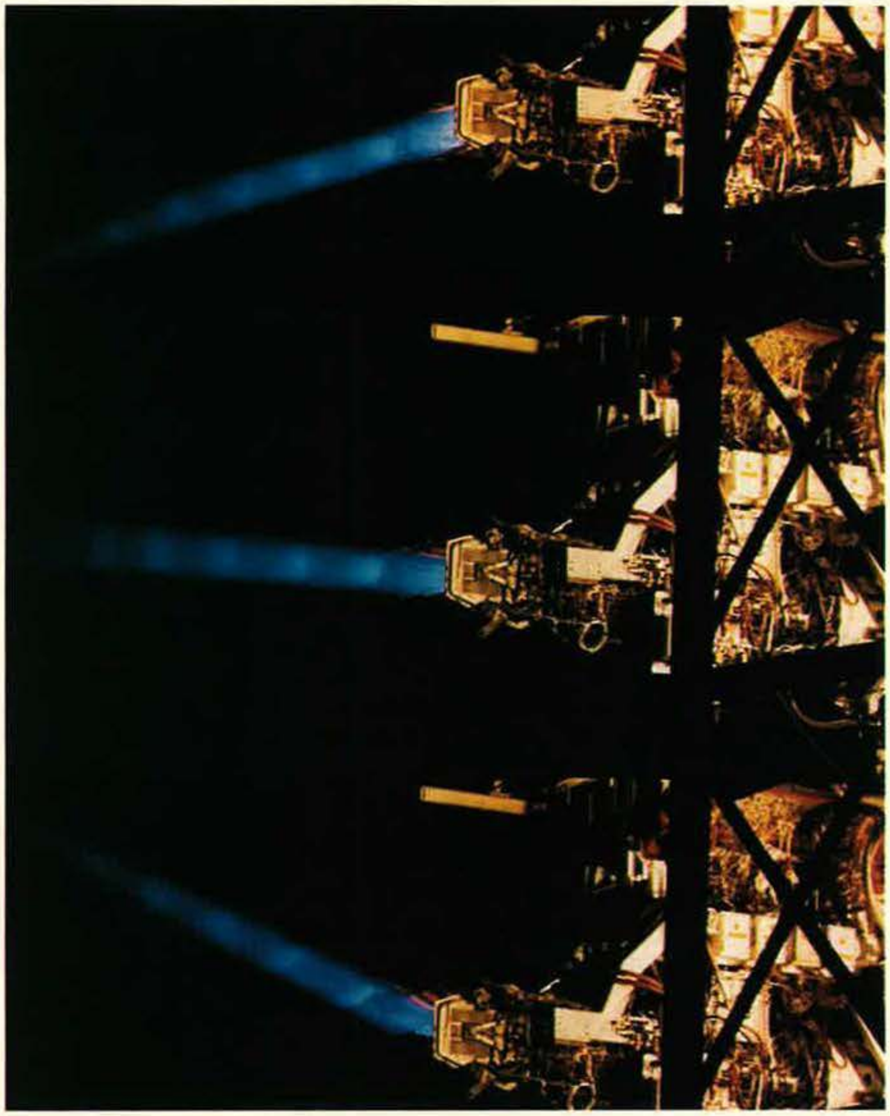
The flight-control computer can direct the thrust of one or both engines upward or downward independently, over a range of plus or minus twenty degrees. The reverse function can be selected at any time, even while in flight and on approach and landing. When the aircraft touches down, the control system automatically directs the thrust into full reverse. This cuts the length of the landing roll by up to seventy-two percent.

Goals of the program include the ability to land and take off from a wet, bomb-damaged runway segment only fifty feet wide by 1,500 feet long. This is to be accomplished at night and 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. Autonomous landing guidance is provided by the navigation pod of Martin Marietta's two-pod LANTIRN system on the aircraft.

First flight of the S/MTD F-15 with nozzles installed came last May. By last December, the program continued on schedule. The aircraft's vectoring and reversing features operated as expected. Pratt & Whitney reports that the thrust can be changed from full reverse to full forward in half a second.

The ability to reverse engine thrust in flight seems to have great potential for US Navy carrier operations and USAF land-based operations. Once the two-dimensional, thrust-vectoring, thrust-reversing concept is fully proven, the Air Force will have the option of modifying F-15s and F-16s to incorporate that capability. Because GE also has the 2-D nozzle capability, USAF once again will have a choice of manufacturers for future production.

For now, the selection of enginemaker for the Advanced Tactical Fighter shapes up as the most important engine decision for years to come.



Although Pratt & Whitney has an advantage in vectored thrust work with the F-15 S/MTD program, General Electric has its own thrust-vectoring research program under way. This particular work is being done for the YF120-GE-100 Advanced Tactical Fighter Engine, but GE is also working on a possible thrust-vectoring nozzle to be retrofitted to the F-16 fleet.

Both GE and P&W are vying for the contract for the ATF engine business, with the potential sale running to $3 billion or more. Both houses have built and tested engines for the ATF. Each company is providing four engines and spares to the competing airframe teams led by Northrop and Lockheed, respectively. First engines were delivered at the end of 1989 and are being mated with the competing airframes in January. First flight of the Northrop YF-23 prototype ATF is also expected this month at Edwards AFB. Lockheed's YF-22 prototype will fly later.

Performance requirements set by USAF for the ATF call for it to meet ever-improving threats to survival in the air-to-air mission. Despite the awesome shifts occurring in its military posture, the Soviet Union's highly sophisticated and numerically superior offensive and defensive weapon systems are expected to pose continuously more lethal threats into the 1990s and the next century. Air Force technologists and contractors have been working to make sure that the ATF will be able to meet and beat the threats and that it can be improved over two or three decades of front-line service.

For the ATF engines, USAF requires efficient supersonic operation without afterburner, the "supercruise" capability. At the same time, it requires increased durability and a higher thrust-to-weight ratio than the IPE's eight to one. The Air Force also requests integrated flight and propulsion controls, short takeoff and landing capabilities, and two-dimensional nozzles. Not all of these features, however, will be included in the prototype aircraft. Some won't be seen until the ATF moves into the full-scale development phase or even into production.

The ATF demonstration/validation phase began in October 1986 and runs until mid-1991. Next phase will be full-scale development, with that contract expected to be awarded around September 1991. Only one engine team will get that contract, a boost toward at least temporary engine supremacy for the winner. General Electric's prototype entry is designated YF120-GE-100; P&W's is the YF119-PW-100.

Both teams are applying their talents, experience, and considerable amounts of their own money to the ATF competition. The Air Force benefits from the money spent and lessons learned in the Great Engine War and the IPE program.

Of course, both engines will have about the same dimensions and weight, in order to fit into either competing prototype airframe. Both are likely to have two-dimensional, thrust-vectoring nozzles. Both will have to deliver around the same amount of thrust and meet other requirements pertaining to high durability and easy maintainability. For example, no special tools unique to either engine will be allowed on the flight line; only the most common tools available to USAF maintenance personnel will be permitted.

The Critical Difference

Despite their important similarities, the two companies diverge in their basic technical approach to meeting the absolute requirement for supercruise without afterburner.

P&W's YF119 is the next-generation, low-bypass turbofan, an evolutionary advance over its IPE F100-PW-229 turbofan, with performance advances achieved through improved materials and design applications and full electronic engine controls. GE is designing its YF120 as a "variable-cycle" engine, which has the fuel economy of a turbofan at subsonic speeds and operates like a turbojet in the supersonic range.

Both companies are confident that their engines will meet or surpass the ATF requirements, based on extensive ground testing performed through the time of delivery of the first engines for installation in the ATF prototypes at the end of 1989.

The two competing ATF engine companies are taking different approaches to meet USAF's stringent requirements for fighter engines. General Electric took the "variable cycle" approach with its YF120-GE-100 (shown here). The engine should have the economy of a turbofan in low speeds and the performance of a turbojet in the supersonic regime.

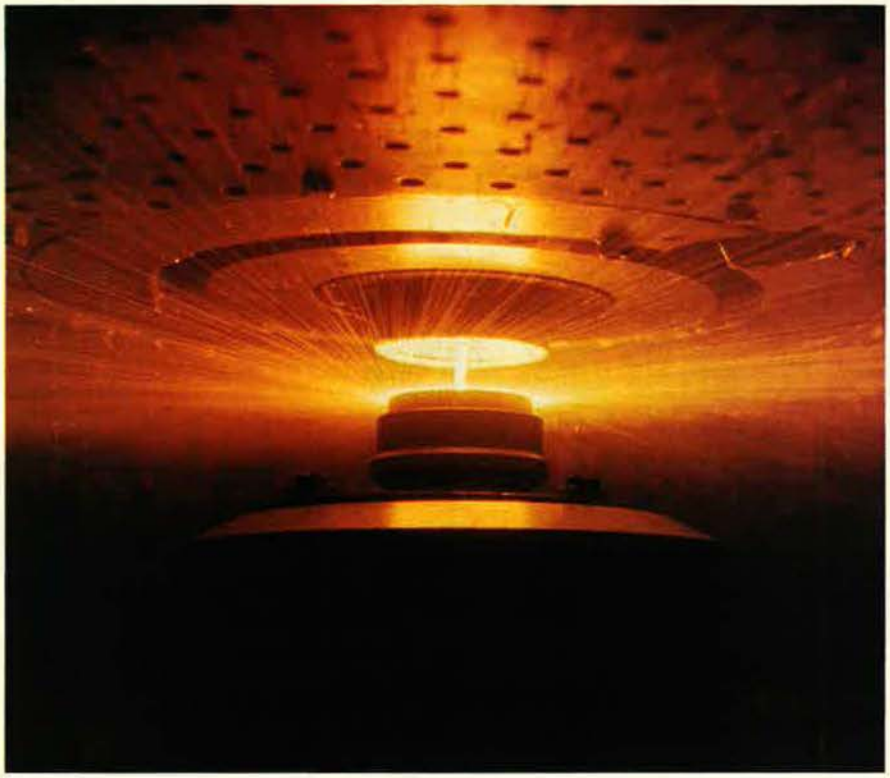
Of the two engines, GE's seems the more daring, technologically. Does the GE variable-cycle design pose a risk to the Air Force and GE? The company believes not and has committed significant amounts of its own funds to ensure its success. Brian Brimelow, GE's Vice President and General Manager of F120 Engine Operations, believes the variable-cycle engine is "the wave of the future." Not only USAF, but also other air forces, will choose it because of its "high and dry thrust," meaning it need not use afterburner in supersonic flight at the highest possible altitudes.

Mr. Brimelow also points out that the GE design uses "no unexplored materials; there is no material in there that we do not understand." His expectations, he claims, have been borne out in testing. If there is a potential penalty in the variable-cycle design, says Mr. Brimelow, it is a small percentage of increase in specific fuel consumption at certain points along the subsonic range.

Walt Bylciw, P&W vice president for F119 programs, says, "The philosophy used to design this engine focused on reducing complexity to achieve greater reliability and ease of maintenance." P&W believes its F119 will meet all ATF requirements, including supercruise and economical subsonic cruise fuel consumption comparable to today's high-bypass-ratio fighter engines.

Both the YF119 and YF120 engines benefit from advances in design capabilities, in reducing the number of parts (and reducing weight), and in use of improved materials. Materials that are lighter and stronger, yet keep their integrity at ever-increasing operating temperatures, are crucial to future improvements in turbine engine propulsion.

When the competing ATF prototypes complete their first flights over the next couple of months, they will be the newest and most advanced known fighter aircraft in the air. New as they are, the engines will be using technologies that began emerging ten and fifteen years ago. Progress beyond the ATF will be



Under the IHPTET Initiative, materials research (like Pratt & Whitney's rapid solidification rate powder metallurgy work, above) has a high priority. At least half of the hoped-for gain in capability may come from lightweight, high-strength materials that can withstand high temperatures.

achieved in part with technologies now being proven in the laboratories.

Twice as Good as ATF Engines

The ATF, with its major jump in performance over present-day fighters, is the baseline for gauging the significance of future turbine developments. These developments, by and large, will come out of a major, multiplayer technological initiative known as IHPTET (Integrated High-Performance Turbine Engine Technology).

Few government-sponsored research and development programs have such a broad sweep. On the government side, the program encompasses the Army, Navy, Air Force, Defense Advanced Research Projects Agency, and National Aeronautics and Space Administration. Working with them are no fewer than seven commercial engine houses: GE, P&W, Garrett Turbine Engine Co., Textron Lycoming, Williams International, Teledyne CAE, and the Allison Gas Turbine Division of General Motors. Other companies, especially materials developers, are also involved.

The principal goal of the IHPTET program can be stated simply: Develop the technologies to double the capability of today's most advanced turbine engines, and do it by the turn of the century. By setting such an extraordinarily ambitious goal, the IHPTET partners are ensuring that there will be progress across the board in all important turbine engine technologies.

The research and development effort is advancing in three phases, using the technology level of the ATF, the Navy's Advanced Tactical Aircraft (ATA), and the Marine Corps V-22 Osprey as the baseline capabilities. According to IHPTET officials, phasing reduces risk and enables early spinoff of promising new technologies as the projects move forward. In Phase I, the goal is to increase standard engine performance by thirty percent; in Phase II, by sixty percent; and in Phase III, around the years 2001 to 2004, by the full 100 percent.

What does the Air Force mean by "doubling turbine engine propulsion capability"? The goal can be achieved in many ways, depending on the criteria used.

Doubling the thrust of the engine while maintaining the same overall weight will translate into a thrust-to-weight ratio twice as good as that of current engines. Conversely, cutting engine weight in half while keeping the same amount of thrust would yield the same result. In rotorcraft, it could mean doubling the range/payload relationship.

For IHPTET purposes, the baseline thrust-to-weight ratio is ten to one. The Air Force seeks to improve on that high standard. Bill Vossman, who runs GE's IHPTET programs, sees Phase I achieving a thirteen-to-one thrust-to-weight ratio, Phase II achieving a sixteen-to-one ratio, and Phase III achieving a twenty-to-one ratio.

Importance of Advanced Materials

Both Mr. Vossman and Fred Polhemus, Pratt & Whitney's Manager of Materials Development, point to emerging advanced materials as critical to achieving the goals. They both say that at least half the gain in capability will be achieved with extensive use of lightweight, high-strength materials capable of operating for long periods at ever-increasing temperatures.

Other areas with high promise, they note, are innovative structural designs and improved aerothermodynamics. Along with those go clever designs to reduce numbers of working parts and the integration of design with tooling and manufacturing techniques.

It seems likely that, if appropriate funding levels are maintained, many if not most of today's laboratory wonders will eventually be incorporated into flying military engines. With so many technologies in early phases of development, it is not possible to calculate their impact with precision. On the record of the past, however, the benefits seem certain to be great. ■

F. Clifton Berry, Jr., is a former Editor in Chief of AIR FORCE Magazine. He saw USAF service in the Berlin Airlift, 1948–49. Later, he was a paratrooper and an officer in the 82d Airborne Division and served in Korea and Vietnam. His most recent article for AIR FORCE Magazine, "The Lifeline Is Still in Danger," appeared in the November 1989 issue.

For too many smaller nations, these weapons—relatively cheap and easy to produce—are "the poor man's atom bomb."

CHEMWAR in the Third World

By **Colleen A. Nash,** Associate Editor

EVEN AS the outlook brightens for cutting superpower stockpiles of chemical armament, the United States is sounding a cautionary note about these dreaded weapons.

Washington warns that Third World nations will continue to build, expand, and possibly even use their own arsenals of poison armament, no matter how new US-Soviet reduction talks turn out.

The warning is underscored in recent Central Intelligence Agency reports to Congress. In spite of efforts to curb the growth of the chemical menace, CIA Director William H. Webster openly concedes "we expect this trend to continue."

For years, only the US and the USSR were known to possess these weapons, and possibly a few other industrialized nations did as well. Now, officials say that fifteen Third World powers either possess or vigorously seek to develop chemical arms, while nine others are kept under watch for signs of acquisition plans (see map). Some of these nations—Iran, Iraq, Libya, Syria, North Korea—are implacable US foes.

It's not just the spread of the weapons themselves that causes worry. Concern is mounting that long-standing barriers to their use are crumbling. A chain of developments is fueling the fear:

- During the eight-year Iran-Iraq war, Baghdad's armed forces resorted to repeated, large-scale use of chemical agents against Iranian forces.
- Iran, after acquiring a crude chemical-weapon production capability of its own, made limited counteruse of poison agents against Iraqi troops.
- In Chad, Libya has been accused in credible reports of having used chemical weapons against Chad government units.
- Compelling evidence exists that Iraq used chemical weapons in 1988 against members of its own Kurdish minority.

Even earlier, fears were aroused by Reagan Administration claims that Russian troops had used chemicals against anti-Soviet Afghan guerrillas and that Soviet-supported Vietnam had done likewise in Southeast Asia. Both claims remain in dispute.

Four Nations' Chemical Programs

When CIA Director Webster sizes up the proliferation problem, he places special emphasis on developments taking place in Iraq, Iran, Syria, and Libya. All four have either used chemical arms or have links to terrorist groups. Brief summaries of programs point up the extent of the danger.

Iraq. Baghdad's military industry has been producing chemical-warfare agents and munitions since the early 1980s. Several thousand tons of agents are produced at the main chemical warfare complex near Samarra and at other plants. At Samarra, Iraq concocts the blister agent mustard and the nerve agents tabun and sarin. Such agents have been combined with artillery shells, rockets, and other delivery means.

Iraq began using nerve and mustard agents against Iranian forces in 1983 and 1984. The Mideast nation now appears to be expanding its production capabilities.

Iran. In response to repeated, large-scale, and evidently effective Iraqi chemical attacks in the early and mid-1980s, Iran began a few years ago to produce and stockpile its own chemical agents and munitions. Intelligence sources maintain that Iran's chemical weapons production facility is located near Tehran. They report that Iran produces blister, blood, and nerve agents and has equipped bombs and artillery shells with these toxic substances. Like Iraq, Iran continues to expand its chemical warfare program.

Syria. Already one of the most heavily armed states in the Middle East, Syria in the mid-1980s launched active production of both chemical agents and deliverable chemical munitions. Syrian forces now are said to possess a large chemical arms production facility and to have incorporated nerve agents in certain weapon systems. US intelligence agencies contend that the Damascus regime is likely to continue a steady expansion of its chemical warfare capabilities across the board.

Libya. Soon, say intelligence analysts, Libya will be able to start large-scale production of chemical agents and munitions in its own domestic facilities. A large production complex near Rabta, said to comprise a chemical-agent production plant and a metal-fabrication facility, has been built for this purpose with the help of West German companies. When fully operational, it is likely to be the single largest chemical warfare agent production plant in the Third World. The plant is expected to produce nerve and mustard agents—potentially tens of tons per day. For the most part, Libya's ability to sustain large-scale production will depend on continued foreign assistance.

Mr. Webster sees several common factors that apply to the chemical programs in all four nations. He points out that each country has given high priority to the programs and shrouded them in official secrecy. Production complexes have been given a high degree of security. In addition, all have relied heavily on foreign suppliers of equipment and expertise.

Classifying Chemical Weapons

The Arms Control Association (ACA), a private, Washington-based group, defines chemical weapons as "toxic chemicals . . . used to injure, incapacitate, or kill." These arms differ in significant ways from biological agents and toxins. Biological agents make use of organisms such as anthrax bacteria. Toxins are based on nonliving chemical substances produced by organisms, such as the deadly botulin toxin.

Chemical agents can be classified according to how they attack the body, how long they persist, and how they can be dispersed. The 1985 Report of the Chemical Warfare Commission, established by Congress, described three significant types of modern agents: blister, blood, and nerve agents.

Chemical agents vary as to how long they will remain lethal. "The simplest rule of thumb," said the Commission, "is that a nonpersistent agent is effective for a matter of minutes after it is dispersed; a semipersistent agent for hours; and a persistent one for days."

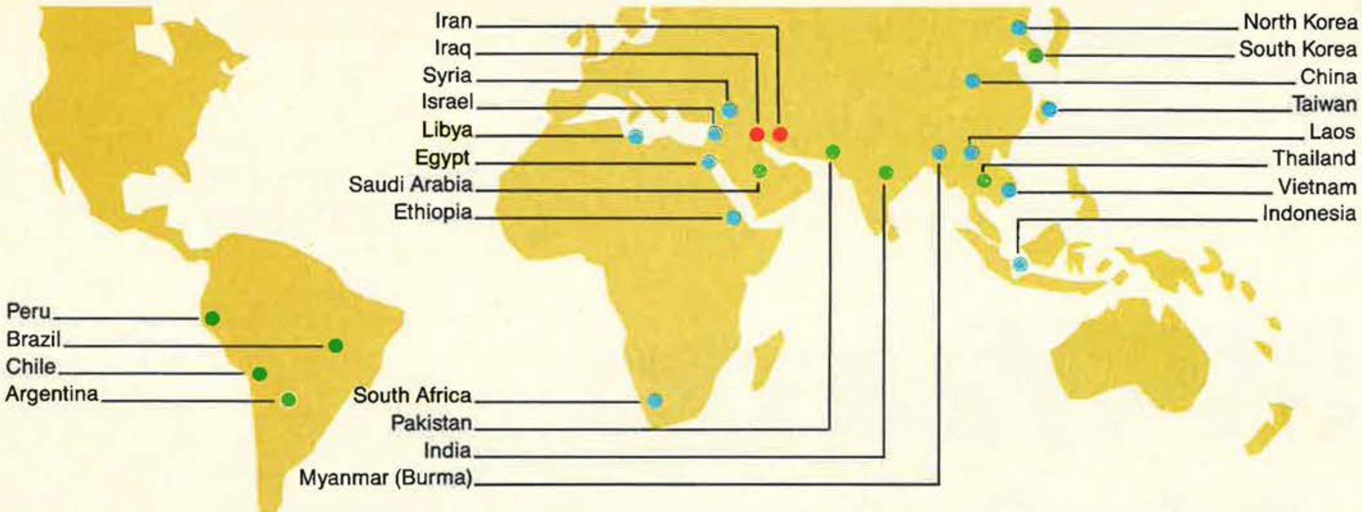
Finally, the Commission explained that although the term "poison gas" is often used, most agents in chemical munitions are in fact liquids, which are dispersed either as droplets or vapor (see chart).

Many factors make such weapons attractive to Third World countries, and these factors contribute to the proliferation problem. A prime reason is that they are affordable.

"Chemical weapons are relatively cheap and do not require exceptional technological expertise to produce or maintain," says an ACA assessment. "For this reason, it has been suggested that they may pro-

Chemical Substances of Military Significance

Type (Code)	Characteristics
Nerve "G" agents Tabun (GA) Sarin (GB) Soman (GD) "V" agents VX	Attacks nervous system Very small doses lethal Kills within minutes Liquid or vapor form Can persist for hours to days "G" agents attack primarily through the respiratory system; "V" agents act by absorption through the skin Chemically related to modern pesticides
Blister Mustard (H) Lewisite (L)	Burns any body surface it contacts Can kill through secondary effects such as blistering in the respiratory system Liquid or vapor form Persists for days to weeks Easy to make Long storage life
Blood Hydrogen cyanide (AC) Cyanogen chloride (CK)	Attacks blood cells, interfering with their ability to carry oxygen High concentrations needed to kill Nonpersistent, dissipates rapidly



Chemical Weapons in Third World Nations

Sources: *Christian Science Monitor,* based on US government officials; CIA

- Confirmed possessors
- Countries suspected of possessing chemical weapons or in the process of acquiring them
- Countries being closely monitored for signs of an acquisition program

Note: Both the US and the USSR possess chemical weapons. Other nations suspected of possessing or in the process of acquiring them are Bulgaria, Czechoslovakia, France, Hungary, Romania, and Yugoslavia.

vide the equivalent of a 'poor man's atom bomb.' "

Though they may not win a war, chemical weapons can hamper and demoralize even the best-prepared enemy. "The main effect of using chemical weapons between two well-prepared adversaries," notes the ACA study, "would be to force both sides to wear cumbersome protective clothing, thus reducing their combat effectiveness."

The Chemical Warfare Commission puts the matter a little differently. "Even if chemical weapons are used only against limited areas," it notes, "if an attacker can force a defender to put on protective gear from expectation of such use, the military effectiveness of the encumbered personnel is cut by fifty percent."

Chemical weapons production facilities can be disguised. Some ingredients found in common insecticides and fertilizers are also used to make nerve agents, and the manufacturing process is similar. Libyan leader Muammar Qaddafi claims that the Rabta facility is intended to produce pharmaceuticals. Mr. Webster points out, however, that "a nation with even a modest chemical industry could use its facilities for part-time production of chemical warfare agents."

Chemical agents are versatile. They can be delivered to targets by bombs, artillery and mortar shells, mines, rockets, missiles, and spray tanks. One ACA report describes how these weapons might be used: "If a chemical war were to break out, 'nonpersistent agents' . . . would typically be used over short ranges where one's own troops might move in after the attack; 'persistent agents' . . . might be used for longer-range attacks."

The 1925 Geneva Protocol

Actual combat use of chemical weapons appears more probable today than at any time in decades. After the first World War, use of chemical weapons was outlawed by the 1925 Geneva Protocol, though production was still permitted.

"The Iran-Iraq war," warns the CIA Director, "ended that restraint and set a dangerous precedent for future wars."

The Protocol states that the "use in war of asphyxiating, poisonous, or other gases, and all analogous liquids, materials or devices, has been justly condemned by the general opinion of the civilised world." Most major nations are signatories.

Different nations interpret the Protocol in different ways. Some, like the US and the USSR, see it as a ban against *first* use only and reserve the right to retaliate in kind if attacked. All parties agree that first use is banned.

For this reason, experts have been dismayed that the expected condemnation of recent chemical weapons use has failed to materialize, most notably in the case of Iraq. Lewis A. Dunn, former Assistant Director of the US Arms Control and Disarmament Agency, has written that "although the US and some other countries have condemned Iraqi use of chemical weapons, broad-based international condemnation by the United Nations or other bodies has been lacking, thus further eroding existing constraints on the use of these weapons."

While it is true that the Soviet Union and the United States have long maintained the largest stockpiles of chemical weapons in the world, these arsenals are viewed as formidable deterrents to their use by either superpower against the other. Moscow says its stockpiles do not exceed 50,000 tons. The size of the US supply, never publicly disclosed, is estimated at 30,000 tons.

While both stockpiles are gigantic, both may soon be reduced. The consensus in both nations is that the size of the chemical arsenals can be cut without raising new security concerns. Even if reinvigorated superpower negotiations result in a chemical weapons treaty, however, the prospect of Third World proliferation—and use—can only grow more menacing. ■

It's supposed to be routine, but fuel is critical, there's no place to land, and if you go down, rescue is impossible.

McMurdo Airdrop

By Arnold J. Mann

IT's 11:30 a.m. as the C-141 StarLifter makes its steady way toward McMurdo Station in the heart of the polar darkness.

We're five and a half hours out of Christchurch, New Zealand, on this midwinter airdrop, carrying food and supplies to the 131 inhabitants of the National Science Foundation's research station at McMurdo Sound in Antarctica. At approximately 12:10 p.m. New Zealand time, the strobe signaling the beginning of the drop zone will come into view, and Maj. William A. Burt will bring us down to 1,500 feet. As the nose of our aircraft crosses the strobe, TSgt. Richard Teal will activate the electric winch that will cut the nylon cargo straps, and forty-six bundles totaling 29,000 pounds will roll like a freight train out of the back of this C-141 and parachute to the people waiting below in the cold and midday darkness of this Antarctic winter.

We're cruising at Mach .77. Last daylight was at 7:35 a.m. Since then, the horizon behind us has been in a state of arrested sunrise. The view from the cockpit has gone from frozen ocean to the Transant-

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At 173 below zero, everything freezes, including the mustache of TSgt. Richard Teal (right) of the 62d Military Airlift Wing, McChord AFB, Wash. SMSgt. Mike Wright (left) of the 62d looks on as the C-141 StarLifter prepares for the third of five passes over the South Pole.

arctic Mountains rising out of the polar landscape under a full moon.

"We used maximum power at takeoff," says Major Burt, the mission commander. "We weren't quite grossed out [carrying maximum payload], but we were close to it."

Part of that weight was cargo. Another 123,000 pounds was fuel. Three hours after takeoff, we got another 60,000 pounds of JP-4 from the KC-10 tanker flying off our left wing. Before we descend to McMurdo, Lt. Col. James Dooley and his KC-10 crew out of March AFB in California will top us off with another midair refueling.

It's only been since 1981, when the Air Force stretched the fuselage of its C-141B StarLifter and added air-refueling capability, that these annual midwinter drops to McMurdo and the South Pole stations have been possible. It's not an essential mission, in the survival sense; the scientists and Navy support personnel at both stations could survive the winter on their stores from the summer's C-130 Hercules and supply ship runs.

This is more of a morale run—delivering fresh produce, mail, equipment, and even the latest movies to those who have been isolated since the Antarctic summer's end in early February. It's also a training mission, in case of an emergency—such as the fire that swept through the Russian station at the South Pole several years ago.

At McMurdo, they all come out for the drop. The Navy people come out in Caterpillars and forklifts to pick up the booty; the rest line up on the hill overlooking the drop zone, just to see the plane come by.

"They're motivated," Major Burt says. "They'll be out there come hell or high water."

The Hazards Below

Everyone will tell you that this is just a routine airdrop—except for the extreme cold. Also, fuel is absolutely critical, there's no place to land for thousands of miles, and there's no possibility of rescue if you do. "McMurdo would basically be a crash landing," says Major Burt. "They've only cleared part of the skiway. If I hit snow or ice drifts, it wouldn't be a pretty sight. But it's a hell of a lot better than the ocean at the Ross Ice Shelf."

The only other landing strip is Dunedin, thirty-five minutes south of Christchurch. "If you're low on fuel," Major Burt says, "it's about 6,000 pounds closer."

Anything affecting fuel is a problem. Four years ago, the flaps stuck during the drop at the South Pole. It took an hour to find the problem—a broken cable detector—and fix it for the climb back to altitude. The alternative was a long, low haul back to Christchurch, consuming twenty percent more fuel.

Last year the cargo doors froze half-open over McMurdo. It took the crew twenty minutes to get them fully open so they could make the drop and the trip back home. Now they recycle the hydraulic fluid before the drop to get the "hot" fluid back into the valves.

This whole mission is planned around a worst-case scenario in a no-land situation.

"We're right at the fuel plan for a [one-malfunction] scenario," Burt says. "We've got enough fuel to get us back to Christchurch with the flaps stuck down or the back doors stuck open or one engine out. But if any two or all three happen, we'll need more fuel from the KC-10. Nobody's ever tried that before—air refueling with the flaps down or the petal doors stuck open."

At 11:45 a.m., SMSgt. Mike Wright and his handpicked crew of loadmasters from the 62d Military Airlift Wing out of McChord AFB, Wash., and New Zealand Army "Kiwi" riggers are making last-minute preparations—checking bundles and parachute riggings.

This is Sergeant Wright's seventh year in charge of the cargo end of this mission, which was originally set up to provide contingency supplies and has evolved into a morale mission. The whole crew is aware of both the potential danger and the need.

"We all get nervous about this trip," Sergeant Wright admits. "There's nowhere to land, and recovery is impossible. [Then there's] the extreme cold weather, the darkness, the unknown. But it's a precision team."

Breaking the Isolation

"The people down there have been isolated for months. I've been down during the summer to bring them out after they've wintered over. They say it's scary. They say it feels like everybody's forgotten them. When we fly over today, they'll all turn out. You can't keep 'em in. 'Drop what you want,' they say. 'We don't care.' It's just our being there, the presence."

The ninety-three feet of cargo space in this 'stretch' -141 is filled with forty-six containers standing six feet high and two abreast all the way back to the cargo doors. Everything's on 'commissary' rollers, as if this were a truck about to deposit its cargo at a loading dock, not an airplane unloading at 1,500 feet. On top of each bundle is a twenty-six-foot ring-slot chute attached to one of two anchor cables running along either side of the cabin.

"It's the same static line assembly that deploys a paratrooper's chute," Sergeant Wright says. "The plane will go to a five-degree, nose-high attitude, and the bundles will make a gravity-type exit."

Everything has been packed in Styrofoam and bubblepack, with a "honeycomb" baseplate to absorb the landing. Today they're dropping the entire commissary—sweaters, boots, CDs, movies, a videotape of the NBA Championship playoffs, 9,000 pounds of mail, spark plugs, light bulbs, an oven, a computer, medical supplies, canned tuna, cornflakes, 519 bottles of frozen milk, and "freshies"—5,000 pounds of fruits and vegetables. The biggest item is a 1,100-pound Caterpillar transmission.

"The heavy-equipment drops are exciting," says TSgt. Mark Lewis.

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Sergeant Wright's handpicked crew of loadmasters, assisted by New Zealand Army "Kiwi" riggers, boosts cargo out the C-141's troop doors. Directly over the South Pole, everything has to go out the side troop doors because the back cargo doors would freeze open. Over McMurdo station, the average temperature is somewhat higher, and the load can go out the cargo doors.

"We can go up to 42,000 pounds on a single platform drop. Two big chutes extract the load out of the locks, and eight 100-foot parachutes take it down to a soft landing."

Sergeant Lewis is an evaluator loadmaster with 6,300 hours on the C-141. Sergeant Wright has more than 10,000 hours. "The people who come down here are the coolest, most qualified ones in the squadron," Sergeant Lewis says.

"It's just a can-do crew," Sergeant Wright says. "It has to be. There's no margin for error. The drop zone, lined with burning smudge pots, is only 290 feet wide and 3,000 feet long. The temperature on the ground can go off the scale. They've only got about an hour to get the 'freshies' in before they freeze."

Yesterday, they dropped twenty-four bundles right on the button at the South Pole, where everything has to go out the side troop doors because the back cargo doors would certainly freeze. It was 173 degrees below zero in the plane. At that temperature, says Sergeant Wright, "The fluid in your eyes crystallizes."

Today it's forty-eight below at McMurdo with unlimited visibility. That can change in seconds. "Four years ago," Sergeant Wright says, "we were twenty minutes from the drop zone when we had a whiteout. We had to go into orbit until it cleared enough so we could slip in and make the drop."

At 11:55 a.m., we begin our descent. Colonel Dooley and his KC-10 crew are off in another direction. "He's headed for the Pole," Major Burt says. "If we need him, though, his sight-seeing mission is canceled."

We've made the entire trip on grid navigation. Longitude is useless down here because all the lines are converging. The compass doesn't work, either. "The needle just pins itself to the bottom of the case," Major Burt says.

The temperature outside is sixty-seven below.

"We make our own weather at the Pole," says Capt. Chris Jellison, the copilot. "The contrails coming out of the back form ice-crystal clouds. You see these circles around the pole. And you can see the shadow of the plane illuminated by the moon. It's really surrealistic."

"It's like being in outer space," says Major Burt.

At noon, we can see Mount Erebus—the continent's only active volcano—where an Air New Zealand jet crashed in 1979, killing 257 sightseers and crew.

"That's McMurdo over there on the left," Major Burt says, pointing to a cluster of lights that looks rather like a mining town.

"There's the strobe!"

The engines come up, and we level off momentarily at 15,000 feet, then turn left to final approach.

12:15 p.m.: "That's Koettlitz Glacier through the moonlight," says a Kiwi rigger who has come up front for the view. "Mount Discovery is to the right. All that brown is the 'dirty ice.' That's Black Island and White Island in the distance. And that's the Ross Ice Shelf."

12:20 p.m.: We're on final approach. Nobody's talking now. The burning smudge pots are lined up like the approach lights at Kennedy International. "You'd think it was a runway," Major Burt says, "not a drop zone in the middle of the Antarctic."

"Back doors coming open!"

Cargo on Target

Now there's the sound of the wind and cold in the cargo space. As we pass over the strobe, Major Burt brings the aircraft to the five-degree nose-high attitude.

At precisely 12:25 p.m., all forty-six packages exit the back of the C-141 in less than seven seconds. One moment the cabin is full; the next it is an open shell, with bits and pieces of wood and rip cords and paper rattling in the wind and the darkness of the open doorway. Then the doors close and the crew cheers.

"You couldn't ask for a better drop!" Sergeant Wright says. "Everything's right on the drop zone. The Snow Cats are already out. Within fifteen minutes they'll be putting the first bundles in the van."

The moment is over. The loadmasters start rolling up the loose straps and cables. Then we all settle down for the long journey back into the sunset. ■

An Air Force veteran, Arnold J. Mann has worked as a writer and editor for more than ten years. This is his first article for Air Force *Magazine.*

OPM profiles the typical civilian in government.

THE FEDERAL FORCE

ACCORDING to statistics compiled by the US Office of Personnel Management, the typical federal civilian employee is forty-one years old and has been with the government for 13.2 years. His (fifty-seven percent are men) grade averages 8.6 on the General Schedule.

The overwhelming majority of federal workers are clustered in five agencies. The Defense Department has thirty-four percent, followed by the Postal Service with twenty-seven percent, Veterans Affairs (eight percent), Treasury (five percent), and Health and Human Services (four percent).

OPM profiles of the typical worker differ slightly, since some include postal workers and others do not. The OPM calculations are based on a work force of 3,112,823.

From 1960 to 1988, the portion of the federal work force located in the Washington, D. C., area rose from 9.6 percent to 11.3 percent. (If postal workers are factored out, the increase was from twelve percent to 14.4 percent.)

Eight states—California, Texas, Illinois, Florida, Virginia, Maryland, Pennsylvania, and New York—each have more than 100,000 federal workers.

Since 1976, minorities increased from 21.6 to 26.5 percent of total employment. Forty-nine percent of all General Schedule workers are in Grades 1 through 5, but seventy-one percent of the women employees and sixty-six percent of the minority employees are in those grades.

Most (seventy percent) of the professional jobs are held by men, but the number of women in those fields has risen by thirty-four percent since 1981.

Forty percent of women are in clerical jobs. Of women hired into clerical jobs in 1976, twenty-four percent have moved to administrative jobs, twenty-four percent to technical jobs, two percent to professional jobs, and three percent to blue-collar jobs.

About forty percent of the men are in blue-collar jobs, and another twenty-eight percent are in administrative jobs.

Forty percent of the men and twenty-two percent of the women are college graduates. In the nation's civilian labor force, 22.9 percent are college graduates.

Average age in the force has dropped from fifty-one to forty-one over the last twenty years. The average supervisor is 46.2 years old with 19.1 years of service.

Between 1970 and 1987, blue-collar jobs shrank from twenty-eight percent to twenty percent of the total.

The proportion of employees in professional and administrative jobs is up, and the proportion in clerical jobs is down. By the turn of the century, OPM says, there will be 157,000 new white-collar jobs and 107,000 fewer blue-collar jobs.

Seventy-five percent of the federal force is eligible for union representation. Fifty-six percent of the workers are so represented.

Five percent of the federal civilians are retired military. Half of one percent are retired officers and 4.5 percent are retired enlistees.

The average annual base salary for full-time permanent employees, as of March 31, 1989, was $30,008.

One twelfth of the permanent federal work force leaves government each year. OPM says that 4.4 percent quit, 2.7 percent retire, and 1.2 percent are separated by "other personnel actions." ■

Thomas Edison tried. So did Alexander Graham Bell, Hiram Maxim, Samuel Langley, and Octave Chanute.

Five Smart Men Who **Didn't** Invent the Airplane

By Bruce D. Callander

THE WORLD has long recognized the Wright brothers' first powered flight in 1903 as a remarkable achievement. For a fuller appreciation of their accomplishment, one need only consider the cases of five smart men who *didn't* invent the airplane.

Their names were well-known: Thomas Edison, Hiram Maxim, Alexander Graham Bell, Samuel Langley, and Octave Chanute. In the late 1800s and early 1900s, all were world-class inventors.

Experts in widely different disciplines, they all came to hold a common belief—that human flight was possible. Some would dabble briefly with the idea. Others would invest years. None would succeed in building a workable flying machine.

The aeronautic investigations of Thomas Edison were the first and briefest. By the 1880s, he had invented the phonograph and perfected the incandescent light bulb. He was looking for new challenges.

His interest in aeronautics may have been sparked by a child's toy known as the Penaud helicopter. Alphonse Penaud of France had applied a rubber-band engine to an earlier toy, the Chinese top, to produce flying models. They performed beautifully, but Penaud's attempt to build a larger, man-carrying machine was frustrated by lack of a workable, lightweight engine.

Edison was intrigued. He decided to find out exactly how much mechanical power was needed to make the operation of a "helicoptal aeroplane" practical. Characteristically, he began in the laboratory. He attached various types of rotors to the end of a vertical shaft powered by an electric motor and measured their lifting power with a platform scale. Edison concluded that it would take an engine weighing no more than three or four pounds per horsepower to do the trick.

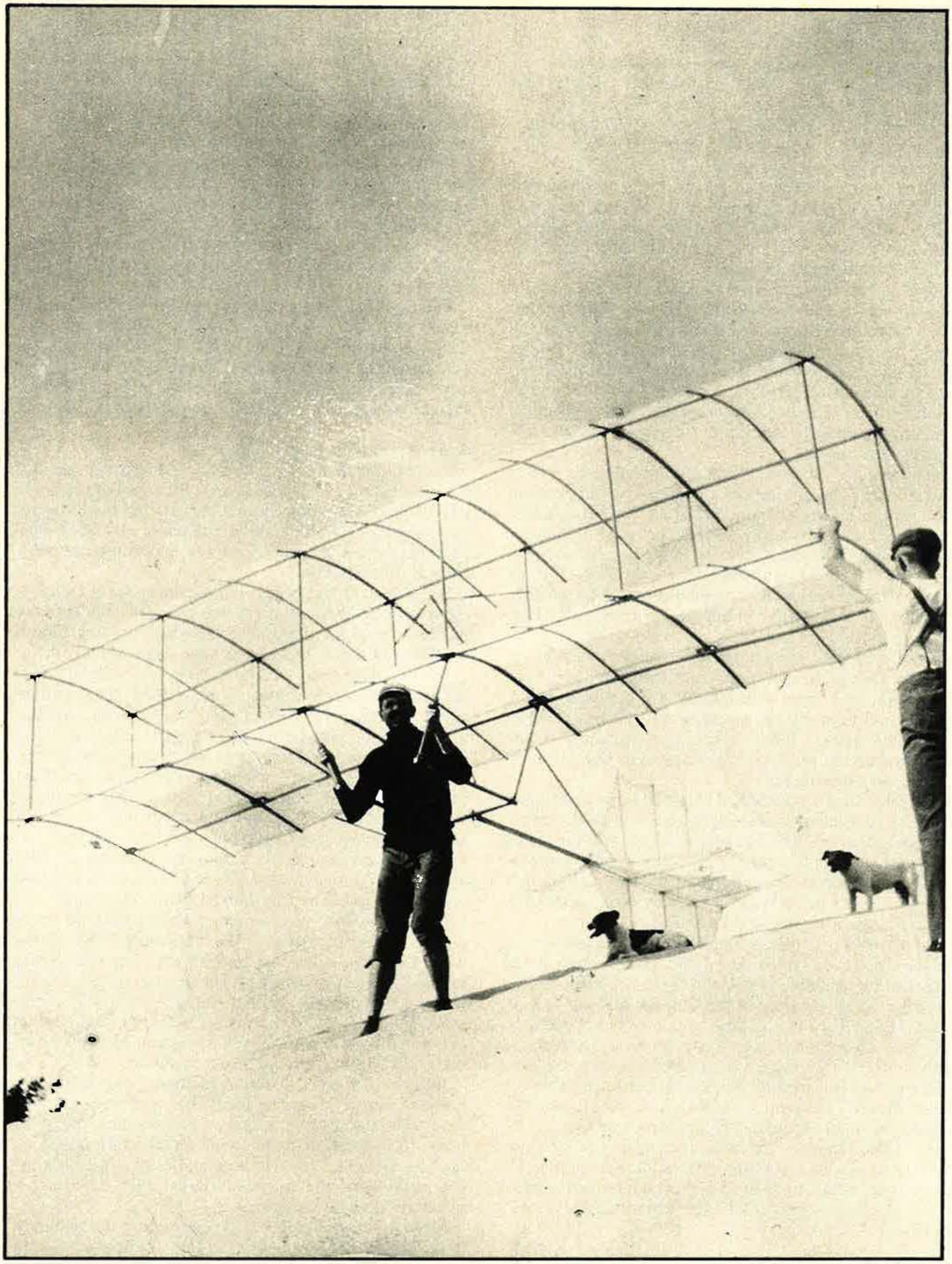
Internal Combustion

Edison devised an internal-combustion engine of sorts. It was fueled by ticker tape treated with nitrates to produce a continuous thread of a type of explosive known as guncotton. It was fed into the cylinder and exploded with an electric charge. The arrangement worked fairly well, but, during a trial, an entire roll of tape was ignited and exploded. One of Edison's assistants was burned, and Edison's hair was singed.

The explosion alone may have discouraged Edison from pursuing the problem of flight. But Edison also shied away from inventions with no commercial promise. In the 1880s, the prospect of a market for a flying machine must have seemed too remote to be worth the effort. His interest in flight continued, but never again did Edison actively pursue airplane projects.

Not long after, another inventor, a rival of Edison's, was seriously studying ways to take to the air. Hiram Maxim, son of a backwoods Maine farmer, had gone to Canada to avoid the Civil War. By 1866, he had returned to New England, taken a job with an engineering firm, and begun to apply his talent for invention.

In 1878, Maxim became Chief Engineer of the United States Electric Lighting Co. and worked to perfect the incandescent light bulb. When Edison beat him to it, Maxim gave up his post and went to Europe, where he remained the rest of his life. It was there, in 1883, that he invented the automatic-firing gun that changed the face of warfare and made him rich and famous.



Octave Chanute intermittently tested man-carrying gliders during 1896 and 1897 and again in 1901 and 1902. His first glider had five wings, but experimentation led him to the biplane design shown here. Unlike most of their fellow would-be flying-machine inventors, Chanute and Samuel Langley both managed to get their machines aloft, albeit for very short flights.

While in England, Maxim began his investigation of flight. By 1894, he had poured 20,000 pounds sterling into the project. The result was a huge contraption with a main wing 110 feet long and four feet wide. It had elevators fore and aft and two propellers driven by steam engines, each of which generated 360 horsepower. The machine was mounted on a half-mile railroad track that Maxim had laid out on his estate in Kent.

Maxim did not expect or intend to fly to any great height. At three and one-half tons, his machine was unlikely to set any altitude records. At this point, Maxim said, he was interested only in measuring the thrust of propellers and lift of wings.

One day in 1894, Maxim climbed aboard his aerial locomotive, eased the throttle forward, and headed down the track. The machine lifted a few inches from the track, but broke through one of the guardrails Maxim had installed along the track to restrain the air machine. Maxim shut off all power and retired from the field of aviation. Like Edison, he concluded that a practical machine would have to await perfection of the internal-combustion engine.

One inventor who went further than either Edison or Maxim was Samuel Pierpont Langley. Langley worked for a time as an engineer and architect, but his consuming interest was astronomy. In 1867, he became Director of the Allegheny Observatory in Pennsylvania and professor of astronomy at the Western University. For his study of solar radiation, Langley invented an electric thermometer, known as a bolometer, to measure the heat in various bands of the sun's spectrum.

Langley might have spent the remainder of his life in astronomy had he not been captivated in 1886 by a lecture on bird flight. He built a whirling-arm device with which to study the aerodynamics of birds' wings and other shapes. When he became Secretary of the Smithsonian Institution in Washington in 1887, he continued the experiments.

In 1891, Langley published his findings in a pamphlet titled "Experiments in Aerodynamics." In 1893, he presented a paper on "The Internal Work of the Wind" at an International Conference on Aerial Navigation in Chicago. The chairman was Octave Chanute, yet another inventor. Born in Paris and raised in New York City, Chanute was a largely self-educated engineer.

In his youth, Chanute had worked for a number of western railroads but made a hobby of collecting all the information available on human flight. In 1863, he had become Chief Engineer of the Chicago and Alton Railroad. He decided it was time to put away his notes on flying and give his full attention to business. In the years that followed, he made a great reputation by building railroad bridges, including one at Kansas City that became the first to span the Missouri River. He also designed the world-famous Chicago Stockyards.

By 1889, however, Chanute once again had the time and the money to renew his interest in aeronautics. He dug out his notes, updated the information, and wrote a series of articles later published in a book titled *Progress in Flying Machines*.

New Forms of Power?

While Chanute was still writing about the experiments of others, Langley was back in Washington trying to develop new forms of power for heavier-than-air flying machines. By 1893, he had flown models powered by carbonic-acid gas and air. Later versions of his models were fitted with tiny steam engines, their boilers flash-heated with gasoline flames. The following year, Langley built a catapult on a houseboat floating on the Potomac River, to be used to launch large models.

On May 6, 1896, Langley launched his Model No. 5 near Quantico, Va. It flew half a mile before it ran out of fuel and landed on the water. That fall, Langley flew his Model No. 6 for about three quarters of a mile. Soon, he announced that, having shown the practicality of mechanical flight, he would leave the commercial and practical development of the idea to others.

The flight was witnessed by members of the Smithsonian staff. Also looking on with great interest was Langley's friend Alexander Graham Bell, who by now was providing some financial support for the experiments and beginning to catch the flying fever. If Langley was ready to quit, his friend Bell was just getting started.

Bell's Kites, Chanute's Gliders

Scottish-born, Bell had come to America to use his father's system of Visible Speech for training the deaf. His study of sound and vibration led eventually to his epoch-making invention of the telephone. By 1893, Bell had become a US citizen and was experimenting with kites in Nova Scotia.

Chanute also had begun active experiments with flying machines. While Langley was flying his models over the Potomac, Chanute was testing man-carrying gliders on the sand dunes of Indiana near Lake Michigan.

His first glider was a cumbersome, five-winged affair. When it proved too unwieldy, he peeled off two wings and flew with three. He removed another wing, and the biplane glider was born. To offset the effect of wind gusts, Chanute fitted the wings with springs so that they could swing backward when wind hit them and then return to normal when it died down. This notion of achieving stability with movable wings became an obsession with him and influenced his later designs.

Chanute continued his gliding experiments in 1897 and described them in that year's *Aeronautical Annual*, a yearbook published by James Means of Boston.

In 1898, world events drew Langley back to aeronautical experimentation. The battleship USS *Maine* was blown up in Havana harbor, and war with Spain loomed. The US government became interested in flight for military purposes. A joint Army-Navy board recommended that Langley be given $50,000 to continue his experiments in manned flight. President McKinley formally asked him to build a test machine.

With help from a young engineer, Charles Manly, Langley began designing a full-size version of his tandem wing models and a lightweight gasoline engine to power it. In addition to their work on this craft, known as the "Aerodrome," the two began building a one-quarter-size model for the purpose of testing a new barge-mounted launching platform.

Meanwhile, Bell still was designing and flying highly unusual kites in Nova Scotia. In 1899, he built a box kite more than fourteen feet long, but could find no wind strong enough to lift it. Though disappointed, he continued to work with kites of various sizes and shapes until he hit on the idea of building a kite composed of tetrahedral cells. When complete, the kite looked like a hive built by bees with a poor sense of geometry, but it flew. Bell dreamed of building a powered version large enough to carry a man.

With the turn of the century, experimentation started to pick up speed. In mid-1901, Chanute visited Chuckey City, Tenn., where he was having a new glider built by Edward C. Huffaker. Huffaker had worked for both Chanute and Langley. Chanute's new glider was made of paper tubing instead of wood spars. The curvature of the wings was designed to vary with changes in the wind. In the end, however, it proved too weak to fly and crumpled when the paper tubes accidentally became soaked in the summer rains.

In the fall of 1902, Chanute tried again, this time with the help of another assistant, Augustus M. Herring. Chanute had had his multiple-winged glider rebuilt and had a new glider made by Charles Lamson of California. Herring tested both, but neither proved successful. After ten days of experimentation, Chanute ended his tests without having produced a workable machine.

Shortly afterward, Chanute stopped in Washington to visit Langley, who was close to finishing work on his Aerodrome. Chanute was no doubt excited by what he saw. By the summer of 1903, Langley was ready to test the one-quarter-size model of his Aerodrome on the specially prepared launch platform.

On August 8, 1903, the model was launched and flew erratically for about 1,000 feet. The problem was with the engine. Someone had overfilled the fuel tank, and gasoline had gotten into the air intake. In every other respect the flight was considered a success, and Langley gave the go-ahead for Manly to test the full-size Aerodrome when conditions were right.

Though problems continued to plague the experiment, the Langley-Manly machine finally was ready. On October 7, 1903, Manley climbed aboard and the catapult sent the machine down the track. To Langley's supreme disappointment, the Aerodrome plunged into the water about fifty feet beyond the houseboat. Langley's official explanation was that one of the Aerodrome's guy posts had snagged on the launching platform.

The machine was repaired, and Manly made another try on December 8, 1903. The Aerodrome was launched, rose briefly, and hovered for a moment. Then it slipped backward and fell into the Potomac. Manly was fished from the river's icy waters, and Langley's attempt to fly came to an end.

The Wrights' Success

Nine days later, on December 17, 1903, Octave Chanute received a telegram from Katherine Wright in Dayton, Ohio. She relayed some dramatic news: Her two brothers, Orville and Wilbur Wright, who had worked extensively with Chanute over several years, had just made four successful manned flights in an aircraft. The race to build "the first" airplane was over.

News of the Wrights' achievement affected the inventors differently. Edison readily hailed the Wrights' achievement. The great inventor himself made no claim to having advanced the progress of aviation. After testing the lifting power of rotors and tinkering briefly with his guncotton engine, he had returned to more familiar ground. Even after fixed-wing aircraft became commonplace, he retained his belief in vertical flight. "Whatever progress the aeroplane might make," he said, "the helicopter will come to be taken up by the advanced students of aeronautics."

In stark contrast, the flamboyant Hiram Maxim made outlandish boasts about his own aeronautical achievements. His main distinction, in truth, is that he wasted more money to produce fewer results than almost any other experimenter. After his brief tests with the steam-powered biplane in 1894, he did no more experimenting until 1910, when he built another biplane that worked only a little better. By the time of his death in 1916, he had accumulated 122 US and 149 British patents, but he was vain and jealous of other inventors, especially of Edison, his old rival in the electric lighting business.

History fails to credit Bell with any major personal achievement in the field of aviation, though he did help foster successful experimentation by others. Well after the Wrights had flown under power, Bell continued to experiment with his peculiar, honeycomb kites in Nova Scotia. By December 1905, he had made one large enough to lift a 165-pound man. The flying machine he envisioned was to be a powered kite that could be towed into the air, travel at low speeds, and float to earth. By 1907, he had built such a machine, a fifty-two-foot-wide array of 3,300 tetrahedral cells arranged on an aluminum frame. Bell's rig, the *Cygnet,* made its maiden flight in December 1907. Towed behind a boat, the *Cygnet* rose to an altitude of more than 150 feet. But the wind died, and the kite descended before the pilot could cast off the tow line. The *Cygnet* hit the water and was dragged behind the boat until it broke up.

Chanute had worked closely with the Wright brothers and was understandably pleased to get word of their success at Kitty Hawk. But his friendship with the Wrights was about to collapse. For years he had written and lectured on the progress of aviation. He had become a sort of clearinghouse for information on the state of the art. By 1903, the Wrights felt he was giving away too many details of their system. Later, under the pressure of patent lawsuits, Chanute's relationship with the Wrights deteriorated even more. After an exchange of increasingly bitter letters, Wilbur wrote Chanute a conciliatory note in April 1910. That November, at age seventy-eight, Chanute died in Chicago.

The Wrights' success doubtless added to Langley's intense disappointment about the highly publicized failure of his Aerodrome a few days earlier. Langley might have taken comfort in the knowledge that his writings were among those the Wrights devoured when they first thought of flying. But his earlier work was discounted by the Wrights, who found errors in his data and flaws in his basic theories. Langley died in February 1906, little more than two years after his failure on the Potomac. ■

Between tours of active duty in 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 was "The Critical Twist" in the September 1989 issue.*

In the summer of 1940, a handful of American airmen risked criminal prosecution to fly alongside the RAF.

THE PRE-EAGLES

By David A. Johnson

THIS summer will mark fifty years since the Royal Air Force held off the Luftwaffe in what Britain remembers as its "finest hour." When they honor the airmen who won the Battle of Britain, Englishmen might well take note of a few Americans who fought even when the US would not.

In the summer of 1940, World War II had been under way for nearly a year. Hitler's Germany was triumphant. With Pearl Harbor more than one year away, the US was still neutral. It was a time, Winston Churchill later observed, when "the British people held the fort *alone* till those who hitherto had been half blind were half ready."

The RAF was alone, but some Americans did not remain neutral. The worst days of the Battle of Britain—from July 10 to September 15—saw a handful of US pilots fighting side by side with England's. They had found unusual ways to join RAF's Fighter Command, where all fought and some died.

At least twelve US pilots were active, perhaps many more. They destroyed at least fifteen German planes. Some names are known: Fiske of 601 Squadron; Donahue of 64 Squadron; Haviland of 151 Squadron; Leckrone of 616 Squadron; Mamedoff, Keough, and Tobin of 609 Squadron. In other cases, all that remains in war records are nicknames: "Tex" or "Uncle Sam."

They were an American vanguard. In RAF service, these Yanks predated even the famous, all-American Eagle Squadrons, the first of which was not formed until September 19. Even though they saw action in the desperate battles of July, August, and early September, they are now mostly forgotten because their presence was never acknowledged.

This was no accident; one of the US Neutrality Acts proscribed any US participation in the forces of a belligerent nation. The United States, being neutral, was determined to keep US citizens out of the war. Violators faced stiff criminal penalties of up to $20,000 in fines, ten years in prison, and loss of citizenship. For those joining the RAF, anonymity seemed the best protection.

"Hunting Trips" in Canada

Most declared themselves Canadians or citizens of Commonwealth countries. Some went to Canada on a "holiday," then simply disappeared. One told the customs officer in Boston that he was off to Newfoundland "for some shooting." No one knows how many Americans fought. British records list many Canadian pilots. How many of these were actually US citizens probably will never be determined.

One who falsely held himself out to be a Canadian was Hugh Reilly, a twenty-two-year-old American who, in the runup to the Battle of Britain, became a Pilot Officer in the RAF.

Reilly not only declared himself to be a Canadian, but also managed by illegal means to obtain an authentic Canadian passport. The available records do not disclose any details about how Reilly managed to acquire it. Mindful that fraudulent use of a passport could land him in a US prison, Reilly swore to secrecy everyone connected with his plot.

The purloined passport did its job. With it, Reilly was able to clear strict wartime customs and immigration controls and reach England, where in early September 1940 he received his RAF commission.

Members of RAF's 601 Squadron sprint to their Hurricanes for another air encounter in the Battle of Britain. 601 Squadron's Pilot Officer Billy Fiske seems to have been the first "official" US combatant to die in World War II.

He was posted to Gravesend, Kent, where he joined Fighter Command's 66 Squadron and took part in the great air battle of September 15 over the south coast of England. The date of the huge clash of RAF and Luftwaffe, the clear turning point of the air war and one of the most decisive battles in history, has been celebrated as Battle of Britain Day ever since.

In following weeks, Reilly continued to fly constantly against German attackers, shooting down a Messerschmitt Bf-109 on September 27. Three weeks later, his luck ran out. Reilly was shot down and killed by the Luftwaffe ace Werner Mölders. The American was buried in a small Gravesend churchyard, his nationality a closely held secret.

Pilot Officer Carl Davis was another Yank serving in RAF's Fighter Command, one whose true citizenship was not so much covered up as it was simply overlooked. In official records, Davis is listed as South African. Davis, indeed, had been born in South Africa, a fact he chose to emphasize when he presented himself to the RAF in the summer of 1940. Davis's parents, however, were US citizens, and so was he. At the time of his service in the RAF, Davis held a US passport.

World War II's First American Ace?

In mid-summer 1940, with the German onslaught about to commence, Pilot Officer Davis was posted to RAF's 601 (County of London) Squadron, which flew Hawker Hurricane fighters out of Tangmere aerodrome in West Sussex. This unit soon found itself in heavy action. So did Davis. By August, Davis already had shot down five German planes. By September 4, the RAF had credited the American pilot with destruction of eleven and a half Luftwaffe aircraft.

Thus, although no official US records ever have recognized him as such, Davis may well have been the first US citizen to become a World War II ace.

Like Reilly, Pilot Officer Davis was shot down and killed, his death coming at the hands of the Luftwaffe on September 6. He is buried in St. Mary's Churchyard in Storrington, West Sussex.

One American pilot who didn't bother to conceal his true citizenship was Pilot Officer Billy Fiske.

William Meade Linsley Fiske III, born in Chicago, was a US citizen who had lived in England since before the start of the war. Fiske came from a wealthy family, attended Cambridge University, and was married to the former wife of the Earl of Warwick. On weekends throughout the 1930s, Fiske honed his flying proficiency in his own private aircraft.

In July, Pilot Officer Fiske was posted to RAF's 601 Squadron, the same unit joined by Davis. He apparently was very popular and respected. One squadron mate, Flight Lt. Archibald Hope, called Fiske "the best pilot I've ever known."

Because Tangmere aerodrome was so near the Channel coast, it was a prime target for the Luftwaffe. Number 601 Squadron was engaged in combat every day. On August 13, during one of his first operational sorties, Pilot Officer Fiske shot down a German Junkers Ju-88 aircraft.

Three days later, however, Messerschmitts jumped Fiske's Hurricane as he was returning to base. The plane, badly damaged and burning, crash-landed at Tangmere. When Flight Lieutenant Hope watched the ambulance crew lift Fiske from the cockpit, he saw that Fiske had sustained burns on his face and hands, but he did not believe the American was near death. However, Hope recalls, "the next thing we heard, he was dead. Died of shock."

One finds frequent references to Fiske as the first US citizen on active military service to die in World War II. Certainly, it appears true that Fiske was the first "official" US combatant to be killed, though some countrymen disguised as Canadians may have died earlier.

A case in point is Flight Lt. Jimmy Davis, yet another American whose actual nationality never came to light during his time of service in the RAF. Acquaintances remember Davis as having flown with RAF's 79 Squadron, based at Biggin Hill. Pilot Officer Donald Stones, who served in the same squadron, recalled that Davis was shot down and killed on June 25, before the Battle of Britain began in earnest. Davis's death therefore would have predated Fiske's by nearly two months.

The US pilots who served in the Battle of Britain came from many different regions and backgrounds. Arthur Donahue described himself as a simple "farm boy" from St. Charles, Minn. After the evacuation of British forces at Dunkirk and the fall of France, Donahue crossed the border to Canada, signed up with RAF recruiters, and arrived in England on August 4. He was posted to 64 Squadron at Kenley aerodrome.

It didn't take long for Donahue to find trouble, and vice versa. Donahue damaged a German Bf-109 on his first sortie. Then, in another engagement, his own Spitfire was badly damaged by a German 20-mm cannon shell. When the Spitfire returned to Kenley, it needed a new fuselage. About a week later, Donahue's Spitfire was attacked by Luftwaffe fighters and set on fire. Pilot Officer Donahue, badly burned and wounded, bailed out of his aircraft and was recovered by rescue teams. He spent the next several weeks in a British hospital.

By the time of his release, the worst of the Luftwaffe assault was over, and the tide of the Battle of Britain had turned in favor of the RAF. Donahue once again sought to join an active unit. He was posted to the first all-American Eagle Squadron, recently activated and forming up. But he was impatient and rejoined his old unit. Later, he won the Distinguished Flying Cross for action over Java. He returned to England to command 64 Squadron. In action over the Channel on September 11, 1942, Donahue was forced to ditch and was never found.

To England by Way of France

Three other Yanks wound up in the RAF by accident. Andrew Mamedoff, Vernon Keough, and Eugene Tobin had gone to fight Hitler by joining the French defense effort. All had been recruited into the French Armée de l'Air. By the time the group reached France, however, the country was being overwhelmed by the German blitzkrieg and was on the verge of surrender.

The three decided to try their luck elsewhere. After evading the advancing German Wehrmacht and crossing into Spain, they boarded the steamer *Baron Nairn,* bound for England, in late June 1940. Two days later, on British soil, Mamedoff, Keough, and Tobin decided to join the RAF. The trio went to the US Embassy for assistance, but got an argument. Ambassador Joseph Kennedy, father of future US President John F. Kennedy, did not like the idea of US citizens fighting in British uniforms and tried to have the three returned to the United States.

To circumvent Ambassador Kennedy and the Neutrality Acts, the three Yanks sought and received the help of an unidentified Member of Parliament. Their new friend got Keough, Tobin, and Mamedoff into the RAF. They lied about their flying time—Tobin increased his total from 200 hours to 5,000—and were taught to fly Spitfires. From flight school, all three were sent to 609 (West Riding) Squadron at Warmwell aerodrome in Dorset.

The three new Squadron members were well-liked and were the center of attention. Lanky "Red" Tobin, from the "Wild West" (*i.e.,* California), was thought to be just like a cowboy in the movies. Andy Mamedoff was crazy about gambling and would wager on anything and everything. Vernon Keough, four feet ten inches tall and known to all as "Shorty," had been a professional parachute jumper before the war. He had to sit on two cushions to be able to see over the top of a Spitfire's instrument panel.

Popular though the three Yanks were, Squadron Leader Horace Darley refused to let them fly in combat until he was certain that they were ready. For a month, they ran errands and flew ferrying missions but saw no fighting.

Inauspicious Beginnings

Finally, on August 16, Pilot Officers Keough, Tobin, and Mamedoff were pronounced "operational." It was the start of the Luftwaffe's maximum effort to knock Fighter Command out of the war and clear the way for a full invasion of Fortress England. Nearly every day, the Luftwaffe's air fleets and the RAF's fighter squadrons inflicted heavy losses upon each other.

The Yanks' first operations against the enemy were not encouraging. On his first sortie, Tobin fired 2,000 rounds of .303 ammunition and burned eighty gallons of fuel, but allowed his target, a Messerschmitt Bf-110, to escape. Shorty Keough's first effort was frustrating; he fired his guns repeatedly at the enemy without evident result. In his first combat, Mamedoff fared worse. His Spitfire was all but destroyed by a German Bf-109, although somehow he managed to land.

Daily at British aerodromes during the late summer and early autumn of 1940, pilots donned flight gear and waited for the scramble. Some killed time with games; American Arthur Donahue wrote an account of his experiences.

Then things began to change. On August 25, Red Tobin shot down his first enemy aircraft, a Bf-110. His best fighting day came on September 15, the climax of the Battle of Britain, when hundreds of Spitfires and Hurricanes intercepted roughly 200 German bombers and 400 fighters in the skies over southern England. As usual, Tobin and the rest of 609 Squadron were up over London. He could see about 100 German aircraft approaching from the south—some fifty Bf-109s above, twenty-five Dornier Do-215 bombers below, and other planes in the distance. As junior man, he was weaving to protect the tails of flight leader and wingman. As his flight was preparing to drop on the Dorniers below, Tobin heard his leader call, "OK, Charlie. Come on in." Before joining up, he looked around and saw three yellow-nosed Bf-109s diving from behind.

He screamed into his microphone, "Danger, Red Section! Danger! Danger! Danger!" At the same time, he throttled back and threw his Spitfire into a 360-degree turn. The German pilots could not slow down and shot past. Tobin fired at the last Messerschmitt as it went by and saw smoke trail from it.

Hitler Was Convinced

Soon, Tobin was all alone. He spotted a Do-215 heading for a cloud bank and dove after it before it could reach safety. Red was able to close to within machine-gun range. He pressed the firing button and immediately saw smoke coming from an engine. "I followed it down and saw a Do-215 make a crash-landing two or three miles east of Biggin Hill," Tobin stated. "Three of the crew got out and sat on the wing."

Pilot Officer Tobin had another confirmed kill and damaged another Bf-109. Shorty Keough was credited with one-half of a kill on September 15; it was also a Do-215.

The Luftwaffe's losses on September 15, about fifty-six aircraft, convinced Hitler that the Luftwaffe was incapable of winning air superiority over the Channel. Operation Sea Lion, the planned invasion of England, was postponed and then shelved completely.

Tobin, Mamedoff, and Keough all died in combat against the Luftwaffe, but not before they had passed some of their hard-won expertise to other US flyers. Four days after the great air battle, on September 19, Tobin, Mamedoff, and Keough became the first pilots transferred to Number 71 Eagle Squadron, where they formed the nucleus of one of the war's most famous flying units. That first Eagle Squadron was joined by two others formed in 1941—Numbers 121 and 133 Squadrons. In September 1942, all three were folded into the US Army Air Force, becoming the 4th Fighter Group. It destroyed more than 1,000 enemy aircraft during the war. This success was based on tactics first learned in the RAF by young men who helped the United States by breaking its laws in 1940. ■

David A. Johnson is a free-lance writer based in Middlesex, England. His book about the London blitz, The City Ablaze, *was published in 1980. He is now at work on a book about the RAF in the early war years, with an accent on the activities of US volunteers. This is his first article for* AIR FORCE *Magazine.*

Valor

By **John L. Frisbee,** Contributing Editor

The Bridge at L'Isle Adam

Neither flak nor flames deterred Darrell Lindsey from completing the mission and saving the lives of his crew.

IN early 1944, the 394th Bombardment Group flew its B-26 Martin Marauders from Kellogg Field, Mich., to England. The 394th entered combat in March, joining other medium bomb groups and fighter-bombers in attacking German defenses and transportation in preparation for the invasion that everyone—Germans and Allies alike—knew was coming. After D-Day, the 394th continued to bomb targets in northern France, supporting the Allied advance from the Normandy beachheads.

On August 7, the Germans launched a counteroffensive aimed at securing Avranches, on the west coast of France. There they hoped to anchor a line that would confine the Allies to areas already held in Normandy and the Cotentin peninsula. A key element for the German armies was transportation to move desperately needed supplies and reinforcements to the front. Most of the bridges over the Seine had been knocked out. One link that remained was the railroad bridge over the Oise River at L'Isle Adam, a few miles north of Paris. It was heavily defended by many batteries of 88-mm guns—a major threat to the B-26s that normally bombed from an altitude of 10,000 to 12,000 feet.

Ninth Air Force sent the 394th against the bridge on August 9. Leading thirty B-26s was twenty-five-year-old Capt. Darrell Lindsey, one of the Group's veteran pilots. He had gone through both pilot and bombardier training and had flown Marauders at MacDill Field, Fla., before joining the 394th as a flight commander in September 1943. This was Lindsey's forty-sixth mission, bringing him to 143 combat hours. He was known for his skill as a pilot and for coolness under fire. Both would be tested that day.

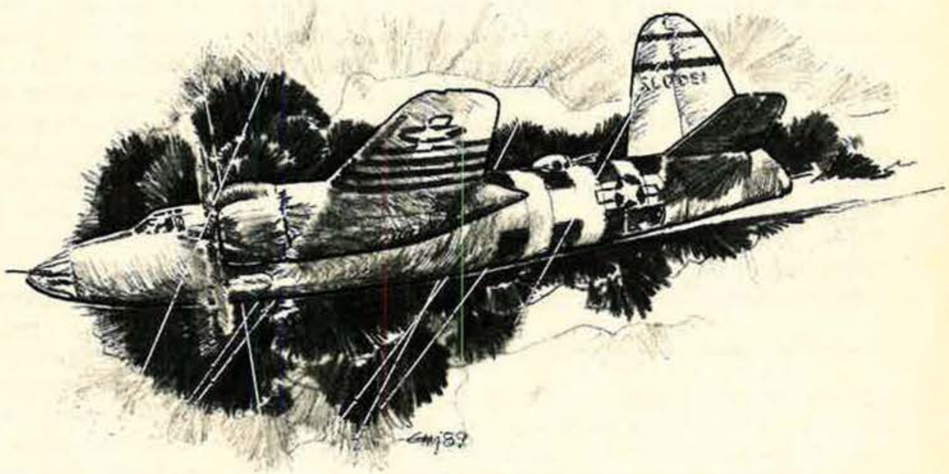
On reaching enemy territory, the formation encountered heavy flak, which continued with few interruptions as they approached the target area. Captain Lindsey maneuvered the bombers past successive barrages with only minor damage. Before starting the bomb run, Captain Lindsey's lead plane was hit, but was able to hold course. Worse was yet to come. On the bomb run, his right engine took a direct hit and burst into flame. The concussion hurled the B-26 out of formation, but Captain Lindsey regained control and resumed the lead, his right wing sheathed in flame. The wing tank could explode at any moment, but rather than giving the signal to bail out and disrupt the formation at this critical point, Captain Lindsey elected to continue the attack. This was a target that could help turn the tide of battle in Normandy.

Immediately after "bombs away," Captain Lindsey ordered the crew to jump while he held the flaming Marauder in a steady descent. The last crewman to leave the plane was the bombardier. As he crawled out of the nose, he shouted that he would lower the landing gear so Captain Lindsey could bail out from the nose of the aircraft.

Using all his piloting skill, Captain Lindsey was barely able to keep control of the doomed bomber, its right wing now totally engulfed in flame. He knew that lowering the gear might throw the plane into an uncontrollable spin, probably making it impossible for the bombardier to bail out. He told the man to leave through a waist window while the aircraft was still under control. By all logic, the tank should have blown by this time. It might hold long enough for the bombardier to jump. It did, but before Captain Lindsey could leave the cockpit, the wing tank exploded. The B-26 went into a steep dive and hit the ground in a ball of fire.

For destroying four railroad bridges and an ammunition dump between August 7 and 9, the 394th Group received a Distinguished Unit Citation. For his heroism and self-sacrifice on August 9, Capt. Darrell Lindsey was awarded the Medal of Honor posthumously. He was the only Marauder crew member to be so honored in World War II.

Uncharacteristic of the formal, stilted citations for combat awards, the citation for Darrell Lindsey's Medal of Honor ends with these words: "All who are living today from this plane owe their lives to the fact that Captain Lindsey remained cool and showed supreme courage in this emergency." For him, completing the mission came first, the safety of his crew second, his own survival last. He was a leader in the finest tradition of the American military services. ■



The right wing of his B-26 Martin Marauder aflame, Capt. Darrell Lindsey regained the formation and chose to continue the attack rather than bail out.

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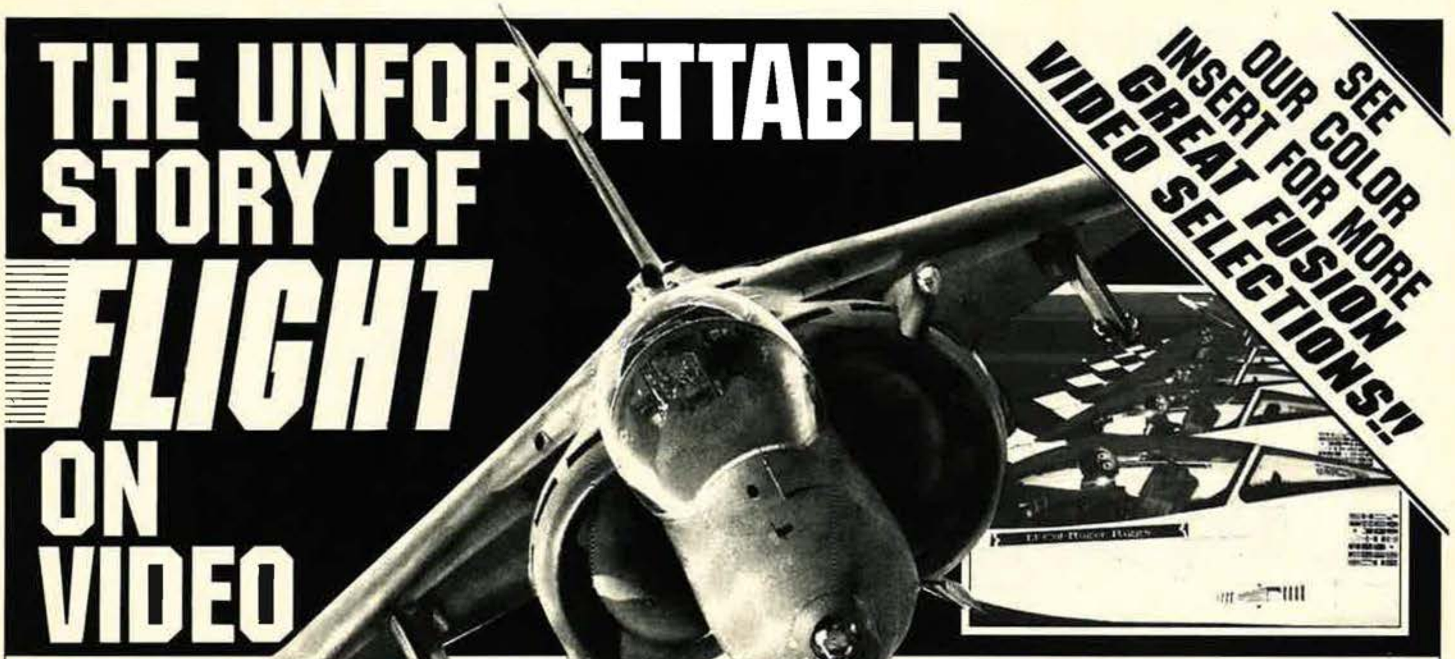

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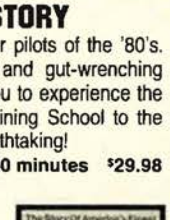

From the Mustang's development to her glory days as deep escort into Germany, this action-packed film is the definitive record of the legendary P-51. Made with the cooperation of the USAF, interviews with combat pilots including Ace, Donald Strait (13 1/2 kills) are interwoven with superb air-to-air and in-the cockpit footage.

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This field has been in continuous operation longer than any other airport in the world.

Eighty Years at College Park

By C. V. Glines

This rare aerial photo shows the College Park Airdrome as it looked around 1910. The tent hangars have been replaced by more permanent structures, and instead of Curtiss and Wright biplanes, the airport now serves some 100 modern, general-aviation aircraft.

TRIVIA question for the aviation history buff: What airport has been in continuous operation longer than any other in the world?

The answer: College Park Airport, Md., 3.5 miles northeast of the city limits of Washington, D. C. The airport's eightieth anniversary was marked by an "air-fair" last September.

One of the specifications in the contract for the purchase of the Army's first airplane was that the Wright brothers would teach two officers how to fly it. The commander at Fort Myer, Va., where Orville Wright had successfully demonstrated the *Flyer* on the post's small parade ground in 1909, asked the Wrights to take their "aeroplane" and fly it elsewhere. They were glad to do so.

Lt. Frank P. Lahm, a balloonist assigned to the US Cavalry, selected the College Park site near the Maryland Agricultural College shortly after the Wright tests were completed. He made an aerial survey in a balloon, followed by an inspection on horseback.

Lieutenant Lahm and Lt. Frederic E. Humphreys, an engineer, were the two officers selected for flight training. Without extra cost, the Wrights included Lt. Benjamin D. Foulois, the only one of the trio assigned to the Signal Corps. He had been the passenger on the required cross-country demonstration flight in 1909.

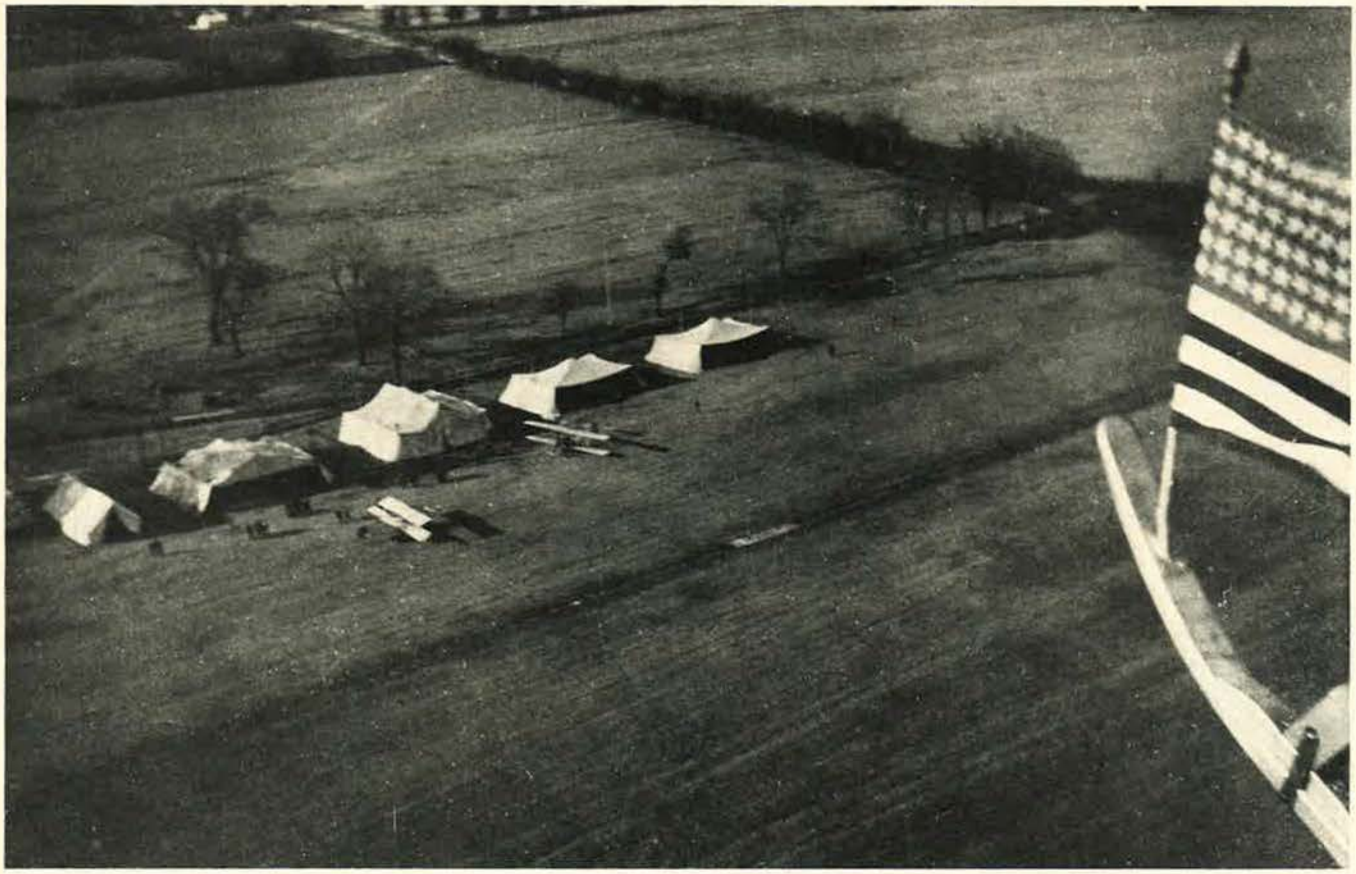
Wilbur Wright made the first dual-instruction flights at College Park with Lieutenants Lahm and Humphreys on October 8, 1909. The next day, Wilbur flashed around a closed circuit 500-meter course at a dazzling forty-six mph for a new world speed record.

Lieutenants Lahm and Humphreys both soloed on October 26, with Lieutenant Humphreys having the honor of being the first Army officer to do so. The *Flyer* crashed on November 3, 1909, during the first flight they made together. Lieutenant Foulois, who had not yet soloed, was ordered by the Chief Signal Officer to take the wreckage to San Antonio "and teach yourself to fly."

A Parade of "Firsts"

The airport boasts several other aviation "firsts." Mrs. Ralph H. Van Deman became the first woman airplane passenger in the US when she flew there with Orville Wright on October 27, 1909. The field became the first military air base in this country when the Signal Corps Aviation School was officially opened in 1911. The first use of field lights took place there on November 17, 1911, when Lt. Thomas DeWitt Milling made several night landings on an area illuminated by two acetylene searchlights. The first "mass cross-country flight" of three planes originated there on May 6, 1912, as did the first "long distance flight" (forty-two miles).

The airport is also the site where the first bombs were



dropped from an aircraft using a bombsight. Riley E. Scott, a former officer in the Coast Artillery Corps, had invented a sixty-four-pound bombsight in 1911. Mr. Scott, lying prone on the lower wing of a Wright Type B airplane piloted by Lieutenant Milling, dropped two eighteen-pound bombs from 400 feet. They landed within ten feet of a four-foot by five-foot target.

Lt. Henry H. "Hap" Arnold flew to 4,764 feet at College Park on January 25, 1912; it took him fifty-nine minutes to complete the climb. He passed the one-mile height on June 1, 1912, and soared to a new world record of 6,540 feet.

Although the flight school was moved to Augusta, Ga., in anticipation of winter weather in November 1911, it returned to College Park the following spring. On June 7, 1912, Col. Isaac N. Lewis, inventor of the famous Lewis machine gun, fired the first aerial shots at a strip of cheesecloth six feet square and scored five hits in the short time he was over the target. His handheld weapon had no gunsights and fired at 500 rounds a minute. Early aircraft radio experiments were also carried out at College Park in 1912.

Rex Smith, a local inventor and attorney, flew airplanes of his own design there from 1910 until 1916. His first successful flight took place on November 20, 1910. The airport has been open to civilian aviators ever since.

On the Historical Register

On August 12, 1918, after Army Air Service pilots had proven the feasibility of scheduled airmail while operating from the polo field in Washington during the previous three months, College Park Airport became the Washington terminus for the Washington-Philadelphia-New York airmail route operated by the Post Office Department *[see "The Day the Airmail Started," December 1989 issue, p. 98]*.

In 1920, College Park was the site of experimental helicopter flights by Emile Berliner. On February 23, 1924, his son Henry made what locals claim to be the "first successful controlled flight by a helicopter."

From 1927 through 1935, the airport was the site of experiments with blind-landing equipment and navigation aids conducted by the US Bureau of Standards. Now a general-aviation airport occupying forty acres of its original 160, the airport was purchased by the Maryland-National Capital Park and Planning Commission in 1973.

In 1977, the airport was added to the National Register of Historic Places in recognition of its significance and continuous use as an airport "from the dawn of motor-powered flight to the modern era." There are seventy-six small general-aviation aircraft based there now; twenty-five others use it regularly as transients. The Federal Aviation Administration has allocated $600,000 for airport improvements now under way.

The list of aviation "firsts" for College Park Airport might include one more: The top four management-level supervisors on the twenty-one-person staff are women. ■

C. V. Glines is a regular contributor to this magazine. A retired Air Force colonel, he is a free-lance writer, a magazine editor, and the author of numerous books. His most recent article for AIR FORCE Magazine was "The Day the Airmail Started" in the December 1989 issue.

Viewpoint

By **Gen. T. R. Milton, USAF (Ret.)**, Contributing Editor

A Rush for the Exits

The game in Europe is a bit friendlier now, but there is still no doubt about whom we are playing. There is danger in assuming that the game is over.

Gen. Emmett "Rosy" O'Donnell, among the world's great raconteurs, had a story for every occasion. The present turmoil in defense brings to mind one of them.

The West Point football team was in New York City for its annual game against Notre Dame, and nearly 80,000 howling fans filled Yankee Stadium. The Army team was proceeding down the field with its signal drill, a custom of that era, when a lineman turned to his neighbor and observed, "Mmm—nice crowd! Who we playing?"

For more than forty years, it has been clear to everyone whom the United States was playing. There have been diversions, including significant ones in Korea and Southeast Asia, but the Soviet Union remained the adversary and the justification for the vast majority of our defense outlays. Now, Gorbymania has humanized the fearsome specter, and the Warsaw Pact has been exposed as an apparently unstable alliance.

Even before the historic events beginning with the great East German jailbreak and ending with the party on the Wall, it was clear that the US defense budget was in for a rough time and that force reductions in Europe were a certainty. But the mood was still cautious.

It is cautious no longer, and the reductions could take the form of a rush for the exits—if certain people have their way.

For a very long time, NATO has been a comfortable alternative to a national defense strategy. NATO, in turn, has avoided coming to grips with its own strategy, that of flexible response. That strategy, adopted somewhat reluctantly in 1967 after considerable US pressure, states that the Alliance must have sufficient conventional forces to resist and repel a conventional attack and to hold off a major conventional attack. Should that fail, NATO will use intermediate and short-range nuclear weapons. Finally, if the situation is still perilous, US and UK strategic nuclear forces will ride to the rescue.

Of course, there have never been sufficient conventional forces, properly deployed and mobilized, to carry out this strategy, and the intermediate nuclear weapons are now history. No one really believes that short-range nukes, with all their implications for Germany, are a realistic option. That leaves the third option in flexible response. So NATO is right where it has always been, dependent on the credibility of the US strategic arsenal, with the US forces in Europe as evidence of that credibility. It is, in a much more elaborate way, reminiscent of Georges Clemenceau's answer to an earnest British emissary who, in the early days of World War I, asked what the French leader wanted from England. One British soldier, answered Clemenceau, who will be an immediate casualty.

The forthcoming conventional arms reductions in Europe will not bring us down to Clemenceau's figure, although the US share of these reductions will be substantial. The Soviets will sustain even heavier reductions if all goes according to plan, but the European standoff will remain, and never mind the fact that the Soviets could redeploy more easily than could Americans who had gone home across the Atlantic and probably demobilized. Strategic weaponry remains, as always, our ultimate strategy.

Whatever the deficiencies in NATO's capability for flexible response, the strategy has worked. The Cold War in Europe seems to be over, and our side has won. Conventional force reductions will now serve as a treaty, and there will be a general assault on Allied defense budgets. That accomplished, Europe will turn its attention to 1992 and the anticipated joys of the European Community's single market, while the political left, on both sides of the ocean, agitates for American withdrawal from Europe and the end of NATO.

That eventuality would be insane, although it is possible, given our behavior after V-E Day. Those were happy times as, arm in arm with our new Soviet comrades, we would see to it that Europe remained peaceful and Germany subdued. The Potsdam agreements, implementing those made at Yalta, will stand forever as examples of American naïveté. The true significance of creating a Soviet network of satellite states in Europe did not register at the time, nor did our leaders realize the malevolence of the Soviet system and its basic incompatibility with democracy. Instead, it was all good fellowship and cooperation. Then, three years after V-E Day, the lesson about the nature of Moscow-style communism came across in the first Berlin confrontation.

From that day on, during the forty-odd years of the Cold War, an American military presence in Europe has been the essential factor in maintaining European stability. That presence need not be so great as it is now—there is, in fact, no precise strategic calculation behind the present commitment—but US military forces in some strength must remain in Europe, not only as visible proof that the West is still united in the cause of democracy, but as a hedge against the possibility that hard-line Soviet soldiers and apparatchiks, faced with eroding prestige and privileges, might put an end to *perestroika* and cause Moscow to revert to its bad old ways.

In short, the game is a bit friendlier now, but there is still no doubt about whom we are playing. ■

Reviews

By Jeffrey P. Rhodes, Aeronautics Editor

The Aviation Careers of Igor Sikorsky, by Dorothy Cochrane, Von Hardesty, and Russell Lee. Last year marked the 100th anniversary of the birth of Igor Sikorsky and the fiftieth anniversary of the maiden flight of the first practical helicopter, the Sikorsky VS-300. As part of its new rotating exhibit honoring Mr. Sikorsky, the National Air and Space Museum has commissioned this beautiful book to address the major themes in the life of the inventor/engineer/businessman/philosopher. Dividing his life into three eras, the book starts in Russia where Mr. Sikorsky designed and flew a number of large aircraft, including the first four-engine plane, the *Grand*. Later he emigrated to the US, where he built several large landplanes, such as the S-29-A and S-35, and a distinguished line of passenger-carrying seaplanes, such as the S-38, S-40, and S-42. The final section deals with the development of the VS-300 and later helicopters. University of Washington Press, Seattle, Wash., 1989. 208 pages with photos, appendices, notes, bibliography, and index. $19.95.

Aviation's Golden Age: Portraits from the 1920s and 1930s, edited by William M. Leary. From the title of this book, most people would expect it to detail the lives of Charles Lindbergh, Amelia Earhart, and Wiley Post. This unusual volume, however, looks at the lives and careers of nine people who rarely got off the ground, but nevertheless made a significant impact on the growth of American aviation. Henry Ford and Harry and Daniel Guggenheim led aviation out of the doldrums that set in after World War I. Brig. Gen. Benjamin Foulois and Rear Adm. William Moffett laid the foundation for the massive Army and Navy air forces during World War II. William MacCraken and Edward Warner provided key leadership for civil aviation during its formative years. George Lewis, a name hardly recognized then, was an important leader in early aeronautical research. Although President Herbert Hoover's administration is rarely remembered fondly, his contributions in placing aviation on a sound administrative and legal base were positive ones. University of Iowa Press, Iowa City, Iowa, 1989. 201 pages with photos, notes, bibliographical essays, contributors list, and index. $22.50.

Dragon Lady: The History of the Lockheed U-2 Spyplane, by Chris Pocock. Unlike other books that accurately describe the U-2 and its systems, this volume, as its name implies, is a brief history of the "Dragon Lady." Starting with the crash program to build the U-2 and the secrecy surrounding it, the book moves on to the training of the initial cadre of pilots, and then to operations. The May 1960 shootdown of Francis Gary Powers brought the U-2 to the world's attention, but the true value of the aircraft was shown (although on the quiet) by its critical performance in the Cuban Missile Crisis. While the CIA will neither confirm nor deny that it trained Nationalist Chinese pilots, an in-depth look at that effort and the pilots' operations over the People's Republic is included. Sections on later U-2 operations and U-2R/TR-1 development and operations also appear in this worthwhile book. Motorbooks International, Osceola, Wis., 1989. 214 pages with photos, bibliography, appendices, and index. $18.95.

Jane's All the World's Aircraft 1989–90, edited by John W. R. Taylor. In the aviation community, the annual arrival of *Jane's* can be likened to Moses coming down from Mount Sinai—it brings with it the truth and is open for all to see. Now in its eightieth year of publication, the book is the standard reference for anyone who has anything to do with aviation. This is also the thirtieth edition of *Jane's* that Mr. Taylor has produced, and it is the editor's reputation for fairness and accuracy to every company in every country that causes the book to be held in such high regard worldwide. As always, the main section of the book contains the facts and figures on every aircraft now in production or under development, while other sections cover sport aircraft, microlights, sailplanes, hang gliders, airships and balloons, and engines. This year there are more than 2,100 entries from 720 different companies, along with some 2,000 photos and line drawings. Jane's Information Group, Surrey, England, and Alexandria, Va., 1989. 808 pages with foreword, glossary, list of first flights, records, illustrations, and index. $140.00.

No Name on the Bullet: A Biography of Audie Murphy, by Don Graham. "To Hell and Back" was the title of Audie Murphy's autobiography, and it is a good description of his life. The son of poor, illiterate Texas sharecroppers, Murphy was seventeen years old, stood five feet, five inches tall, and weighed 120 pounds when he enlisted in the Army. During a two-year period during World War II, he won the Medal of Honor and a permanent place among America's heroes by single-handedly turning back an entire German infantry company with a .50-caliber machine gun. Sergeant Murphy became the most decorated soldier in American history. After the war, he went on to a long career as a Hollywood actor. Suffering from delayed-stress syndrome, he sought release in bouts of womanizing, gambling, dangerous practical jokes, and violent outbursts. Viking Penguin, Inc., New York, N. Y., 1989. 396 pages with photos, filmography, notes, and index. $19.95.

A Race on the Edge of Time: Radar—The Decisive Weapon of World War II, by David E. Fisher. The development of the atomic bomb forever changed warfare and, in the aftermath of its use, the world. However, Mr. Fisher asserts that the development of radar was the more important scientific advance, in terms of its influence on both military and civilian aviation. It would have taken an invasion and a fearful loss of life, but Japan would have been defeated eventually without the atomic bomb. On the other hand, the development of radar in England during the late 1930s, was "the one thing that allowed us to defeat Nazi Germany, and if its utilization had been delayed by only five or six months, the outcome of the Second World War would have been reversed." This book is the complete developmental history of radar, part technical description, part commentary, and part adventure story. Paragon House, New York, N. Y., 1989. 371 pages with photos, diagrams, appendix, notes, and index. $14.95.

The Second World War, edited by Col. Thomas E. Griess. This outstanding three-volume set was written by the history department staff at the US Military Academy at West Point. The cadets are taught to think in terms of "threads of continuity," to view military history in context of other events, and this boxed set looks at World War II in the same manner. The first volume covers the War in Europe and the Mediterranean area, "the story of an unusually successful Allied coalition bringing crushing force to bear on an astonishingly resilient Germany." The second volume, just as thorough in its historical presentation, covers the War in the Pacific. The appendices to both books are a treasure trove for the military scholar. They contain such information as casualty lists, orders of battle, and organizational charts. The third volume is a color atlas of all major Allied and Axis campaigns. Avery Publishing Group, Inc., Wayne, N. J., 1989. 902 pages with photos and charts, notes, appendices, bibliography, and index. $69.95.

THE AIR FORCE'S FREQUENT FLYER PROGRAM.

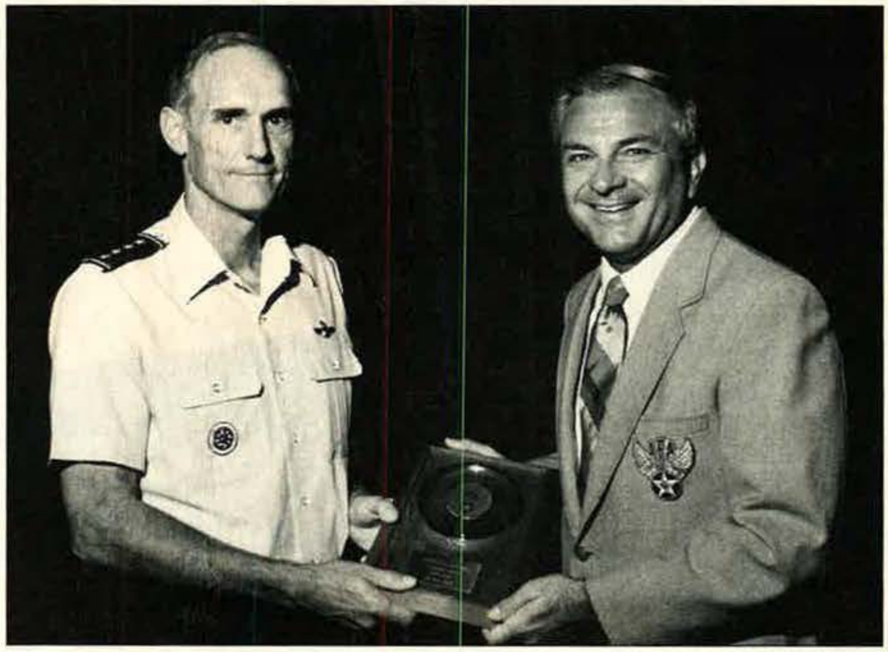
AFA/AEF Report

By **John R. "Doc" McCauslin,** Chief, Field Organization Support Group

North to Alaska

The **Anchorage (Alaska) Chapter** held its annual awards banquet recently with AFA Board Chairman Sam E. Keith, Jr., serving as guest speaker. Students Stacy Marcott and Rewa Hintz each received the Chapter's Robert C. Reeve Memorial Scholarship, worth $1,000. Both are seniors at Chugiak High School in Eagle River, Alaska, and maintain near-perfect academic records while remaining active in the community. Ms. Marcott has received an appointment to the US Naval Academy, and Ms. Hintz will attend Purdue University. John-Christian Anderson, a junior at nearby West High School, garnered the Chapter's $500 Michael Monaghan AFJROTC Scholarship, named for the late USAF major who cowrote (with John Cloe of Eagle River) *Top Cover for America*.

The awards banquet, hosted by Anchorage Chapter President Herman Thompson, also paid tribute to the 43d Tactical Fighter Squadron of Elmendorf AFB. In addition to performing its daily mission of intercepting any Soviet aircraft that approaches Alaska, the squadron had no report-



Gen. Merrill A. McPeak, Commander in Chief of Pacific Air Forces, accepts an AFA commemorative clock from Hawaii Chapter President Tom Keeney. The General gave a progress report on his first year as PACAF's Commander in Chief. A crowd of 250 at a Chapter meeting heard the General's address at the Hickam AFB NCO Club. A former member of the Thunderbirds, General McPeak came to PACAF in 1988 after commanding TAC's 12th Air Force and US Southern Command's Air Forces.

At its annual awards banquet, AFA's Anchorage Chapter honored the Gertsch family for their outstanding community service. From left, National Chairman of the Board Sam E. Keith, Jr.; MSgt. Robert L. Gertsch; Mrs. Karen Gertsch; Robert, James, and Chris Gertsch; and Chapter President Herman Thompson.

With AFA's National Headquarters as a backdrop, AFA leaders took time out during their annual orientation to pose for this photo. National President Jack C. Price, Chairman of the Board Sam E. Keith, Jr., National Secretary Thomas McKee, and National Treasurer William Webb (front row, from left) met with newly elected National Directors and Vice Presidents, State Presidents, and Under-40 Directors in order to discuss operations and programming for 1990.

able Class A or B mishaps, achieving more than 20,000 accident-free flying hours. It also plays an active part in the surrounding community. Mr. Keith and fellow members of AFA also honored MSgt. Robert L. Gertsch and his family for their outstanding contributions to the Salvation Army, Family Food Center, Little League, and Drug-Free Youth Program.

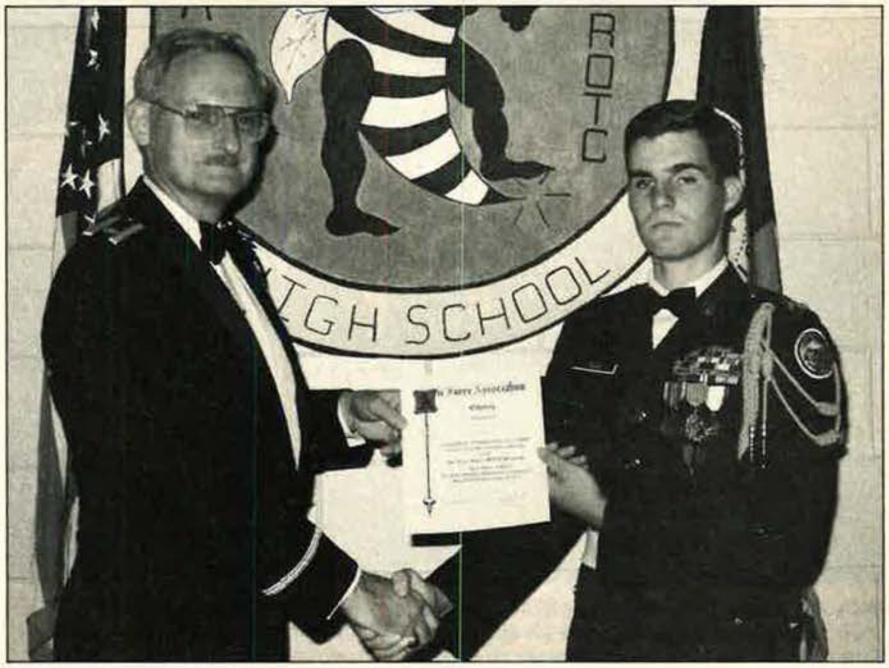
North Central Workshop

In Sioux Falls, S. D., National Vice President (North Central Region) John E. Kittelson hosted the North Central Regional Workshop. Participants from North Dakota, South Dakota, and Minnesota found the day-long sessions extremely productive as they discussed Air Force recruiting, AFROTC support, and such AFA issues as chapter programming, budgeting, leadership succession, and upcoming state conventions. Minnesota State AFA President Doyle E. Larson led the discussion with chapter

Rep. John P. Murtha (D-Pa.) (center), an influential member of the House Armed Services Committee, was the keynote speaker at the Oklahoma State Convention at Altus. Flanking Representative Murtha, proudly displaying his gifts of a B-1B model and hat, are State President Aaron Burleson and State Secretary LaVerne Shaw.

presidents, and each chapter president gave a briefing. A representative from AFA headquarters informed the workshop on national AFA issues.

A formal evening program held in conjunction with the workshop featured guest speaker Brig. Gen. John J. Salvadore, Commander of the USAF Recruiting Service, addressing the future of the Air Force in terms of manpower, training, and long-range plans. In addition to Mr. Kittelson, Ray Peterman, National Vice President (Midwest Region), and Robert Jamison, representing the mayor of Sioux Falls, were among the dignitaries to hear the General's excellent talk. Recruiting Group Commander Col. Herb Meyer, 3504th USAF Recruiting Group, distributed awards to the top ten recruiters of the region: SSgt. Joe French, Master Recruiter; TSgt. Bruce Matthews, Top Enlisted Programs Recruiter; SSgt. Terry Lloyd, Top OTS Recruiter; SSgt. Vic Comstock, Top Medical Recruiter; TSgt. Bruce Trickel, Top Nurse Recruiter; SSgt. Mark Weichman, Recruiter of the Year; SSgt. Greg George, Rookie Recruiter of the Year; SSgt. Mark Delaney, Nonprior Service Recruiter of the Year; TSgt. Frank Tiller, OTS Recruiter of the Year; and SSgt. Mike Wilcox, Top AFROTC Summer Scholarships Programs. Also at the banquet, AFA Medals of Merit were presented by Mr. Kittelson to South Dakota State Vice President Dean Hofsted and past National Vice President (North Central Region) Paul Markgraf.



With AFA's Southeast Georgia Chapter lending major support, Wayne County High School held its annual AFJROTC awards banquet in Jessup, Ga. Here, Chapter President Maj. Donald N. Edmands, Jr., presents an AFA AFJROTC Medal Citation to Cadet Maj. Jey Mosley. The Chapter exemplifies the 1989 National Convention theme, recognizing the youth of today as the leaders of tomorrow.

Convention and Chapter News

Utah State AFA held its annual convention in Wendover, Utah, on the Nevada border. National AFA officers in attendance included Jack C. Price, President; William Webb, Treasurer; William J. Gibson and Nathan H. Mazer, Directors; and Jack Powell, Vice President (Rocky Mountain Region). State President Glenn Lusk and all six of Utah's chapter presidents were also on hand to hear astronaut Cmdr. Robert L. "Hoot" Gibson, USN, relate tales of his travels in space. Commander Gibson, a veteran of shuttle missions on the *Challenger, Columbia,* and *Atlantis,* has 442 hours in space and is currently assigned to the NASA Astronaut Office in support of upcoming shuttle flights.

In an initiative to establish a chapter in the Cedar Rapids, Iowa, area, National Director Don Adams traveled to the Hawkeye State for a dinner briefing. Here, from left, Lew Rapier (chapter organizer), Mr. Adams, Cadet Lt. Col. Gail Slama (Det. 250, Iowa State University), "Doc" McCauslin (Chief of AFA's Field Organization Support Group), and E. G. Houghton (an AFA charter member) get together after the meeting.

To celebrate its anniversary and the Air Force Birthday, the Tacoma (Wash.) Chapter donated $2,000 to nearby McChord AFB. Chapter President Bob Baltzell (left) presents the check to Deputy Base Commander Col. Rodney Chiapusio and Youth Program Director Linda Wojcik. Wing Commander Col. Michael McCarthy, former State President Dick Lewis, and National Director Sherman Wilkins also attended.

The **York-Lancaster (Pa.) Chapter** held a recent chapter meeting in Lancaster, followed by a chapter dinner. Chapter President Bernard J. Nichols introduced Mrs. Eleanor Green, President of Flight #40 of the USAF Mothers Club, who spoke about the concerns of Air Force mothers and their efforts to support people on active duty all over the world. A field organization staffer from AFA headquarters then gave a talk on "National Pride in America" and recommended that the Air Force Mothers Club and AFA could cooperate at the chapter level to support the Air Force mission and its people. Those interested can contact the Air Force Mothers organization at P. O. Box 77, Fishertown, Pa. 15539.

At this year's Wisconsin State Convention in Milwaukee, the Billy Mitchell Chapter presented $350 in support of Civil Air Patrol Cadets and instructor staff. Here, Chapter Deputy for Aerospace Education Herbe Dralle (right) and Wing Recruiter Dori Dralle accept the check from Chapter President Gene Feller.

MOVING?

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Maj. Gen. Philip Killey (center), Director of the Air National Guard, gave an interesting talk recently at a joint meeting of the Dacotah (S. D.) Chapter and the Sioux Falls Downtown Lions Club. Pictured from left, Dacotah Chapter Treasurer Chuck Nelson, National Vice President (North Central Region) John Kittelson, General Killey, Dacotah Chapter President Bob Johnson, and South Dakota Vice President Bob Jamison.

The **Thomas W. Anthony (Md.) Chapter** and personnel from nearby Andrews AFB have begun a project to construct a memorial that recognizes Prisoners of War and those Missing in Action. To be located adjacent to base operations on Andrews, the monument will be a lasting tribute to the US military of all services and all wars. The projected total cost of the monument is $165,000, and September 1990 is its target date for completion and dedication. Tax-deductible donations may be sent to The Andrews AFB Community POW/MIA Monument Foundation, P. O. Box 8446, Temple Hills, Md. 20748-8446.

The Deland, Fla., Museum of Art and Embry-Riddle Aeronautical University, with a big assist from the **General James R. McCarthy (Fla.) Chapter** and the Mathews Gallery in Daytona Beach, brought a first-class exhibition of aviation art to Florida's Atlantic coast. The show (assembled by the Smithsonian Air and Space Museum) was titled "Into the Sunlit Splendor" and consisted of thirty-five large oil paintings and sketches by William S. Phillips, military aviation artist and Air Force veteran.

Renovation of the historic, century-old armory at the University of Minnesota came a little closer to realization when the **Gen. E. W. Rawlings (Minn.) Chapter** chipped in with a $25,000 donation to the University of Minnesota Armory Foundation. Col. David J. Dean, USAF, Commandant AFROTC at the University; Lt. Col. Marvin D. Trout, USA, Commandant of Army ROTC at the University; Brig. Gen. Joseph Kazak, Assistant Adjutant General of Minnesota and Cmdr. Trudy Lynne Hoag of the USN/USMC ROTC accepted the check. Chapter President Charles K. Melby kicked off the Chapter's fund-raising efforts by making the first contribution. The Chapter has adopted Det. 415 of the AFROTC as its recipient for exceptional support in the Twin Cities area.

Have AFA News?

Contributions to "AFA/AEF Report" should be sent to J. R. "Doc" McCauslin, AFA National Headquarters, 1501 Lee Highway, Arlington, Va. 22209-1198. ■

Coming Events

February 1–2, **TAC Symposium,** Orlando, Fla.; February 22–24, **AFA Board of Directors Meeting,** San Antonio, Tex.; March 30–April 1, **Great Lakes Regional Workshop,** South Bend, Ind.; April 6–7, **South Carolina State Convention,** Charleston, S. C.; April 7, **Iron Gate Salute,** New York, N. Y.; May 11–13, **New York State AFA Convention,** Rome, N. Y.; May 18–20, **New Jersey State Convention,** Cape May, N. J.; May 25–27, **AFA Board of Directors Meeting,** Colorado Springs, Colo.; July 13–15, **Pennsylvania State AFA Convention,** Philadelphia, Pa.; July 13–14, **Texas State AFA Convention,** Fort Worth, Tex.; July 26–28, **California State Convention,** Los Angeles, Calif.; September 7–8, **Colorado State Convention,** Colorado Springs, Colo.; September 17–19, **AFA National Convention and Aerospace Development Briefings and Displays,** Washington, D. C.; October 13, **North Central Regional Workshop,** Bloomington, Minn.

Bulletin Board

The **Aviation Cadets Alumni Association** is seeking information to help cadets locate former classmates. To be included in the computerized files, send your name, flight class, and the locations of your primary, basic, and advanced training. Also seeking copies of graduation orders. **Contact:** Maj. Bob White, USAF (Ret.), 54 Seton Trail, Ormond Beach, FL 32074.

The ***Pacific Stars and Stripes*** Alumni Association, Inc., is seeking contact with former employees of the Pacific-area editions of *Stars and Stripes*. **Contact:** Maurice L. Martin, 20540 Leonard Rd., Saratoga, CA 95070.

Seeking information on the whereabouts of **TSgts. Michael Wascom** and **Betty (DuFour) Wascom,** who were stationed at Little Rock AFB, Ark., in 1982. **Contact:** SSgt. Betty L. Park, Rte. 1, Box 82, Shepardstown, WV 25443-9708.

Seeking information on **Capt. Ed Haraburda,** who was last seen in 1945 diving his P-51 on a strafing run in Germany. **Contact:** Frank Haraburda, Fedhaven, FL 33854-8055.

Seeking information on the whereabouts of **Francis Leo Miller,** who was a copilot in the 388th Bomb Group in England during World War II. He was shot down September 28, 1944, and was a POW at Stalag Luft 1. His last known address was in Laurel, Md. **Contact:** John R. Kern, Jr., 6208 Artemus Rd., Gainsville, VA 22065.

Seeking identities, whereabouts, or fates of World War II **bombardiers. Contact:** E. C. "Ned" Humphreys, Jr., Bombardiers, Inc., 200 Van Buren St., #2109, Daphne, AL 36526.

Collector is seeking additional notes to complete collection of **military payment certificates** used overseas from 1946 to the Vietnam era. Will trade or buy notes and provide historical information on request. **Contact:** Nick Schrier, P. O. Box 60104, Sacramento, CA 95860.

Author seeks information on the history of **Johnson AB, Japan,** especially in the period prior to World War II. **Contact:** Paul Alford, 151 Stansbury Dr., Santa Maria, CA 93455.

Seeking information, photos, or slides of the following aircraft: **F-101, F-100,** and **F-102.** Also seeking information about and photos of Operation Sun Run of November 1957. **Contact:** Checuz Francesco, P. O. Box 6, 31015 Conegliano (TV), Italy.

Seeking contact with anyone who has diaries, photos, documents, or other information pertaining to **Air Training Command medical services,** for a history of same. **Contact:** Thomas A. Manning, Command Historian, Hq. Air Training Command, Randolph AFB, TX 78150-5001.

Seeking information on the whereabouts of personnel of the **32d Fighter Squadron,** 6th Air Force, who served in Puerto Rico, Curacao, Aruba, or Panama between 1943 and 1945. **Contact:** Donald L. Baker, 824 Bridlewood Rd., Copley, OH 44321.

Seeking information on former members of 93d Bomb Group, particularly **409th Bomb Squadron.** Seeking 409th Panda Patch. **Contact:** James McCloskey, 1 Silver Sage Court, Cockeysville, MD 21030.

Seeking information on the whereabouts of relatives of **MSgt. Raymond Harding Miller,** who was stationed at RAF Lakenheath, England, from 1953 to 1956 and later at MacDill AFB, Fla. His last known address before his death in 1973 was in Jacksonville, Fla. **Contact:** Trudy Hunns, 4 Terrington Close, Emneth, Cambridgshire PE14 8AB, England.

Mascoutah Military Museum is seeking donations of **aviation artifacts,** including unit histories, patches, and equipment, especially helmets, oxygen receivers, and ejection chairs. **Contact:** John D. Roy III, 611 Mary Jane St., Lebanon, IL 62254.

Seeking information on the whereabouts of **Edward Olson** (or Olsen) of New Jersey, believed to be USAAF, who was stationed in or near Romford, England, in 1944–1945. **Contact:** Edward Beaird-Surridge, 30 Old Forge Rd., Layer de la Haye, Colchester, Essex CO2 0JS, England.

Seeking photos or drawings of a suicide plane that the Japanese used during World War II that was known as the **Baka Bomb** or Cherry Blossom. It was a rocket-propelled aircraft, carried aloft and launched from a parent aircraft. **Contact:** Ed Allgor, 16 Canyon Lane, Westbury, NY 11590.

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 all former members of **821st Bomb Squadron** (M) who were at Selfridge Field, Mich., in 1944. **Contact:** CMSgt. Robert W. Dyer, USAF (Ret.), 718 Windrock Dr., San Antonio, TX 78239.

Seeking information on the whereabouts of **Col. Merrit A. Reeves, Jr.,** who served in World War II and retired sometime around 1970. **Contact:** Capt. Brook Hill Snow, USAF (Ret.), 3115-4 E. Jefferson St., Orlando, FL 32803.

Collector of astronaut autographs seeks the whereabouts of **Manned Orbiting Laboratory** and **Air Force astronauts.** These men were selected as astronauts and subsequently returned to Air Force duty after their respective programs were canceled. **Contact:** Edward J. Bizub, 1579 Franklin St., Clark, NJ 07066.

Seeking photographs of C-47, C-53, C-109, and CG-4A gliders of the **316th TCG (Nos. 36, 37, 44, and 47 TC Squadrons)** when based at Station 489 (Cottesmore) from February 1944 to May 1945, for a history of RAF Cottesmore. **Contact:** Flt. Lt. N. J. Roberson, RAF, TOCU GS, Royal Air Force, Cottesmore, Oakham, Leicestershire LE15 6BS, England.

Information on **2d Lt. Richard C. Henry,** an F-84 fighter pilot assigned to the 53d FBS at Fürstenfeldbruck, Germany. He was killed on November 2, 1952, shortly after completing a 100-mission tour in F-80s at Seoul, Korea. **Contact:** Col. David M. Williams, USAF (Ret.), 5312 Alta Bahia Court, San Diego, CA 92109.

Seeking information on the whereabouts of members of **crew #533 of the 785th Squadron,** 466th Bomb Group, 2d Division, 8th Air Force, who were stationed at Attlebridge, England, during World War II. **Contact:** Arthur S. Bass, 1507 N. 5th St., Blytheville, AR 72315.

Will buy *Battle Aces* **pulp magazines** from the 1930s. Also *G-8s.* **Contact:** G. C. Burns, Box 2308, Framingham, MA 01701.

Author seeks to interview Air Force fighter pilots who flew **F-105 aircraft from Thailand** on missions against North Vietnam during the Vietnam War. **Contact:** Luis Soto, 30-06 44th St., Apt. 1-A, Long Island City, NY 11103.

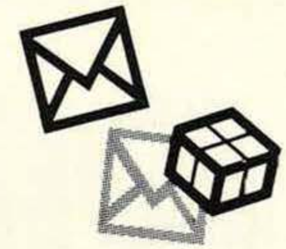
Seeking information on the whereabouts of **Milton "Marty" Martin II,** who was stationed at RAF Upper Heyford, England, until April 22, 1989, when he returned to San Antonio, Tex. **Contact:** Elke A. Gillard, 26 Cromwell Court, Letchworth, Hertsfordshire SG6 IDT, England.

Seeking information on the whereabouts of the following people who were at USAAF Station 523 Coombe House Combat Home in 1944: **Capt. Leroy B. Everett, Jr.** of Houston, Tex.; **Lieutenant King,** "Pub Crawler—19th RCD;" and flight surgeon **Capt. Howard P. Wheeler** of Georgetown, Tex. **Contact:** R. C. Harris, Jr., 4813 Burton SE, Albuquerque, NM 87108.

Writer seeks memorabilia, orders, etc., from attendants or cadre of **Citizens Military Training Camps** (CMTC), conducted by the US Army 1921–1940. **Contact:** D. Kington, 831 38th Ave., San Francisco, CA 94121.

Information requested on USAF pilot **Boyd Bernard Gwin,** who was killed in an aircraft accident in February 1952. **Contact:** Douglas Gwin, 5714 Snowden Ave., Lakewood, CA 90713.

Seeking donations and loans of memorabilia related to the **34th Tactical Fighter Squadron,** especially from the Vietnam War era. Items are to be displayed in the squadron. **Contact:** 2d Lt. Douglas A. Johnson III, USAF, Adjutant, 34th Tactical Fighter Squadron (TAC), Hill AFB, UT 84056-5000.



Mailing Lists

AFA occasionally makes its list of member names and addresses available to carefully screened companies and organizations whose products, activities, or services might be of interest to you. If you prefer **not** to receive such mailings, please copy your mailing label **exactly** and send it to:

Air Force Association
Mail Preference Service
1501 Lee Highway
Arlington, Va. 22209-1198

Unit Reunions

Arnold Air Society/Angel Flight Squadron
The Colonel James B. Irwin AAS and Angel Flight Squadron at Samford University are hosting the Area VII/Region C Conclave on February 16–18, 1990, at the Sheraton Perimeter Hotel in Birmingham, Ala. **Contact:** Capt. Robert W. Sandlin, Jr., Arnold Air Society and Angel Flight, Area VII/Region C Area Conclave Hq., AFROTC Detachment 012, Samford University, Birmingham, AL 35229.

Bataan and Corregidor
The American Defenders of Bataan and Corregidor will hold their national convention May 11–18, 1990, at the Riviera Hotel in Las Vegas, Nev. **Contact:** John Crago, 615 Lehmeyer St., Huntington, IN 46750.

Cannon AFB
Personnel who were stationed at Cannon AFB, N. M., will hold a reunion June 15–17, 1990. **Contact:** Bertha Wells, 312 W. Yucca, Clovis, N. M. 88101. Phone: (505) 763-3198.

Caterpillar Ass'n
The Caterpillar Association of the US will hold a reunion July 27–28, 1990, at the Embassy Suites Hotel in Green Bay, Wis. **Contact:** Lt. Col. Johnny Brown, P. O. Box 1321, Kenosha, Wis. 53141. Phone: (414) 658-1559.

Holland Liberation
Military personnel who participated in the Liberation of Holland or who lived there between 1940 and 1945 will hold a forty-fifth anniversary celebration May 4–6, 1990. **Contact:** Ben Mulder, P. O. Box 647, Lynden, WA 98264.

Santa Ana AAB
Personnel from the Santa Ana Army Air Base Wing (SAAAB) will hold a reunion March 24, 1990, at Orange Coast College in Costa Mesa, Calif. **Contact:** Alvin E. "Bud" Anderson, P. O. Box 1764, Costa Mesa, Calif. 92628. Phone: (714) 631-5918.

Sweden Internees
Former Army Air Forces personnel, including internees, Mustang pilots, Carpetbaggers, Air Training Command personnel, and anyone involved in Scandinavian operations between 1944 and 1945 will hold a reunion in June 1990 in Sweden. **Contacts:** Sune I. Lundberg, 1194 Washoe Dr., San Jose, CA 95120. Phone: (408) 269-3942. The Association of Americans Interned in Sweden, P. O. Box 4954, Santa Rosa, CA 95402.

BAD 2 Ass'n
BAD (Base Air Depot) 2 members who served in Warton, England, during World War II will hold a reunion March 8–11, 1990, in Melbourne, Fla. **Contact:** Ralph Scott, 228 W. Roosevelt Ave., New Castle, DE 19720.

U-2/TR-1
U-2/TR-1 pilots and squadron navigators are planning to hold a reunion September 28–30, 1990, in Tucson, Ariz. **Contact:** U-2 Reunion Committee, P. O. Box 60312, Tucson, AZ 85751.

7th Bomb Group
Members of the 7th Bomb Group (World War II) will hold a reunion October 3–6, 1990, in Tucson, Ariz. **Contact:** Emil S. Gavlak, 4111 E. Whittier, Tucson, AZ 85711. Phone: (602) 881-1352.

11th Bomb Group
The 11th Bomb Group will hold a reunion May 16–20, 1990, in Nashville, Tenn. **Contact:** Robert E. May, P. O. Box 637, Seffner, FL 33584. Phone: (813) 681-3544.

14th MAS
The 14th Military Airlift Squadron will sponsor a fiftieth anniversary reunion November 16–17, 1990, in San Bernardino, Calif. **Contact:** Lt. Karl E. Mize, USAF, 5280 N. Little Mountain Dr., Apt. D4, San Bernardino, CA 92407. Phone: (714) 887-9205. AUTOVON: 876-5613.

31st Fighter Officers Ass'n
Members of 31st Fighter Officers Association will hold their fiftieth anniversary reunion April 11–14, 1990, in San Antonio, Tex. **Contact:** Lt. Col. Gene Keyes, USAF (Ret.), 6003 Royal Breeze, San Antonio, TX 78239. Phone: (512) 657-7671.

Class 41-C
Members of Class 41-C (Barksdale, Brooks, and Kelly AFBs, Tex.) will hold a reunion September 13–16, 1990, in Colorado Springs, Colo. **Contact:** Joe Williamson, 2322 Country Club Dr., Sugar Land, TX 77478. Phone: (713) 242-7019.

46th/72d Recon Squadrons
The 46th and 72d Reconnaissance Squadrons

(1946–55) will hold a reunion September 30–October 2, 1990, at the Marriott Riverwalk Hotel in San Antonio, Tex. **Contacts:** Brig. Gen. Donald E. Stout, USAF (Ret.), 9210 Jole Cove, San Antonio, TX 78239. Phone: (512) 656-8926. Bo Bowers, 13004 Trent, San Antonio, TX 78232. Phone: (512) 491-0533.

Class 56-F
Members of Class 56-F will hold a reunion July 1–5, 1990, in Long Beach, Calif. **Contact:** John Monkvic, 3625 S. Ross, Santa Ana, CA 92707. Phone: (714) 662-7348.

68th Fighter Squadron
The 68th Fighter Squadron (World War II) will hold a reunion April 13–16, 1990, in San Antonio, Tex. **Contact:** Chester V. Novak, 7200 Romilly Oval, Parma, OH 44129. Phone: (216) 842-5062.

81st Fighter Squadron
Members of the 81st Fighter Squadron (World War II) will hold a reunion May 18–20, 1990, in Orlando, Fla. **Contact:** 81st Fighter Squadron Reunion Committee, P. O. Box 162882, Altamonte Springs, FL 32716-2882.

91st Bomb Group
The 91st Bomb Group (H) will hold a reunion August 22–25, 1990, in Seattle, Wash. **Contact:** Charles R. Hackstock, 14224 S. E. 288th St., Kent, WA 98042. Phone: (206) 631-3978.

95th Tactical Fighter Training Squadron
Members of the 95th Tactical Fighter Training Squadron will hold a reunion March 30–April 1, 1990, at Tyndall AFB, Fla. **Contact:** 1st Lt. David L. Bryant, USAF, or Lt. Col. Rich White, USAF, 95th Tactical Fighter Training Squadron/CCE, Tyndall AFB, FL 32403-5086. Phone: (904) 283-4209 or (904) 283-2658.

314th Fighter Squadron
The 314th Fighter Squadron, 324th Fighter Group, will hold a reunion April 27–29, 1990. **Contact:** Al Bowers, 257 Harmony Rd., Gibbstown, N. J. 08027.

315th Fighter Squadron
The 315th Fighter Squadron, 324th Fighter Group (World War II), will hold a reunion April 19–22, 1990, in Orlando, Fla. **Contact:** Eugene J. Orlandi, 311 Third St., East Northport, NY 11731. Phone: (516) 368-9193.

344th Bomb Group
Members of the 344th Bomb Group, which included the 494th, 495th, 496th, and 497th Bomb Squadrons, will hold a reunion June 7–10, 1990, in Dayton, Ohio. **Contact:** Lambert Austin, 344th Bomb Group Association, 5747 Darnell, Houston, TX 77096-1111. Phone: (713) 774-3030.

369th Fighter Squadron
The 369th Fighter Squadron (World War II), which included the 368th and 370th Fighter Squadrons of the 359th Fighter Group, will hold a reunion August 9–11, 1990, in Atlanta, Ga. **Contact:** Anthony Chardella, 105 Mohawk Trail Dr., Pittsburgh, PA 15235.

Reunion Notices

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.

456th Fighter Squadron
Members of the 456th Fighter Squadron, 414th Fighter Group, will hold a reunion in 1990. **Contact:** James H. Baird, 1645 Plummer Dr., Rockwall, TX 75087.

781st Bomb Squadron
The 781st Bomb Squadron and 465th Bomb Group headquarters personnel (World War II) will hold a reunion August 22–26, 1990, in Boston, Mass. **Contact:** Jim Althoff, 2 Mount Vernon Lane, Atherton, CA 94025. Phone: (415) 325-8356.

4080th Strategic Recon Wing
The 4080th Strategic Reconnaissance Wing will host its thirty-third anniversary reunion May 24–27, 1990, in Del Rio, Tex. **Contact:** Patricia Deason, 1910 Avenue B, Del Rio, TX 78840. Phone: (512) 775-1341.

4505th Air Refueling Wing
The 4505th Air Refueling Wing and ancillary units will hold a reunion June 22–24, 1990, at Langley AFB, Va. **Contact:** Clarence "Rocky" Weishar, 2104 N. Armistead Ave., Hampton, VA 23666. Phone: (804) 838-1437.

Langley Field Officers
I would like to hear from officers who served at Langley Field, Va., between 1944 and 1947 who would be interested in holding a reunion. **Contact:** Lt. Col. Robert E. Noziglia, USAF (Ret.), 11761 Edenberry Dr., Richmond, VA 23236-3201.

Class 50-G
I would like to hear from members of Class 50-G (Waco/Lubbock, Tex.) interested in organizing a reunion. **Contact:** Fred L. Toerge, 820 Thompson Ave., #28, Glendale, CA 91201.

Class 69-01
I am trying to locate members of Class 69-01 (Reese AFB, Tex.) for the purpose of organizing a reunion in 1990. **Contact:** Michael S. Oakey, 6 Cokeberry St., The Woodlands, TX 77380. Phone: (713) 363-2571 or (303) 444-7718 (Doug Batchelder).

63d School Squadron
The 63d School Squadron, which was stationed at Kelly Field, Tex., between 1936 and 1941, is planning a reunion. **Contact:** CMSgt. Robert W. Dyer, USAF (Ret.), 718 Windrock Dr., Windcrest, San Antonio, TX 78239. Phone: (512) 599-6407.

63d AAFFTD
For the purpose of planning a reunion, I am seeking the whereabouts of aviation cadets who were in primary training at the 63d AAFFTD School in Douglas, Ga., from 1941 through 1944. **Contact:** Buddy R. Guest, 222 Pardridge Pl., DeKalb, IL 60115.

401st Fighter Group
Anyone from the 401st Fighter Group and associated squadrons (325th, 326th, and 327th) interested in attending a reunion held in Stamford, Conn. this year? Members of the 64th Airdrome Squadron are also welcome. **Contact:** Roderick Loveland, 13 Culloden Rd., Stamford, CT 06902.

470th Bomb Group
Members of 470th Bomb Group (H) who were stationed at Tonopah Army Airfield, Nev., as well as support personnel, combat crews, instructors, and other survivors of the B-24 training programs who served at Mountain Home, Idaho, are organizing a reunion in Tonopah, Nev. **Contacts:** Maj. Harold P. Edwards, USAF (Ret.), 808 Jamestown Rd., O'Fallon, IL 62269. Allen Metscher, P. O. Box 1212, Tonopah, NV 89049.

Bob Stevens'

"There I was..."

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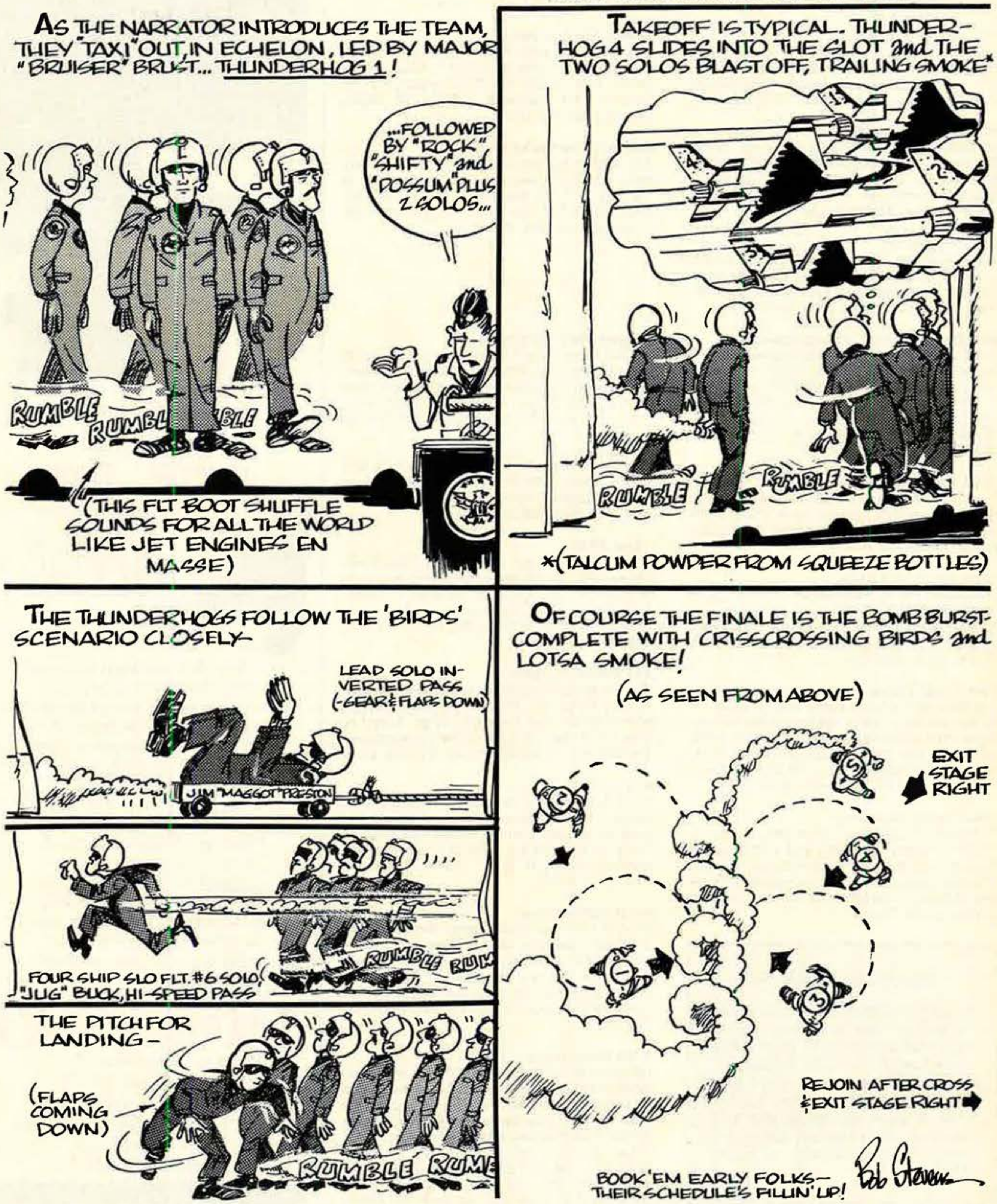

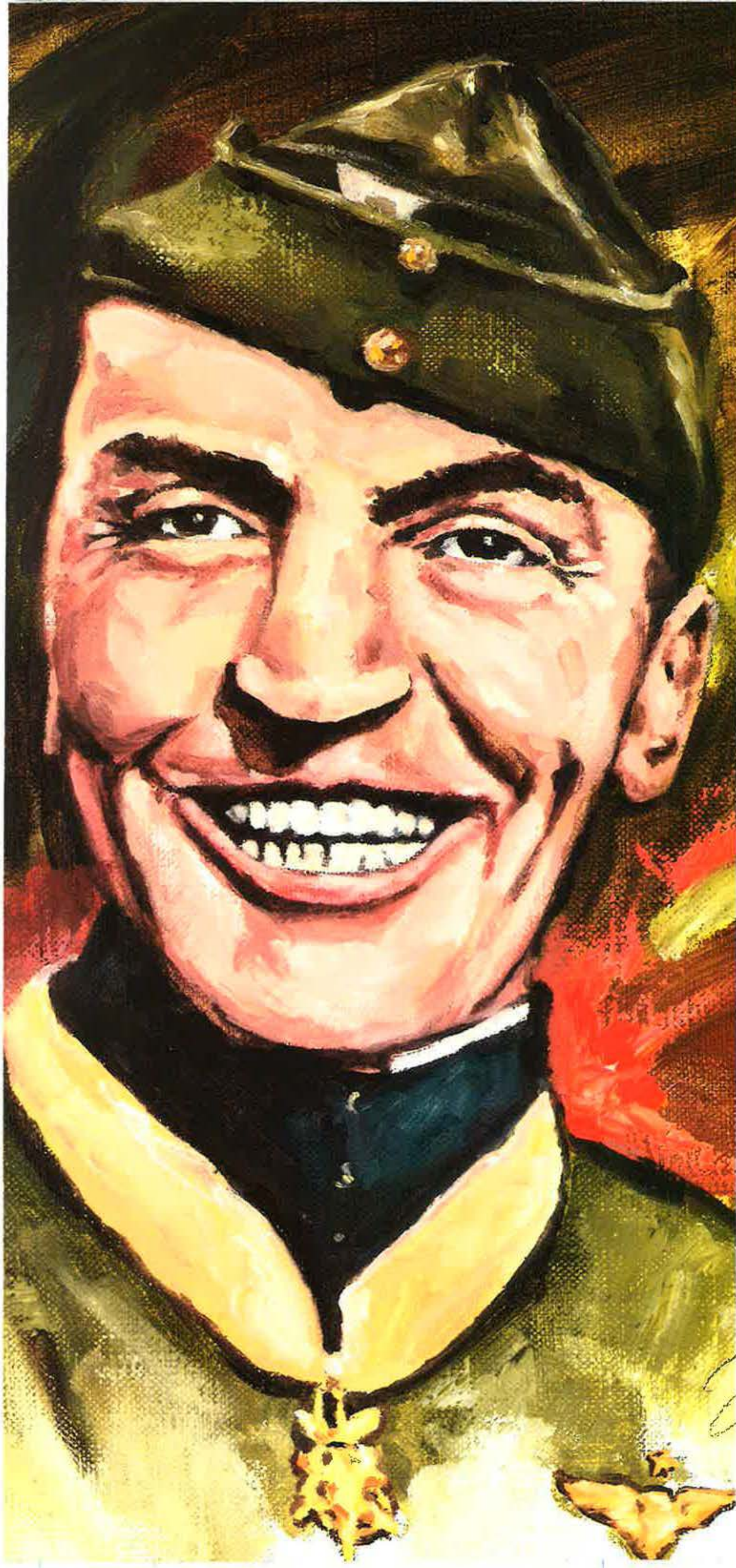

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