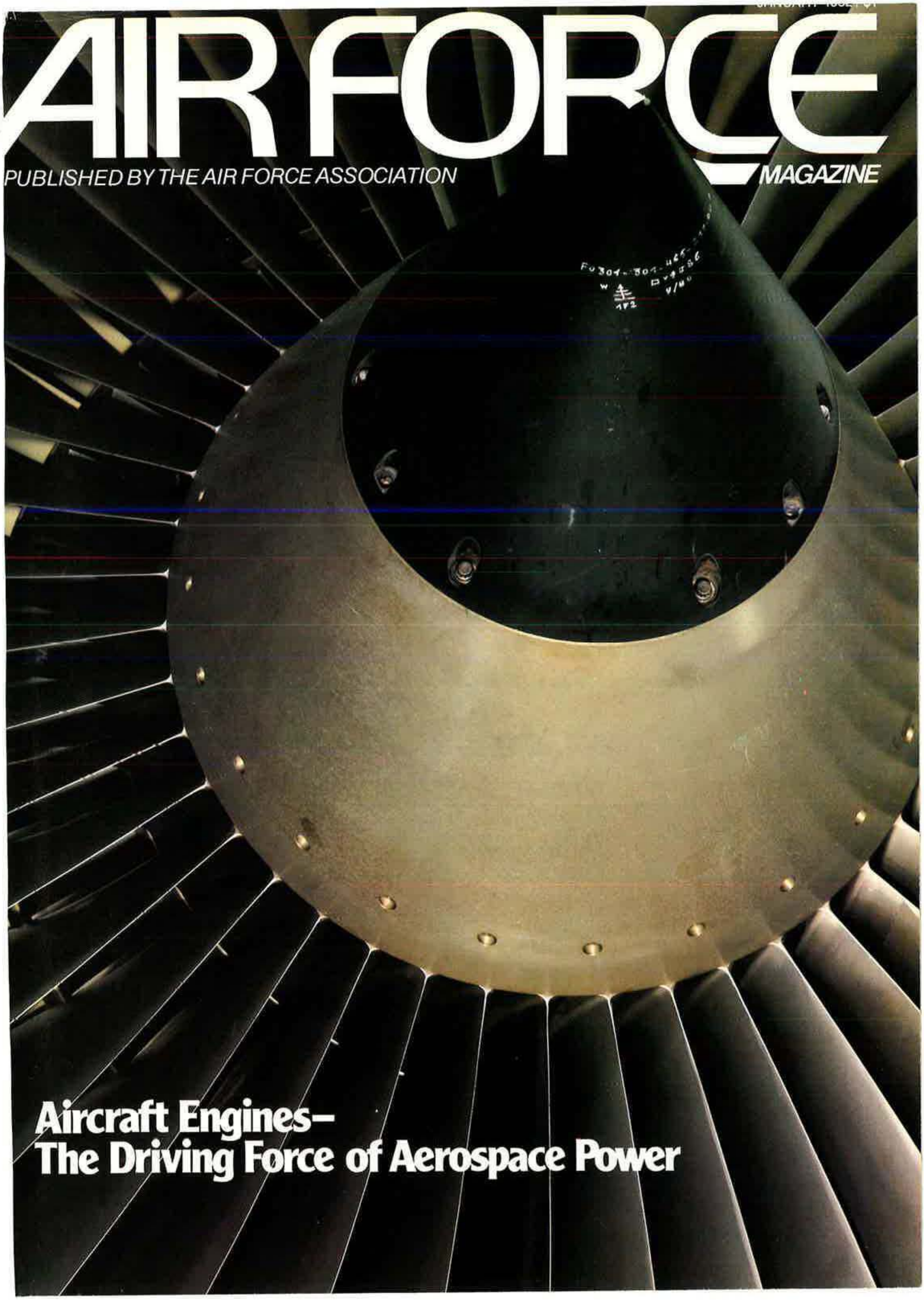
AIR FORCE MAGAZINE

PUBLISHED BY THE AIR FORCE ASSOCIATION



Aircraft Engines–
The Driving Force of Aerospace Power

The GE technology edge: durable fighter turbofans with turbojet characteristics.

General Electric's new supersonic fighter turbofans benefit from technology that is *five years more advanced than any competitive engine.* And these advances are proven by endurance testing far more severe than previous standards. Accelerated Mission Testing (AMT), for example, subjects an engine to over 30 times the number of full throttle cycles and 12 times as many afterburner lights as traditional 150-hour qualification tests.

The F404 is a 16,000 lb. thrust engine in production for the U.S. Navy F/A-18 multi-mission aircraft. It has also been selected for the Canadian CF-18, the Australian F/A-18, the Swedish JAS aircraft, and is being offered in several other fighter competitions. The F404 has also been selected for the new F-5G intermediate fighter.

The F101 DFE, a derivative of the F101 developed for the U.S. Air Force B-1, is in the 27-30,000 lb. thrust class. It has been funded by the USAF and USN in a development and flight test program to provide competitive production alternatives in the large fighter engine thrust class. This engine has met all its fixed price contract requirements, completed its flight clearance tests, and conducted outstandingly successful flight test programs in both the USAF F-16 and USN F-14.

F404-powered McDonnell Douglas F/A-18 — Production

F101 DFE-powered General Dynamics F-16 — Flight Test

General Electric is truly setting *new standards* for fighter turbofans:

- **OPERABILITY:** Exceptionally stall-free engine operation and stable afterburner operation through the entire fighter envelope, with no throttle restrictions. Pilots report that F404 and F101 DFE turbofans behave like General Electric's famed J79 fighter turbojet. As one pilot said, "I can really fly the aircraft up to its capabilities." Said another, "Amazing response for a turbofan — as good as a turbojet."
- **DURABILITY AND RELIABILITY:** Proven by record-breaking AMT tests on both engines. Hot section lives equivalent to 2,000 mission hours of the toughest fighter operation were demonstrated on the F101 DFE without significant distress — and the parts will be put back in engines for more testing. With their preeminent hot section technology, GE engines offer *twice* the hot section life of any other engine in service.
- **OPERATING COSTS:** From simpler design through advanced technology. For example, GE engines feature single-stage turbines, machine ring combustors, mi ed flow afterburners, and thousand fewer parts than other engines. Simplicity *plus* durability provide low maintenance costs. This is a direct result of low engine removal rates, where General Electric's engines have a preeminent record: The J79 removal rate in the F-4 is three per 1,000 flight hours. The TF34 in the A-10 is under two per 1,000. And the F404 and F101 DF are on track for two per 1,000. Tru new industry standards!

F101 DFE-powered Grumman F-14 - Flight Test

When you need advanced fighter capability, GE gives you th technology edge...durable turbofa with turbojet characteristics.

Great Engines From General Electric's Advanced Technology

GENERAL ELECTRIC

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MAGAZINE

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This Month

JANUARY 1982 • VOLUME 65, NUMBER 1

ABOUT THE COVER

If the mission is to fly and fight, then more than superior airframes and accurate, lethal armament is necessary—the engine powering the aircraft is the heart of meeting the mission. On the cover is a closeup of the General Electric/SNECMA CFM56 engine. A special section on aircraft engines begins on p. 58. (Photo courtesy GE Aircraft Engines)

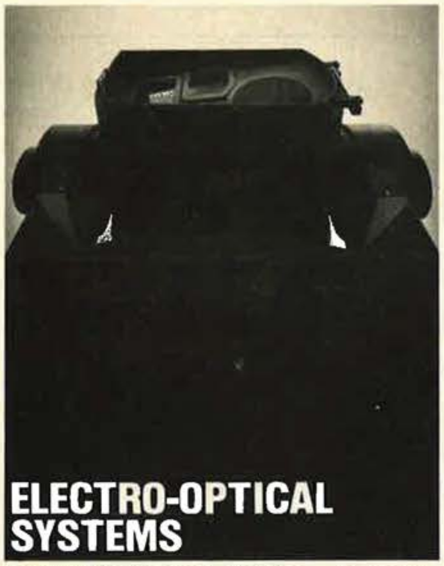
Departments

At Northrop, people and their ideas make advanced technology work.

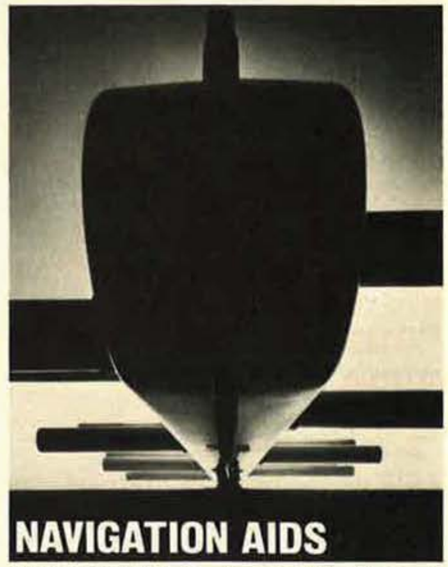
Aircraft Division — Hawthorne, California. Aircraft research, design, development, and manufacturing.

Electronics Division – Hawthorne, California. Navigation and guidance systems, digital computers and information processing systems.

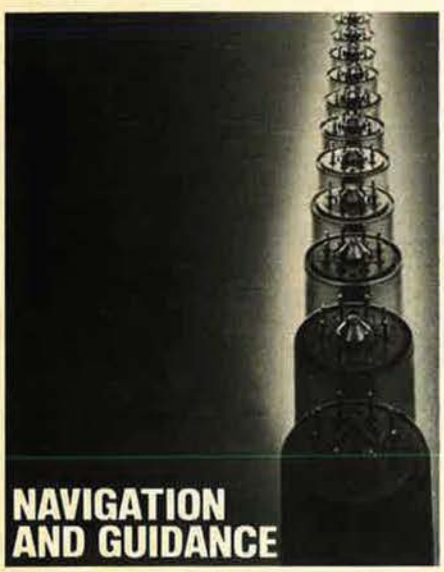
Defense Systems Division – Rolling Meadows, Illinois. Strategic and tactical electronic countermeasures systems.



Electro-Mechanical Division — Anaheim, California. Advanced electronic/electro-optical sensor systems.



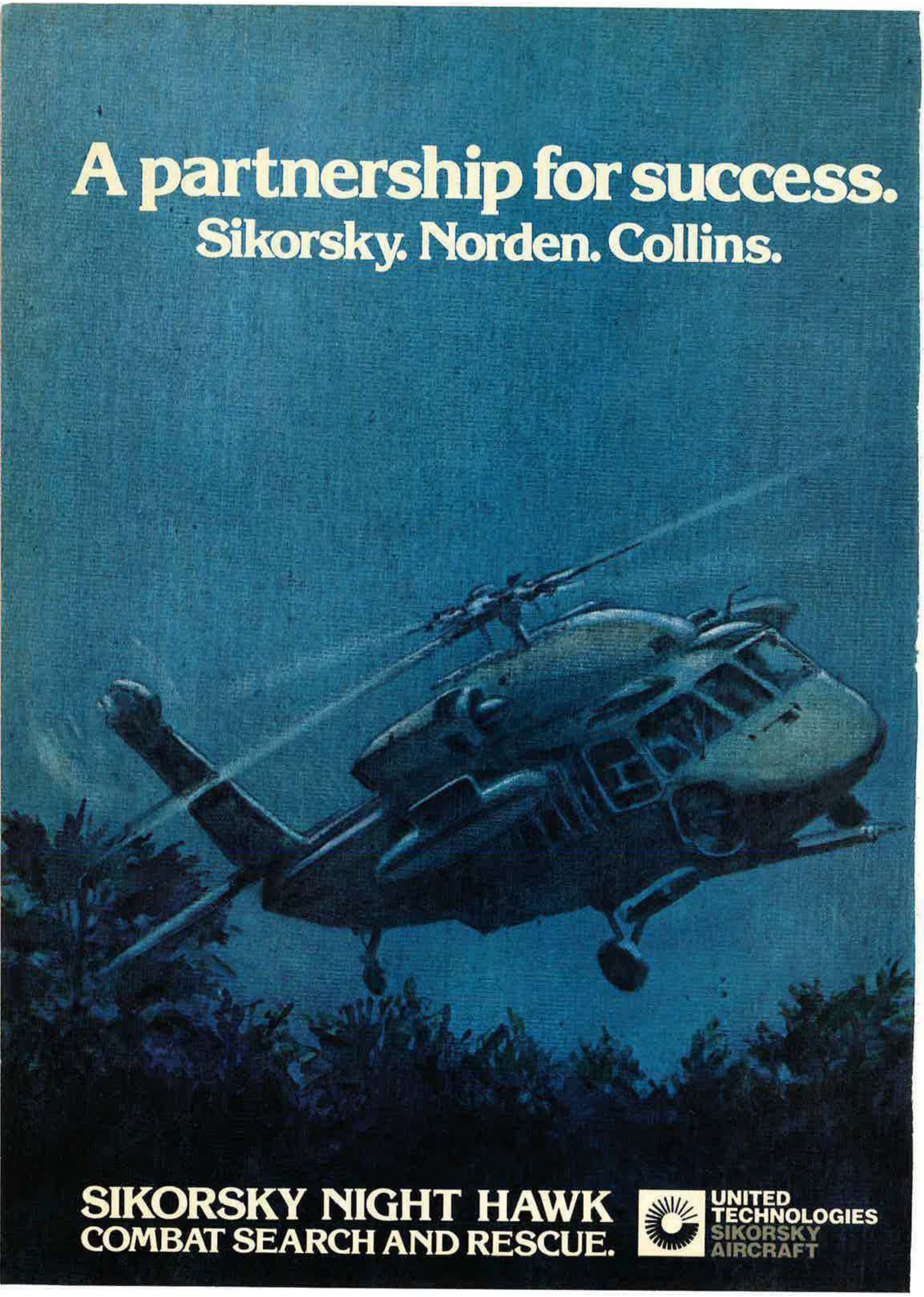
Wilcox Electric, Inc. — Kansas City, Missouri. Instrument landing systems and ground-based navigation aids.



Precision Products Division — Norwood, Massachusetts. Gyroscopes, accelerometers, inertial guidance and control systems.

Ventura Division — Newbury Park, California. Remotely piloted vehicles, aerial training targets, aircraft subassemblies.

Aircraft Services Division — Hawthorne, California. Aircraft services, base support, training, communications, facilities, management.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SIKORSKY NIGHT HAWK
COMBAT SEARCH AND RESCUE.
UNITED TECHNOLOGIES
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AN EDITORIAL

The Time Is Late

STARTING the New Year with a resolution is a hazardous game, because one makes them with good will and then feels badly when they fall by the wayside in February.

But there is one resolution AFA members can make—and keep—that will be helpful to the security of this nation.

RESOLVED: To spread the word that this country is in danger, and the time is late.

To AFA members, that may seem a rather simple resolve to make and keep. But it is not, as you will realize upon reflection. The current tide in the media seems to be running the other way—that is, saying the threat to our nation has been overblown, that we're turning the corner, that the Russians have changed their goals; that US military leaders seek bloated budgets to support the "military-industrial complex"; the list is endless.

And wrong.

The times haven't been more hazardous since 1938–40. But the problem is that too many people with platforms and microphones are repeating the misleading nostrums of those days. They are lulling the opinion-makers and the mass of people into thinking the threats to the US are artificial. They seem to envision a kitchen somewhere near the "Tank" in the Pentagon basement where the "threat of the week" is cooked up and served just at budget time to scare the pants off the legislature. Wrong again.

The threats are real, well-documented, and have been around for years. Their magnitude and intensity, across the spectrum of technology, numbers, methods, and geography, have accelerated in the past five years.

As AFA President John G. Brosky told an Ohio audience in December: "There are a lot of people who are tone deaf when it comes to the global realities of our time. . . . They have arbitrarily canceled the Soviet threat. . . . The extension of this Pollyanna view of the world, of course, is the conclusion that if there is no threat, you don't need a deterrent posture." Of course, he's right; the realities are hazardous and to be ignored only at national peril.

What's needed is awareness among the entire US population that the threats are real and the time is late. Also, the public must recognize what President Brosky calls "the historic truth that military preparedness prevents war . . . [and that] weakness invites conflict." Recognition of that truth is not popular, but it is necessary.

The "Pollyanna" view that President Brosky mentioned was popular in regard to the Soviet "Backfire" bomber a couple of years ago. The Pollyannas tried to maintain that the Backfire could not reach the US. But listen to John W. R. Taylor, Editor of *Jane's All the World's Aircraft*, in his annual "Aerospace Survey," beginning on page 40 of this issue: "Nobody pretends any longer that the supersonic bombers known to NATO as Backfire have a range too short to launch their nuclear missiles against targets in the US. Such aircraft are in service now, in large numbers." The Pollyannas wanted to wish them away, or shorten their range, but the Russian leaders did not cooperate.

Mr. Taylor, writing in late November for this January issue, cited Soviet production figures for 1980. In that year, they produced 1,300 fighters and fighter-bombers, and 350 transport aircraft. By contrast, he said, "the FY '82 budget inherited by the Reagan Administration had total provision for only ninety-six F-16s, thirty F-15s, and four TR-1 reconnaissance aircraft for USAF."

The Reagan Administration came into office partly on an expectation by the voters that he would redress the national security imbalance they felt, even if their leaders glossed it over. But the Reagan team got off to a slow start in national security and foreign affairs. It was not until October that the President made and announced his package of strategic decisions. But to his credit, he made them as a package of interacting programs that, in the strategic arena, came to grips with the issues.

President Reagan also made sure the American people heard about his decisions, because their understanding of the issues and support for the work that needs to be done is crucial to turning the tide. That is where AFA leaders and members can help—to point out, as AFA President Brosky has, the truths that need to be told.

The public needs to be aware of what is at stake. The Congress plays an important role in that process. Regarding strategic decisions, the Senate Foreign Relations Committee held hearings on the package in November, and invited a number of government and public witnesses to respond to questions and to illuminate the issues. They invited AFA Executive Director Russ Dougherty to testify, being mindful of his experience as Chief of Staff, Allied Command Europe, and Commander in Chief, Strategic Air Command. He told the committee: "If we fail to take advantage of these remarkably prescient and brave decisions by this President, there is reasonable doubt that we will have another, timely opportunity to redress the rapidly shifting balance of power."

That is the point: We, the American people, by acting now can take advantage of the decisions and move to redress the balance. The time is late. AFA members can make the difference, because they can spread the word that "deterrence is everybody's business" in this country. That's a New Year's resolution easy to make, and worth working to keep.

—F. CLIFTON BERRY, JR., EDITOR IN CHIEF

The demanding world of airlifters able to handle outsized equipment begins with the cargo compartment. It must be big enough to handle enormous amounts of cargo. It must be low enough to the ground to provide fast, easy loading and, above all, unloading in remote areas where sophisticated ground handling equipment does not exist. And because there are times when time itself is as precious as the cargo, a strategic airlifter needs straight-through cargo handling—an aft opening, a nose opening. Drive-on, drive-off.

This is no longer theory. Events—actual operations—have proved the case for drive-on, drive-off, straight-through cargo compartments.

But fast loading and unloading alone does not make a great strategic airlifter. The cargo compartment must be large enough to handle bulky, outsized cargo—lots

AIRMAIL

The Bolt from the Blue

After reading your November '81 issue, I was once again struck by the continued narrow-minded thinking on US strategic doctrine. Why opt for MX, "Big Bird," etc., when a change in our basic strategic doctrine would accomplish what the billions of dollars in these type of expenditures only promise?

Consider what I call the "bolt from the blue" strategic doctrine. This doctrine would state that the US would no longer continue funding huge and expensive second-strike forces. Instead, by altering the mix of the Triad, we would develop a very lethal first-strike force that could take out Soviet C^3 in a surprise "surgical" attack. Also, we would exercise the option to use it at an indeterminate time.

Since the Soviet Union is indeed a centralized dictatorship, I daresay that the Communist Party would fear a direct personal attack, such as a "bolt from the blue," far more than a diffuse second strike against their entire military-industrial complex.

I know that if I were a Party "apparatchik" reading these words in my comfortable dacha, I'd be choking on my vodka and caviar.

Capt. Richard M. Dickson, USAF
Sheppard AFB, Tex.

Commissary System

As a relatively new member of the Air Force Association, I have been quite impressed by your magazine. It is informative, timely, and generally has several articles of particular interest to me.

In the November issue, I was quite interested in the AFA Policy Papers adopted at the 1981 annual national convention, but feel compelled to comment on one item in the paper on Defense Manpower Issues. With a single exception, I agree completely with the AFA position on the various issues, and feel that the one item of disagreement involves an unfortunate misconception. In regard to the military commissary system, it is stated that AFA "strongly opposes efforts to reduce this benefit through contracting-out of commissary sales store operations" *(p. 42)*.

There is absolutely no basis to assume that contract operation of commissary sales stores would, in any way, reduce the benefit to military customers. In fact, to the limited extent that the Air Force has contracted out a portion of commissary operations, the exact opposite has been true. A recent survey of commissaries at Air Force bases where shelf-stocking has been contracted out, as a result of a comparative cost analysis, has shown that the general cleanliness of the facility has been improved, the shelves are more fully stocked with merchandise, and sales have increased substantially. These conversions have only occurred when a detailed comparative cost analysis has shown that significant cost savings would be achieved, and have produced the additional benefit of improved performance.

On the basis of this experience, it is reasonable to expect that contracting the entire commissary operation would produce even greater cost savings and improvement in operations. This would certainly appear to enhance rather than reduce the benefit to commissary patrons.

Thank you for your excellent magazine and for this opportunity to express my views on this issue.

Lt. Col. W. D. Russell, USAR (Ret.)
Silver Spring, Md.

Frocking Fracas

Your November 1981 "Speaking of People" article titled "Promotion Quota Frustration" *(p. 114)* cites a typical example of our leadership being significantly out of tune with those whom they purport to lead. Air Force leaders note that the proposed practice of frocking selectees waiting for promotion lists to catch up would depart from tradition, be cosmetic at best and easily construed as a phony, nonmilitary type action, and would "aggravate the impact on nonselectees." It seems that everyone agrees it's a good idea except for the ones who can implement it—a situation that occurs all too often in the Air Force.

What good is tradition if it serves no apparent purpose? It appears to me that a relatively young service such as the Air Force can best serve itself and its mission by setting new trends that can offer potential benefits. I defy anyone to demonstrate that frocking is more phony, nonmilitary, or cosmetic than reserved parking places at the BX and Officers Club for O-6s and above.

On the subject of "aggravation of nonselectees," I consider myself something of an authority, having been passed over four times for lieutenant colonel. Frocking of selectees would not bother me at all. However, I would like to add, this is the first time I've noticed that anyone of star rank particularly cared whether I was aggravated or not.

Good ideas initiated by and affecting people near the bottom of the pecking order are pitifully slow in percolating to the top. In 1964, I submitted a suggestion for a major change in the regular augmentation program. It was rejected because "all the major commanders agree that [the current system] provides a great incentive." My proposal was implemented a few years later for exactly the reasons I stated, except someone else got credit for it.

It would also seem reasonable for the Air Force to undo actively the damage the controlled OER system did a few years ago, and continues to do to officers who have controlled twos and threes in their records. However, the top brass say, "What's done is done, and *we* (note the irony of that) have to live with the results."

Such thinking is of no help in maintaining an all-volunteer military force.

Maj. James M. Bruner, USAF
Norton AFB, Calif.

Bears and Wild Weasels

Reference Bob Stevens's "There I Was . . ." in the November '81 issue:

Bob says the backseater in the F-105F/G was called a "BEAR" because he's in his pit. I always thought


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NATO's Air Forces needed an advanced class of Ejection Release Units (ERUs) for the interdiction mission of their aircraft. **EDO did it!** Every stores station on West Germany's Tornado will be equipped with an EDO ERU. They're the Tornado's "claws".
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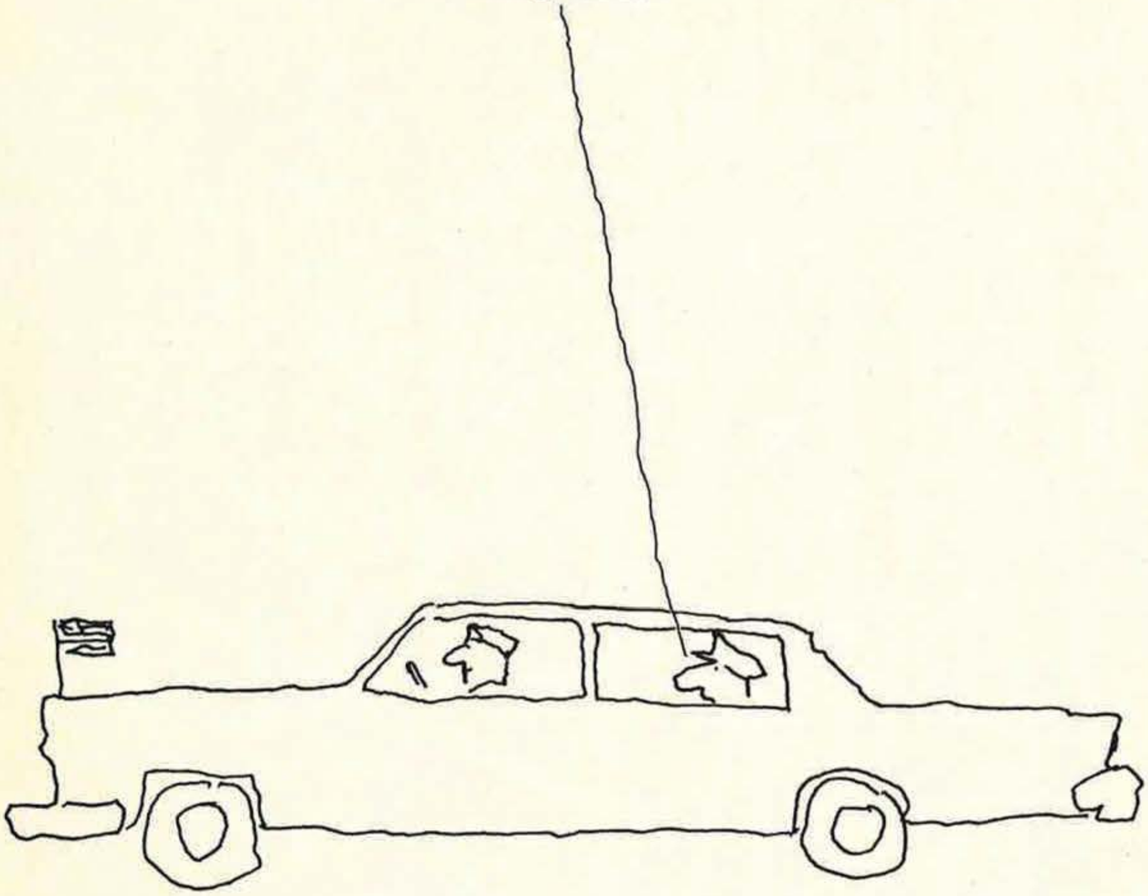
King who?



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BEAR was an acronym for "Bravery, Enthusiasm, And Reason!" (That's when it's applied to the backseaters who flew with the Wild Weasels.)

R. K. Markel
Corona, Calif.

Second the Motion

This letter is in reference to a November '81 "Airmail" letter *(p. 5)* from Maj. Paul T. Burnett. Flatten the pyramid? *Second the motion!*

I was an enlisted man in the US Navy during World War II; I entered USAF aviation cadet service in late 1950 and graduated in November 1951. I went immediately to a combat tour in Korea, as did my entire graduating class.

The vast majority of the flying personnel in our outfit were WW II recalled reservists. Many of them stayed on active duty. This put me and my contemporaries behind a huge hump of recallees vying for promotion all along the line. Some of us did not make it!

We lived in constant fear of the up-or-out concept. The OGLA made it impossible for all of us to make field grade. The Air Force lost many good officers to this up-or-out program. Most would have been happy to stay as captains until retirement.

I agree with Major Burnett's logic—his argument should be heard in Headquarters.

Maj. Joseph F. Daly, USAF (Ret.)
San Pedro, Calif.

Another View From the Grass Roots

I read with some consternation the letter "View From the Grass Roots" in the November 1981 issue *("Airmail," p. 5)*, and I feel another viewpoint is warranted.

The author of the letter claims that morale is nonexistent, and that virtually no family life *is* SAC's way of life for a crew member. Shallow insight and a narrow point of view is my only explanation for such a statement.

The backing arguments of six months a year of either alert duty or TDY are where the biggest fault lies. Most of the people in our squadron are "rarin' to go" on TDYs, and a great deal of competition goes on for the few trips we receive. As for alert, there is more time to spend with your family than on normal duty days. Most SAC alert facilities have excellent visitation facilities (some even have private rooms), swimming pools, and areas where you can prepare and eat a family meal.

The biggest plus from alert is the CCRR awarded. How many jobs

AIRMAIL

could you find where you had those days completely off? Ask some of your friends in MAC and TAC how many days a year they spend TDY or on rotation overseas, and you will see that SAC stacks up very favorably. As busy as most wing flying schedules are, alert—amazingly enough—is one of the best times for family togetherness.

The second problem addressed in "View From the Grass Roots" is that of morale. As for morale problems, I'll bet you could ask ten "crewdogs" how morale is and get ten different answers. True, morale could be genuinely low at any particular base at any particular time. However, each wing is different, and it would be very false to assume that just because morale at your base is bad, so is morale elsewhere.

The morale in my wing is good and I don't see any reason to expect morale to change. It all depends on your point of view.

So, next time you think morale is getting low, take a peek out of your shoebox and see what other people are really doing and thinking. I think you'll shed a positive light on being one of SAC's finest.

Capt. James E. Meier, USAF
Dyess AFB, Tex.

October Feedback

I have been a member of the Air Force Association since the early days. After all these years it was a most pleasant occurrence to find an entire issue of AIR FORCE Magazine *(October '81)* dedicated to the air reserve forces.

We who have served in the Air Force Reserve are very proud of our "ready now" force. It is great to see the air reserve forces recognized, at last, in a publication I value so highly.

Col. Desco E. McKay, USAFR (Ret.)
Indianapolis, Ind.

I have been reading the October issue, and appreciate the "Total Force" spread. The air reserve forces do have a vital role in our defense. The Air Reserve, Air Guard, and active Air Force do make up the *total* Air Force.

The strength of the defense is greatly enhanced by this concept, since the country will not support—and cannot afford—a large military force in being.

Lt. Col. Paul H. Campbell, USAFR
West Lafayette, Ind.

I am disappointed in your October 1981 issue. Purportedly, it is a special edition devoted to the Reserve Forces. Yet, except for a short paragraph in General Bodycombe's article, there is no explicit reference to the Individual Mobilization Augmentee (IMA) program of the Air Force Reserve.

Considering the number of Air Force Reservists who are IMAs and the large—indeed astonishing—variety of duties they perform, I expected a feature article devoted to the IMA program. Although the Air Force's mission is aerial warfare, many in the Reserve, as in the active force, support this mission by *not* serving in flying units.

I hope that the next time you publish a comparable issue on the Reserve Forces you provide more information on the many men and women serving in IMA positions.

Col. Walter Jajko, USAFR
Washington, D. C.

• *Evidently, Colonel Jajko overlooked the discussion of the IMA program in the article "The Air Reserve Personnel Center Mission: Mobilization," by Senior Editor William P. Schlitz, beginning on p. 64*
—THE EDITORS

Pilots and Personnel Policy

Numerous reports published by AIR FORCE Magazine, the Manpower and Personnel Center of the Air Force, the national media, and even "Air Force Policy Letter for Commanders" from the Office of the Secretary of the Air Force indicate a serious retention problem and shortage of pilots and navigators in the Air Force.

The last estimates I saw were a shortage of 3,000 pilots and navigators in the period ending September 1981, with an eventual shortage of 3,400 pilots by 1982.

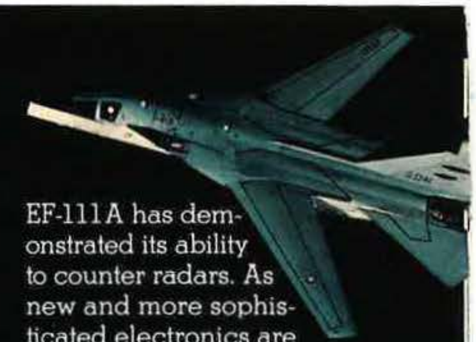
If this is a crisis for the Air Force, let's attempt to solve it. For the past two and one half years, I have attempted through all channels to enter the Air Force. My qualifications were that of being a commissioned pilot for the Army. Of all my inquiries, I did not receive one acceptable reply—in fact, one such reply I received over the telephone from the Manpower and Personnel Center was that I was overqualified! Another reply, this one from the Office of the Secretary of the

THE EF-111A. ITS SIGNIFICANCE BECOMES MORE APPARENT EVERY DAY.

Potential aggressors will soon have to contend with an imposing weapon. The U.S. Air Force's newest dedicated tactical jamming aircraft—the EF-111A.

Developed by the USAF and Grumman, the EF-111A will be able to detect, identify and disrupt the electronic air defenses of enemy armor and strike forces. In support of our own air-to-ground operations, the EF-111A will loiter miles from enemy territory as a standoff jammer, or fly along with our strike forces and nullify hostile radar deep behind the lines.

Against simulated Central European air defenses—the densest in the world—the



EF-111A has demonstrated its ability to counter radars. As new and more sophisticated electronics are developed the EF-111A's built-in growth potential lets it adapt to meet the threat. Thus, a full complement of EF-111A's would multiply the effectiveness of defending forces many times over and give the USAF an increased deterrent to aggression.

The EF-111A. A real answer to a real need.

Grumman Aerospace Corp., Bethpage, Long Island, N.Y. 11714.

THE PAYOFF IS PERFORMANCE.

GRUMMAN

Air Force, stated they did not require somebody with my qualifications. I *am* trainable!

Age (now thirty-one, then twenty-eight), I am sure, had something to do with not being considered for the Air Force. If this was so, why not just say it? I felt that, being a former military pilot, age could be waived. There is no problem passing a Class 1 flight physical, if given the opportunity.

I want a career, or at least the opportunity for a career, with the Air Force. I know the direction I am heading. I don't want the training to get out in a few years to fly with an airline.

In my opinion, the Air Force isn't using all means available to fill its ready positions.

David S. Walton
Dallas, Tex.

We in uniform are quick to attack Congress or the Administration concerning personnel policies. The fact is that the Air Force buries its own head in the sand on these issues.

A case in point has happened to me twice within the last year. In both instances there were openings in the Air Force for a rated pilot that I wanted very badly and for which I was qualified. Since I have lived in nineteen locations in the last twenty-five years, I did not look forward to two or three more moves in my career. Therefore, I had decided to retire if I was not successful in obtaining either of the assignments.

Both assignments were in the state in which I plan to retire. I was assured that I was well-qualified for the jobs. In fact, I had been requested, by name, for one and was told by TAC that it was a "perfect job-man fit."

However, in both situations, I was told by AFMPC and TAC that they could not support releasing a fighter pilot to a job that could be filled by any other pilot. The stated reason was that it is a matter of Air Force policy not to assign a fighter pilot to a "pilot general" capacity, even though they would lose me through retirement. The irony is that my fighter pilot status is in name only. I have not been used in a job requiring fighter pilot expertise for the last two years.

Can the Air Force afford to lose trained people due to an inflexible policy? How do they justify having to fill two slots instead of one? . . .

I suggest we cease playing ostrich with illogical policies and get our heads out of the sand—before we find our heads placed in an even less desirable location.

Lt. Col. Harold R. Alston, USAF
Nellis AFB, Nev.

AIRMAIL

Oops!

You burst our bubble!

We are extremely proud of the fact that our bright Electronic Security Command airmen garner honors in AFA's Air Force Outstanding Airmen competition. Our TSgt. John M. Barger was no exception. He has been an excellent representative of the type of dedicated young people performing important ESC missions at bases around the world.

I know that the more than 12,000 members of ESC share my disappointment in seeing John's former unit, the 6981st Electronic Security Squadron, identified as an AAC organization in your November 1981 issue of AIR FORCE Magazine *(p. 82)*. As a young command intensely proud of its heritage and increasingly important electronic warfare mission, we are justifiably proud of our strong enlisted force which produces such professional performers as John Barger.

We are the Air Force's newest major command and must frequently correct those who continue to refer to us by the name of our predecessor—USAF Security Service—or confuse us with ESD, AFSC's Electronic Systems Division. So we depend on such fine publications as AIR FORCE Magazine to keep the record straight!

Maj. Gen. Doyle E. Larson, USAF
Commander, ESC
San Antonio, Tex.

More Curse Than Blessing?

As C^3 technology improves, it may become more of a curse than a blessing. Even under the best conditions, there is no substitute for choosing good personnel for the job, then standing back and letting them do it.

C^3 conjures visions of a football coach who not only tries to call all of the plays, but also installs earphones in each player's helmet to direct them each step of the way. If that weren't bad enough, imagine how players trained that way would perform when the coach's plug is pulled.

Merely having C^3 capability is an almost irresistible temptation for rear echelon commanders. Imagine you are at home watching the Super Bowl with a direct line to your favorite quarterback's helmet. Could you resist?

Paul J. Madden
Seattle, Wash.

Best Seat in the House

In reference to the fine article, "The Bombardier and His Bombsight," by Michael J. Nisos *(September '81, p. 106)*: There are a few inaccuracies I could argue with.

Right off the bat, in reference to the editorial comment at the top of p. 106: The first—*exclusive*—bombardier training began on July 16, 1940, at Lowry Field, Colo. Prior to that time almost all bombardiers were enlisted types.

Graduated from the Air Corps ordnance school as ordnance-armorer-gunners, they were fully qualified in the operation, care, feeding, and maintenance of the Norden bombsight, which was standard equipment in the B-18, and other types, long before 1940. In the early days, security was very tight on the Norden sight. When not in use, it was kept locked up, usually under guard, and was carried to and from the airplane in a closed container by two armed ordnance-armorers.

Incidentally, if my memory serves me correctly, the first of many bombardiers killed in combat was MSgt. Meyer Levin, combat crew member on the B-17 piloted by Capt. Colin P. Kelly, Jr., following a strike on a Japanese warship, the *Ashigara*, off Aparri in the Philippines on December 10, 1941. Kelly's B-17 was shot down by fighters as it returned from the strike.

And, as a former ball turret gunner, I'd dispute Mr. Nisos's claim of the "best seat in the house." Mine would rotate 360 degrees in azimuth, and from zero to minus ninety degrees in forty-five seconds.

Terence R. St. Louis
Kirtland AFB, N. M.

• *Author Nisos comments: "I agree with Mr. St. Louis on his azimuth rotation of 360 degrees and zero to ninety degrees in forty-five seconds; however, he was looking around and down while the bombardier was looking forward and up 180 degrees in all directions.*

"Ball turret gunners, besides their technical skills, also needed that special measure of courage and dedication, along with the other members of the crew. I was once lowered into a ball turret in a B-24 and fired the guns. I knew then what an embryo feels like, and I would not like to be suspended out there in space—let alone firing the guns at the enemy!"

Start Talking

I would like to clarify a point in the November 1981 issue of AIR FORCE Magazine. In his article, "Inauspicious Resumption of Arms Talks" *(In Focus . . . , p. 9)*, Edgar Ulsamer labels the acronym START (strategic arms reduction talks) a coinage of the Reagan Administration.

During confirmation hearings before the Senate Committee on Foreign Relations, Eugene Rostow, the current Director of the Arms Control and Disarmament Agency, stated that "from now on I suggest we should have a new acronym—not SALT, but START, for Strategic Arms Reduction Talks."

However, a similar term was used as early as September 30, 1972, when a Joint Congressional Resolution approving the SALT I Interim Agreement (Public Law 92-448) was passed. It called specifically for "the President to seek at the earliest practicable moment Strategic Arms Reduction Talks (SART)."

Evidently, the Reagan Administration feels "START" has a better ring to it than "SART."

1st Lt. Donald R. Falls, USAF
Bolling AFB, D. C.

389th Bomb Group

I am trying to locate several men who flew with my father during the summer of 1943.

Dad was assigned to the 389th Bomb Group (H), 565th Bomb Squadron, Eighth Air Force. His unit was stationed at Hethel Field, Station 114, near Norwich, England. During July, August, and September of 1943, the 389th BG was detached to the Ninth Air Force at Benghazi in North Africa in order to participate in the low-level Ploesti oil field raid of August 1, 1943.

Former crew members and duty positions were as follows: Lt. Walter J. Stabrowski, navigator; Lt. Cecil D. Stout, bombardier; Lt. William R. Gilliat, navigator; TSgt. Grover A. Edmiston, bombardier; and Lt. Kenneth B. Packer, group station ten.

Four members of my father's original B-24 Liberator crew were killed in action according to records. Perhaps someone can furnish me with family contacts for these men: Lt. Joseph H. Hardison, pilot; TSgt. Beverly W. McLellan, radio operator; SSgt. William H. Schermerhorn, gunner; and SSgt. Andrew J. Smilnyek, flight engineer.

I wish to share the information I have gathered with these men and their families.

Hugh R. McLaren
915 E. Missouri
Phoenix, Ariz. 85014

Jimmie Angel

Wanted: Any information relating to Jimmie Angel, former movie stunt pilot from "Hell's Angels," "Dawn Patrol," and other aviation movies of the 1920s and '30s.

Also, anyone who flew with Angel in Latin America in the 1920s, '30s, or '40s, please contact me at the address below.

Paul Ron Eversole
Drawer G
Crownpoint, N. M. 87312

AIRMAIL

97th Bomb Group

I am trying to locate anyone who was connected with the 97th Bomb Group (WW II) with information concerning Lt. Col. P. A. Antonio Cardenas Rodriguez of the Mexican Air Force.

Colonel Rodriguez, who in 1943 was part of the Mexican Mission of Observers in North Africa, was assigned to the 97th while Col. Stanley J. Donovan was the commanding officer. In Colonel Rodriguez's book, *Mis Dos Misiones,* he reports that he participated in a number of bomb missions (one to Sicily on May 21, 1943).

I would like to find out how many missions Colonel Rodriguez participated in, the dates and targets of the missions, and the crews he flew with. Any help would be appreciated.

Santiago Flores Ruiz
San Diego Aerospace Museum
2001 Pan American Plaza
Balboa Park
San Diego, Calif. 92101
Phone: (714) 234-8291

453d Bomb Group

To any 453d Bomb Group aircrew or personnel who were based at Old Buckenham, England: I am compiling information for a 453d Bomb Group history.

The things I need most for the history are as follows: pictures of places around the base, pictures of planes and bomber crews, and especially any stories of missions or happenings around the base or in briefings.

Even if you have only a suggestion as to the title of the history, I would be happy to hear from you.

Chris McDougal
3921 67th St.
Urbandale, Iowa 50322

F-80s in Korea

I would like to hear from anyone who was associated with the F-80 in postwar Japan or during the Korean War.

The purpose of this request is to gather material and information for an article, and also to compile a current address list to help put old friends back in touch.

Warren E. Thompson
7201 Stamford Cove
Germantown, Tenn. 38138

F-4 Phantom

I am writing a book about the F-4 Phantom II, and I'd like to hear from GIFS, GIBS, maintenance personnel, and anyone connected with the F-4 program in any way.

Stories about the Phantom's maintainability and combat record would be most welcome. Items of special interest are R&D, recce, and EW Phantoms.

Photos and negatives will be returned on request.

Justin G. Castillo
PEA Box 144
Exeter, N. H. 03833

F-101 Voodoos

Very dedicated enthusiast involved in lifelong research project would like to correspond with any pilots, maintenance personnel, or individuals who might possibly have photographed McDonnell F-101A/C Voodoos in service with the 481st, 522d, 523d, and 524th Tactical Fighter Squadrons of the 27th Tactical Fighter Wing at Bergstrom AFB, Tex., in 1957–59.

Also required is photographic material on the F-101A/C Voodoos of the 78th, 91st, and 92d Tactical Fighter Squadrons of the 81st TFW at RAF Bentwaters and RAF Woodbridge, England, during 1959–65.

Sgt. Gary D. Powell, USAF
PSC Box 1018
Mather AFB, Calif. 95655

497th Tactical Fighter Sqdn.

I am the biggest "phan" of the Phantom II, and collect anything connected with the aircraft.

I'd like to ask for help in obtaining a patch which I believe belonged to the 497th Tactical Fighter Squadron during the Vietnam War.

The patch shows a half moon with a caricature of the "phantom's" head, with a star to the left and a starshell going off to the right. The patch bears the words "Night Owl" across the top.

I would enjoy hearing from anyone attached to the 497th TFS, and from any Night Owls who can provide me with any information about their missions.

John P. Watterson
1911 Gracewood Dr.
Greensboro, N. C. 27408

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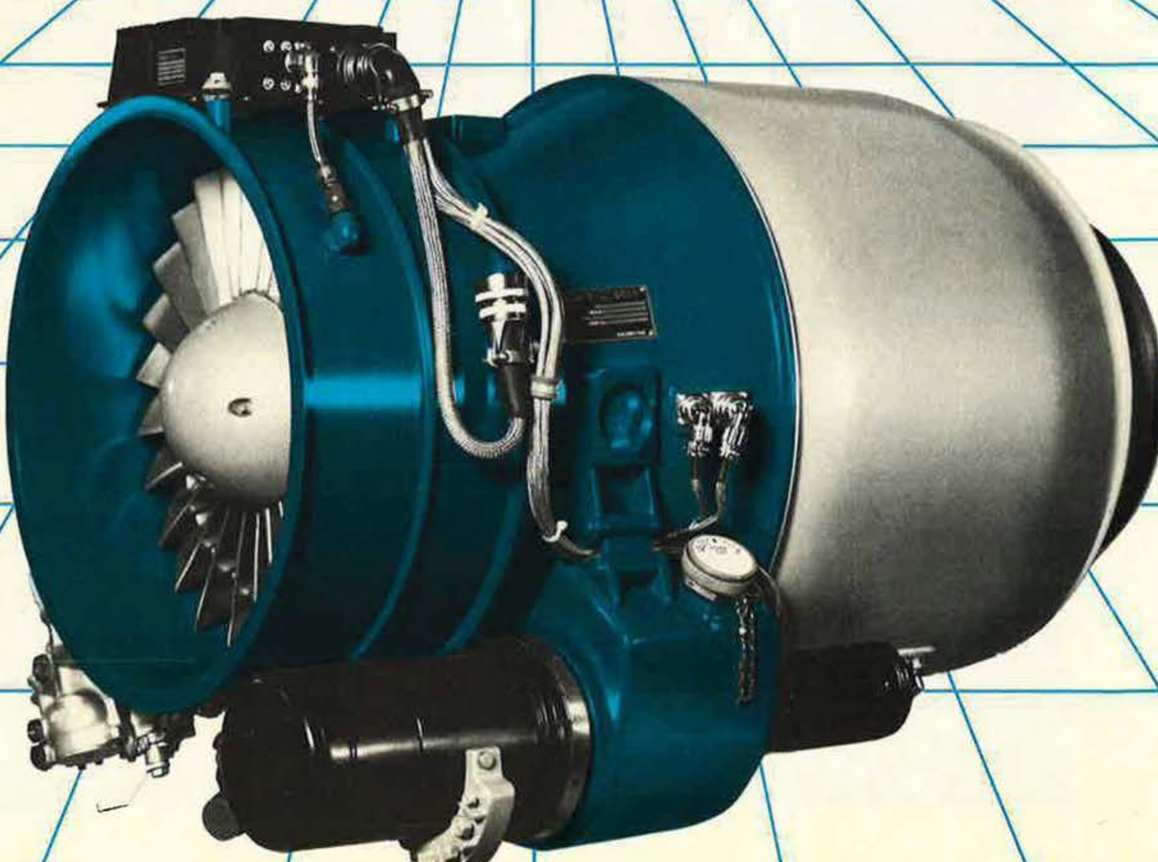

IN FOCUS...

By Edgar Ulsamer, SENIOR EDITOR (POLICY & TECHNOLOGY)

Washington, D. C., Dec. 2

End of the Threshold Test Ban Treaty?

The Administration has formed a high-level interagency group to review the advisability of resuming high-yield underground nuclear testing. Reason for this review is the recognition that inadequate, heavily scaled down testing of the current and future families of US nuclear warheads could jeopardize the effectiveness and reliability of the nation's strategic deterrent.

In July 1974, the US and the Soviet Union signed a Treaty on the Limitation of Underground Nuclear Weapon Tests, usually referred to as the Threshold Test Ban Treaty, as a companion to the Limited Test Ban Treaty signed in 1963 that prohibits all nuclear weapon testing in the atmosphere, in outer space, and underwater. The Threshold Test Ban prohibits testing of nuclear devices with a yield exceeding 150 kilotons, meaning, in effect, all new strategic warheads developed by the US since 1974. This includes the two warhead types planned for MX, the warhead of the air-launched cruise missile, and high-yield warheads for ballistic missile defense prototypes.

While the arms control lobby has been successful in the past in persuading the executive branch and Congress that full-up testing of nuclear weapons is not necessary, some Reagan Administration officials see evidence to the contrary and favor ending US adherence to the Threshold Test Ban Treaty. That treaty, like SALT II, has not been ratified by Congress.

MX Status Report

Secretary of Defense Caspar Weinberger has set up a Strategic Modernization Program Executive Committee (EXCOM) under the chairmanship of Dr. Richard DeLauer, Under Secretary of Defense for Research and Engineering, that will "facilitate the coordination of the various facets of this program among the services and appropriate elements of the OSD staff."

Composed of the senior leadership of the Defense Department and the services, EXCOM is to work out as-yet-unresolved elements of the five-pronged strategic modernization program. In announcing formation of this special group, Secretary Weinberger explained that the Administration's rejection of the multiple protective shelter (MPS) basing mode for MX proposed by the Air Force should not be confused with "rejection of deception per se. . . . The Administration intends to explore deceptive basing of offensive missiles and defensive components as an option within the BMD [ballistic missile defense program, one of three long-term basing approaches to be pursued by the MX effort]." Secretary Weinberger added that "to do otherwise would exclude highly effective tactics, for example preferential defense [meaning defense of only silos or shelters housing a missile as opposed to decoy sites], which the US could use to gain leverage against the Soviet threat."

A subpanel of EXCOM, chaired by the Deputy Under Secretary of Defense for Strategic and Theater Nuclear Forces, is being set up to "ensure an integrated and balanced defense/offense system which could take advantage of deceptive techniques" in both MX and associated BMD deployments, according to Secretary Weinberger.

Meanwhile, studies and research undertaken subsequent to the Administration's decision to drop MPS from further consideration tend to put in doubt two of the long-term basing modes singled out by the Administration for further research and development.

In the case of the so-called deeply buried basing, the problem of the life support system's vulnerability to chemical and biological warfare appears to be next to insurmountable. Also, the costs and environmental impact associated with this approach, which relies on digging out the missile from deep underground sites some time after Soviet ballistic missile strikes, create hurdles at least as formidable as those that caused MPS to stumble.

Latest evaluation of the continuous patrol aircraft, or "Big Bird," which involves air-launching MX, produced equally discouraging results in the form of high cost, inadequate survivability, and operational drawbacks.

Launch during high international tension, or on early warning, into fractional or full orbits—a scheme considered and discarded some time ago—is being reexamined and is gaining some favor in OSD. Its principal merit is said to be its ability to ease the vulnerability of silo-based MX weapons whose warheads could be placed into a space sanctuary for limited periods of time. The orbiting warheads could be deorbited on command either to descend on their targets or for retrieval by aircraft, if tension subsides.

The original objections to this approach were vulnerability to false alarms or Soviet spoofing as well as the danger of such precautionary launches being misconstrued by the Soviets as direct attack, thus triggering instant retaliation. Lastly, deployment of nuclear weapons in space is prohibited by a treaty signed by the United States.

In hearings before the Senate Armed Services Subcommittee on Strategic and Theater Nuclear Forces, Gen. Richard H. Ellis, USAF (Ret.), former SAC Commander in Chief, recommended that the Administration's self-imposed deadline for coming up with a permanent basing mode for MX by 1984 be foreshortened to one year, arguing that "we have studied the MX system for some fifteen years. . . . I think it would be difficult to come up with something that we haven't looked at [before]."

He added that there "are shelves loaded" with previous studies, including those options the Reagan Administration is interested in. The former head of SAC counseled against hardening shelters that MX is to be deployed in beyond present levels on grounds that the money can be better spent on other aspects of strategic force modernization. The

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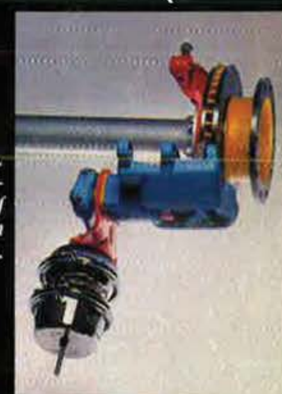

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technical experts, he said, simply don't know how to harden silos sufficiently to provide protection against the accuracy levels attributed to the Soviet ICBM force.

The Administration's strategic force modernization package, General Ellis asserted, will not help in closing the "window of vulnerability" over the next five years because "nothing is being added that has not already been in production" except for the B-1B, which won't attain operational status within that period.

Heritage Foundation Scores Administration's Defense Record

The Heritage Foundation, which helped shape much of the original thinking of the Reagan Administration, especially in the field of national security, stingingly criticized the Administration's performance after nine months in office. In what it termed a "Mandate for Leadership Report, The First Year," the Foundation handed the Administration a report card that flunks it in the defense sector although giving it passing grades in domestic policy.

Said the conservative think tank, many of whose savants and experts are now ensconced in senior Administration jobs, "while Soviet weapons investment over the past decade has exceeded that of the United States by over $355 billion—some ninety percent per year—and Soviet arms production outstrips that of the US three to one, the Reagan defense spending request for this fiscal year is only one percent higher than Jimmy Carter's."

Equally disturbing to the Foundation's analysts is the absence of an "articulated policy framework. There is as yet no Reagan Five-Year Defense Plan to guide our defense improvements. Although the President has pledged to close the window of vulnerability, comparative force analyses show that under the Administration's current program, the period of strategic vulnerability is growing deeper and broader."

The Foundation hurled its strongest thunderbolt at what is termed the Administration's "failure to address US strategic force vulnerability and modernization requirements in a timely and coherent fashion. . . . Its key strategic initiative—MX basing—is strategically incomprehensible because it fails to respond to the need to provide for the survivability of US land-based forces."

The Foundation's findings are equally scathing in terms of its perceived failure to "implement critical,

IN FOCUS...

time-urgent quick fixes to our nuclear deterrent forces, thus perpetuating their vulnerability." The Administration's solution to the problem of near-term vulnerabilities has been rescheduling of the "arrival of the window of vulnerability" to the second half of this decade, even though vulnerability of the US ICBM force in the early 1980s was a prominent campaign theme of the President, the Foundation charges, adding: "The cynic would charge that the window of vulnerability has been officially postponed in order to justify the Administration's utter failure to redress the problem. A more charitable explanation would suggest that the present defense leadership does not understand the meaning of strategic vulnerability, or the threat that it poses to our national security and to our ability to conduct a coherent and consistent foreign policy."

The Foundation study praises the decision to field 100 B-1Bs while continuing research and development on an advanced technology bomber, but excoriates as egregiously inconsistent the plan to deploy MX in existing silos rather than in a survivable, deceptive basing mode: "Replacing unsurvivable Minuteman or Titan missiles with equally unsurvivable MX missiles will do nothing to redress the essential vulnerability of the system, which stems from the basing of the missile, not from the missile itself."

The Foundation asserts that the "Administration contention that hardening planned MX silos improves survivability invites accusations of disingenuousness. Exhaustive studies unanimously concluded that, using current technology, silos cannot be hardened to withstand an attack from increasingly accurate Soviet ICBMs."

Somewhat uncharitably, the Foundation reminds Secretary of Defense Caspar Weinberger of testimony he furnished during his confirmation hearings before the Senate Armed Services Committee, to wit: "Simply putting MX into existing silos would not answer several concerns that I have; namely, that these are well known by the Soviets and, secondly, that you can't harden them sufficiently to improve their invulnerability." Air Force studies conducted in the wake of the strategic force modernization decision, the Heritage Foundation claims, "reaffirm the ineffectiveness of hardening efforts against even existing Soviet capabilities."

In the area of quick fixes, the Foundation vents its frustration over the Administration's decision to delete from the current budget "an effective but inexpensive program to increase the number of Minuteman warheads by deploying stockpiled Minuteman IIIs in existing silos." Contending that such a step also would have facilitated the rapid retargeting of surviving missiles, the Foundation argues that "if one accepts the doubtful proposition that it is sensible to deploy the MX in vulnerable Minuteman silos in 1986, it follows that one should be willing to spend far less to immediately maximize the capabilities of any surviving Minuteman ICBMs."

The Foundation applauds the emphasis given strategic command control and communications (C^3) by the Administration's strategic package, but charges that only scant attention is being paid to survivability and endurance of these systems. The report also claims that strategic instability is increased by the Administration's alleged emphasis of launch on warning rather than of survivable, enduring warning and C^3 capabilities.

The Heritage Foundation's report also upbraids the Administration for slowing the construction rate of Trident SSBNs "from Carter's one and a half per year to only one per year," for dropping one Trident from the current budget, and for slipping completion of the new Trident base at Kings Bay, Ga., until 1992.

The Foundation, which provided Candidate Reagan with information critical of SALT II during the campaign, is clearly peeved that the Administration continues to comply "unilaterally" with the terms of the unratified treaty, "a ploy begun under Carter." The problem is compounded, according to the Foundation's findings, by "as many as thirty-five well-documented Soviet violations of the SALT treaties and other arms-control treaties. Despite campaigning against the SALT II Treaty, the Reagan Administration has failed to challenge these Soviet actions."

Failure to challenge these alleged treaty violations, the Foundation report contends, diminishes the prospects for a more equitable SALT III accord, reduces the urgency of boosting intelligence collection and analysis capabilities needed for SALT verification, and "renders all arms-control treaties a sham."

IN FOCUS...

An Outlandish Proposal

Eugene V. Rostow, Director of the US Arms Control and Disarmament Agency (ACDA), made this startling assertion recently before the Political and Security Committee of the UN General Assembly: "The United States views the effort to bring the nuclear weapon under international control as the most important task of those who seek to realize the promise of peace. Without success in this effort, no other success in the field of arms control will be possible."

This anachronistic notion harkens back to the period immediately following World War II when the US enjoyed a nuclear monopoly and somewhat naïvely offered to place its nuclear weapons under international control to dissuade other countries from developing their own. This high-minded scheme was interred with the subsequent Soviet development and deployment of "A" bombs and "H" bombs.

The goal of placing US strategic nuclear forces under international control—and the notion that the Kremlin would follow suit—seems utopian, especially for an Administration committed to restoring the nation's strategic deterrent. Whether ACDA Director Rostow means to transfer control of the Strategic Air Command and the other SIOP (single integrated operational plan) forces from the National Command Authorities to UN Secretary-General Kurt Waldheim or some other international official was not spelled out by his speech.

Adding incongruity to this episode is that the remainder of the ACDA Director's UN address (Mr. Rostow, until assuming his present position, served with distinction on the Committee for the Present Danger, a staunchly pro-defense group and vocal opponent of unilateral arms control) pursues a rather tough line. The USSR, for instance, is chastised as the "last remaining traditional colonial empire [whose] policy of expansion, fueled by the extraordinary growth of the Soviet armed forces, and particularly of its nuclear forces, has produced a situation of growing tension and instability in the world."

Thus, it is possible to suspect that the suggestion to internationalize the SIOP forces was injected into Mr. Rostow's UN speech by arms-control ideologues, many of whom remain firmly entrenched in the ACDA structure.

A noteworthy, constructive element of the ACDA Director's UN address was his assertion that in future arms-reduction talks this country will not confine itself "to negotiating only about those aspects of a problem which can be resolved by resorting to national technical means [of verification, generally thought to mean spy satellites and other advanced sensor technologies]." Rather, there will be emphasis on "cooperative measures between the United States and the Soviet Union, such as detailed data exchanges and provisions to enhance the confidence of each side in data obtained by national technical means."

The US, he explained, will seek verification provisions which "not only ensure that actual threats to our security resulting from possible violations can be detected in a timely manner but also limit the likelihood of ambiguous situations developing." Mr. Rostow stressed that Soviet acceptance of cooperative measures to improve verifiability of specific limitations "may be the best test of its commitment to serious arms limitations on both a bilateral and multilateral basis."

The Military Space Policy

Air Force Under Secretary Edward C. Aldridge, Jr., recently outlined a number of growth areas in the military space mission, citing prominently a new, more capable Shuttle, improved protection of US space assets from interference and destruction, and deployment of space-based systems that provide for an "assured survival" capability.

A "Block II Shuttle," with a greater payload, more volume, and a broader range of orbital capabilities, according to Mr. Aldridge, would permit "expanded use of man in space for assembly of large structures, service of our orbital payloads, or manufacturing of special materials."

Satellites, in the future, will need more on-board processing and direct readout of processed information to tactical commanders as well as more cross-linking of information to reduce dependence on overseas ground stations and to provide continuous global coverage.

With an interagency group headed by the White House's Office of Science Technology Policy engaged in a top-to-bottom review of US space policy, Mr. Aldridge's recommendations, although presented to the National Space Club as personal, take on added meaning.

Significantly, he singled out this policy goal: "The US must have confident and free access to space to exploit its unique potential and to deny its use when considered harmful to US interests." It seems illogical, he stressed with regard to the Space Shuttle, that "our highway to space should be a single lane road in which the only access onto this road is a single pad at the Kennedy Center."

Equally illogical would be confinement of US access to space to "three, or four, or five highly complex launch vehicles [since] fleet grounding, launch failures, or both could severely limit our access to space." The Administration, therefore, plans to "continue the Titan III production to provide for a highly reliable expendable booster backup to planned Shuttle flights launching DoD payloads during the Shuttle transition period."

For the long term, the Administration is exploring the need for a mixed fleet of Shuttle and expendable launch vehicles. Equally important from the viewpoint of national security is the role of the Vandenberg Shuttle facility, "not only to launch satellites in polar orbit but to provide another facility to hedge against any kind of catastrophic event at Kennedy that could deny its use," according to Secretary Aldridge.

In the area of new missions, he underscored the importance of "aircraft detection from space." Generally, a new management structure for space system operations is imperative since it is clear already that "we cannot continue to look to NASA as our country's launch service organization in the Shuttle area. . . . The current way in which we operate space assets must be more coordinated and integrated in the future as we expand our space operations and commence routine launches of military satellites with the Shuttle," according to Mr. Aldridge. The answer, he suggested, may be some form of "Space Command" in charge of launch services and satellite operations. The Air Force, he added, is moving in that direction.

Washington Observations

★ The US intelligence community recently informed Congress that there is evidence that the Soviets have developed a new strategic bomber similar in size and performance to the B-1B, an aircraft expected to reach operational status in about five years. Whether or not the Soviet aircraft is undergoing flight testing was not disclosed. ■

SCIENCE/SCOPE

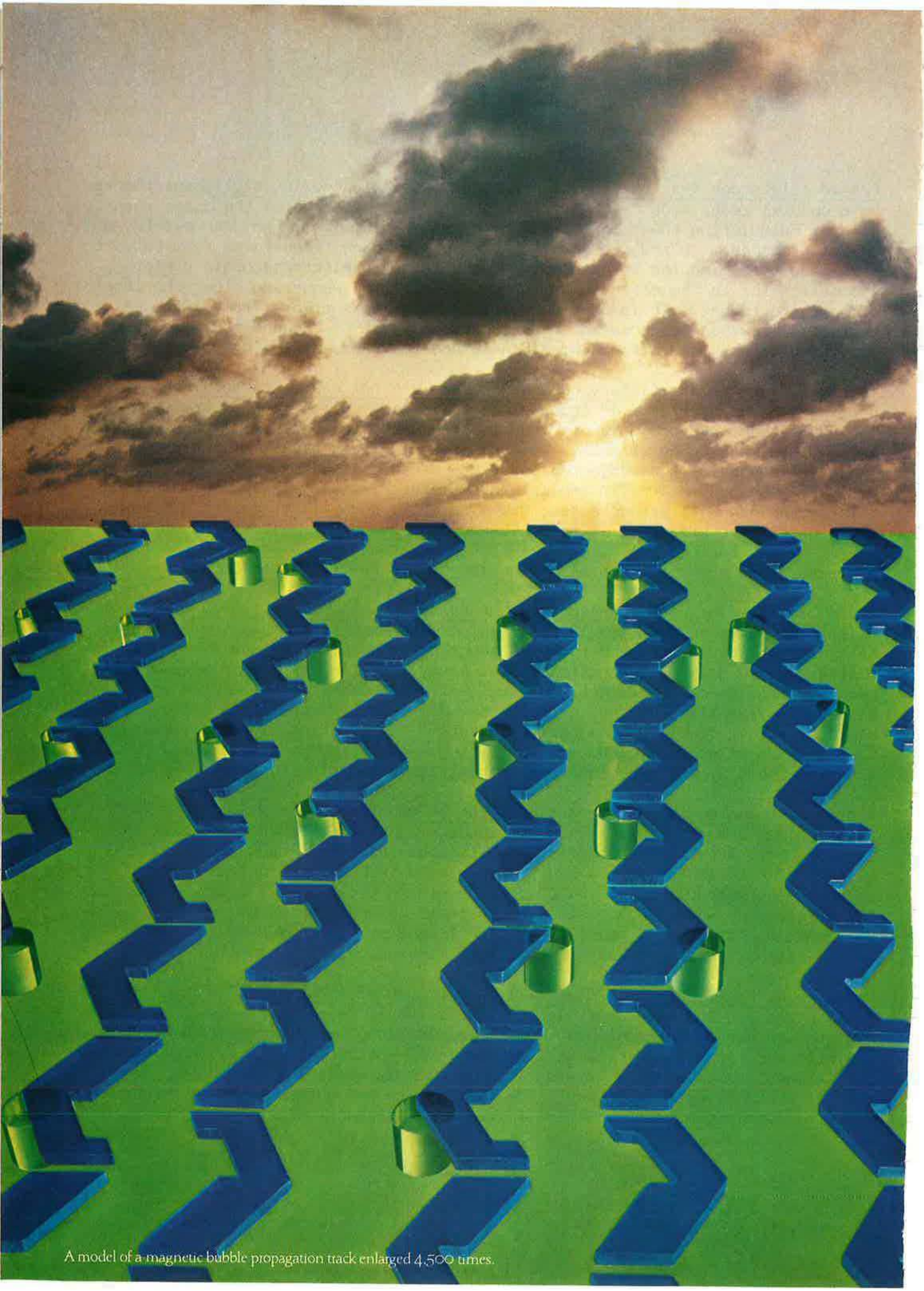
F/A-18 pilots can fire their guns with great precision during dogfights, thanks to a special radar mode. The aircraft's AN/APG-65 radar tells the pilot when to fire by calculating the target's relative motion from its range, range-rate, and position change. It reduces scintillation by changing frequencies from pulse to pulse and averaging the returns to find the target's electromagnetic center. (Scintillation is the effect of a "bright" radar spot wandering along the length of a moving target. It is caused by strong radar reflections from different surfaces.) Hughes produces the radar under contract to McDonnell Douglas Corp. for the U.S. Navy and Marine Corps F/A-18 and the Canadian CF-18.

Tactical displays at military command centers are now easier to read, thanks to a device that projects vivid color pictures in sizes up to five meters square. The Hughes HDP-4000 projector is used in ground stations to display maps, status information, and computer data. An exclusive component called a liquid-crystal light valve enables the projector to create pictures that are much brighter than ordinary home projection TV. While conventional displays are limited to two colors, the new unit projects red, green, orange, and yellow against a black background. The projector is portable and self-contained. It has no moving parts, except for cooling, and needs little maintenance. A model of the color projector that meets surface ship requirements is now being designed.

The millimeter-wave radar seeker for the new Wasp anti-armor missile has begun flight tests to see how well it distinguishes tanks and other military targets from non-target vehicles and their surroundings. Wasp, which would be fired in clusters of 10 or more against masses of enemy tanks, must have this capability because it is to pick a target and aim itself with almost no help from the launching aircraft. For the tests the seeker is housed beneath an aircraft equipped with a complete data analysis system. It is being flown day and night in all kinds of weather, including rain, fog, and snow. Hughes is developing Wasp for the U.S. Air Force under a competitive validation contract.

A new laser designator and rangefinder can be mounted on the U.S. Army's Fire Support Team armored vehicles or on tripods. The Hughes Ground/Vehicular Laser Locator Designator (G/VLLD) directs an invisible beam of coded laser pulses at a target. The reflected pulses can be detected by special sensors in aircraft or laser-homing weapons, or can be used to determine the target's range. Engineering development models have been used in laser-guided weapons tests since 1977. One unit, operating at a pulse repetition frequency commonly used for laser-guided weapons, served in more than 15,600 missions without a malfunction.

Norway's NATO air defense system will be improved with the addition of a new air defense radar. The Hughes Air Defense Radar (HADR) is a remote-controlled radar designed to provide air defense commanders with long-range, three-dimensional surveillance information. It will automatically detect, classify, and report on all targets in its area of coverage. HADR has extremely low sidelobes, which make it virtually jam-resistant. The system also has automatic troubleshooting and fault isolation to substantially reduce maintenance costs.



A model of a magnetic bubble propagation track enlarged 4,500 times.

AEROSPACE WORLD
News, Views & Comments

By William P. Schlitz, SENIOR EDITOR

Washington, D. C., Dec. 7

★ Beginning this past November and continuing into December, the US flexed its Rapid Deployment Force muscle in the Mideast for the second consecutive year.

During the exercise—known as Bright Star '82—Army and Air Force elements deployed to the area from CONUS and Navy and Marine Corps units from the Indian Ocean.

Specifically, in Egypt about 4,000 Army and Air Force personnel participated in joint desert maneuvers with Egyptian military forces in the vicinity of Cairo West Air Base, an encore to the previous year's exercise that involved about 1,400 US military.

Army units included a XVIII Airborne Corps headquarters element and an 82d Airborne Division battalion task force, both from Fort Bragg, N. C. A telling point in the exercise was that for the first time six Air Force transports with some 600 paratroopers aboard flew fourteen hours nonstop from CONUS to the drop zone in Egypt. Prior to the deployment, the troopers had been conditioned to Egyptian time by eating and sleeping to counter jet lag. Other factors included sleep aboard the aircraft during the transatlantic crossing and a special diet.

The total paratroop contingent of nearly 900 was equipped with all provisions needed for combat, including 105-mm howitzers, jeeps armed with antitank missiles, and Gamma Goat utility vehicles dropped from other transports flown into Egypt from unidentified staging bases in Europe.

The paratroopers were spearheaded in a night jump by a detachment of Special Forces Green Berets and an Air Force Command Control Team to secure the drop zone.

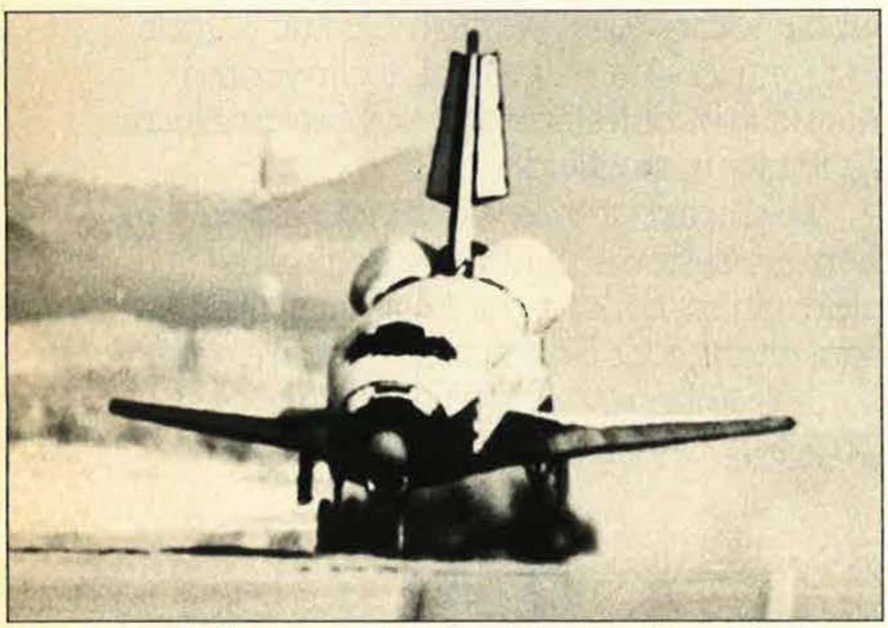
On the ground, the airborne force linked up with a battalion task force of the 24th Infantry Division (Mechanized) from Fort Stewart, Ga., that was airlifted from CONUS. The unit's tanks and armored personnel carriers were landed by sea.

Involved in Bright Star besides the MAC transports and SAC tankers was a headquarters element from Ninth Air Force, Shaw AFB, S. C., and A-10s of the 353d Tactical Fighter Squadron, Myrtle Beach AFB, S. C. A number of B-52s flew nonstop air-refueled sorties round trip from Minot AFB and Grand Forks AFB, N. D.

Bright Star was not confined to operations in Egypt. In the Sudan, about 350 Army, Navy, and Air Force personnel joined in an exercise with the Sudanese military, while in Somalia some 300 Army and Navy people conducted logistics training at Berbera.

In Oman, Navy and USMC forces in the Indian Ocean participated in an exercise coordinated with that nation's military.

Supervising the US's multicountry activities was Lt. Gen. Robert C. Kingston, USA, Commander of the Rapid Deployment Joint Task Force.



A historic aerospace first–the reuse of a spacecraft. Here Space Shuttle Columbia *on the dry lake bed at Edwards AFB, Calif., following a smooth-as-silk landing that climaxed November's second orbital flight. Although the mission was shortened because of a defective fuel cell, it was deemed a success. And with less damage to* Columbia *than anticipated, a third mission in March looks good.*

★ The first transpacific crossing by a manned balloon this past November also set a record for distance traveled by a crewed lighter-than-air vehicle: 5,300 miles (8,528 km). *(For a recap of the first nonstop transpacific flight—the fiftieth anniversary of which was recently celebrated—see box, p. 32.)*

The feat was accomplished by two adventurers who have already made an indelible mark in the world of ballooning: Ben Abruzzo and Larry Newman. The two—with Maxie Anderson (who with his son Kris made the first transcontinental balloon flight in April 1980)—made history with the first transatlantic balloon passage aboard *Double Eagle II* in 1978.

The Pacific crossing in *Double Eagle V* was described as a "roller-coaster ride." Besides stormy weather, there was the repeated process of icing at altitude that caused the twenty-six-story-high vehicle to plunge precipitously followed by melt-off at the lower heights This continued throughout the four-day journey from Nagashima in central Japan to a forced landing caused by weather in California's Mendocino National Forest.

Abruzzo and Newman were accompanied by fellow Albuquerque resident Ron Clark and Japanese-born

The United States Air Force Sword of Honour

Commemorating the 40th Anniversary of the Second World War

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Every year, organizations and individuals ask Wilkinson Sword to devote their skills to the making of special swords for great occasions, or as small limited editions for collectors and investors.

Occasionally, they have to decline these invitations, for true craftsmen swordsmiths are very rare artisans these days, and only commissions of exceptional interest and prestige, and of the highest order, can be allowed to claim their attention.

It has in fact taken many months of highly skilled and painstaking work to create this outstandingly beautiful and valuable sword. The blade is embossed with the United States aircraft used during the second world war which helped to destroy the Luftwaffe and the thousands of bombing raids which destroyed the Nazi regime.

This sword is 33 inches in length, the cross piece and pommel are made from surgical steel and are silver plated. The grip is made of Rosewood and is hand french polished. On the shell guard is the official United States Air Force Badge which is also silver plated. Please be advised that there is no accompanying scabbard.

Of course, collector value does tend to relate directly to the edition limit, and it is in those cases where this has been severely restricted (perhaps to as few as a thousand swords) that the astute investor is likely to see the most satisfying return.

Only one thousand of the United States Air Force Sword of Honour will be made, suggesting that these magnificent replicas are likely to be highly regarded by shrewd collectors, and certainly promising that they will take a proud place amongst the most valuable limited editions to bear the prestigious Wilkinson Sword name.

This sword is not available to the general public—*only* to serving and past members of the United States Air Force. It will not be advertised in any newspaper or periodicals other than the "Air Force" magazine and other pertinent Air Force pamphlets.

This sword is $U.S. 295.00 plus $U.S. 3.00 shipping charges direct from the Sword Division in Canada.

Delivery of these swords is expected to be between six to eight weeks. **[Customs duty is extra]**

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restaurateur (Benihana chain) Rocky Aoki, who financed the $250,000 venture.

Despite the triumph of being first in a balloon to cross the Pacific, the quartet's original plan had been much more ambitious. They had intended to span North America and the Atlantic and continue across Europe, perhaps reaching the western borders of the Soviet Union. To this end, stowed aboard the gondola of the helium-filled *Double Eagle V* was a thirty-day supply of food.

★ AFSC's Armament Division, Eglin AFB, Fla., is currently testing a prototype of the new GPU-5/A 30-mm gun-pod weapon system under an accelerated program.

According to Maj. David Kaplan, test program manager with the Munitions Systems Program Office, the weapon is being developed to provide USAF's high-speed fighter/attack aircraft with the ability to destroy enemy tanks and other armored vehicles.

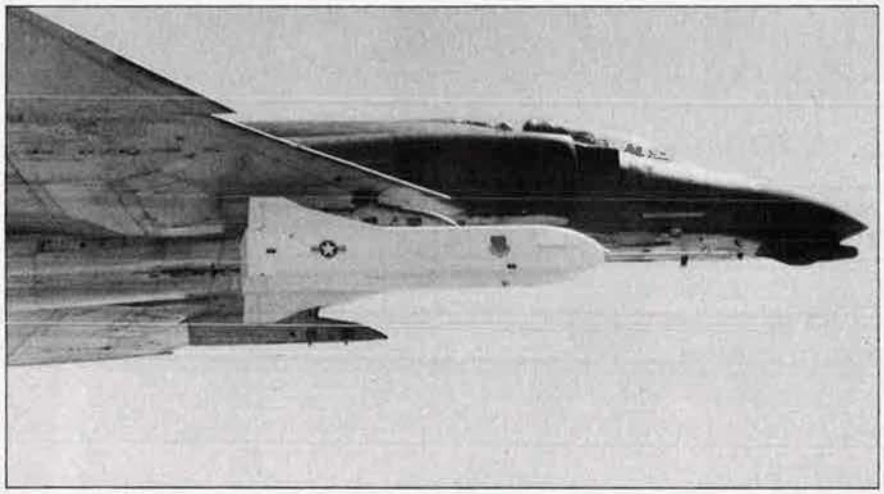
The GPU-5/A system is a four-barrel version of the much larger, longer, and heavier GAU-8 seven-barrel gun that is mounted internally in the A-10 Thunderbolt II. The gun pod is completely self-contained and can fire the entire family of 30-mm ammunition at a rate of 2,400 rounds per minute (forty rounds a second). It holds 353 rounds and weighs less than 2,000 pounds (907 kg) fully loaded.

Because of its relative light weight and its self-contained pneumatic power supply, the gun pod is suitable for mounting on any aircraft wing pylon with standard thirty-inch mounting racks. Thus, Air Force F-4s, A-7s, F-16s, and F-5s, among other aircraft, could be transformed into effective tank killers.

AEROSPACE WORLD

The gun-pod system is currently in the ground-test phase of its development trials, and according to officials the weapon's static firing tests have gone "very well." Compatibility and air-to-ground effectiveness tests at Eglin will be jointly conducted by the Tactical Air Warfare Center and the 3246th Test Wing under the direction of the Munitions System Program Office.

General Electric Co., Burlington, Vt., has been issued a contract for full-scale engineering development of the weapon with the first production pods slated to roll off the production line in September 1982.



Prior to its first test launch, a Low-Altitude Dispenser aboard an F-4D flying at Mach 0.91. For details on the new munitions container, see item.

Capt. Ed Zamorski holds a round of 30-mm ammunition that will arm the new GPU-5/A gun-pod system currently under development. See item above.

★ In another munitions matter, officials report that during the first test flight of the Low-Altitude Dispenser (LAD), the aerodynamic vehicle performed as expected.

LAD, being developed by the Air Force Armament Laboratory, Eglin AFB, Fla., is designed to dispense quantities of submunitions with pinpoint accuracy from such Air Force aircraft as the F-16, F-15, F-111, F-4, and A-7.

LAD is unique in that, once released, it will be able to climb and maneuver to optimum altitudes, allowing its lethal submunitions to be dispensed high enough for arming, stabilization, and target orientation, officials said.

A major feature of the prototype dispenser would allow pilots either a direct or standoff attack against heavily defended targets while maintaining altitudes as low as 100 feet. LAD submunitions could include airfield attack, antiarmor, and defense-suppression weapons. Equipped with sensors, they would be sophisticated enough to identify and lock on to a number of targets after LAD is released from the aircraft and dispenses its load.

LAD weighs in at 2,500 pounds (1,130 kg) and will carry about 1,400 pounds (635 kg) of submunitions.

A contract with Brunswick Corp., Costa Mesa, Calif., calls for delivery of nine dispensers at a cost of $3.8 million. The recent LAD was released at Mach 0.91 at 10,000 feet (3,048 m) over a Gulf of Mexico water range. Future launches of the eight remaining test LADs will be over Eglin's land ranges carrying a variety of submunitions, officials said.

★ The results have been encouraging in the year since Air Force Com-


Powerful stuff. When it comes to sheer performance, nothing—but nothing—beats the F-15 and


16 fighters and their F100 engines from Pratt & Whitney Aircraft, a division of United Technologies.

munications Command fielded a program to deal with the severe imbalance in overseas assignments vs. those in CONUS for a certain type of AFCC specialist.

Of the more than 2,000 technical controllers in the Air Force, AFCC is responsible for about eighty percent, with most overseas. Technical controllers troubleshoot communications systems by either spotting potential breakdowns before they occur or routing traffic around failed elements until they are repaired.

In the US, most of this work is accomplished by commercial concerns. Abroad, the military services are responsible.

With so many tech controller slots to be filled overseas, these specialists were serving too many tours overseas and short, infrequent ones when home. This led to morale, retention, and other problems.

In coming to grips with the situation, AFCC, more or less, broadened the types of work tech controllers can do in the communications field while at the same time expanding the work designation of others.

These AFCC initiatives have resulted in the increase of 146 tech controller slots in the US and the reduction of 110 abroad. About another 100 job conversions will be required to attain the sought-after one-to-one balance, officials said. This goal could be achieved by 1983.

★ In another Air Force communications matter, AFCC has created a sort of strike team to provide emergency communications.

The new staff element at Hq. AFCC, Scott AFB, Ill., is dubbed "Hammer Ace" and is to be operational next March under AFCC's deputate for operations, plans and readiness.

Officially known as the Special Purpose Communications Division, the new unit will be manned by AFCC's best communications engineers and technicians. They are to be equipped with the latest state-of-the-art miniature communications equipment.

Neglected History: First Transpacific Flight

Two great aviation pioneers that America apparently forgot have finally been honored.

Clyde Pangborn and Hugh Herndon, Jr., were the first men to fly the Pacific nonstop. And when they departed the wide windswept beaches of northern Japan in autumn 1931, they began an international friendship that today represents one of the two nations' time-tested ties.

As barnstorming, daredevil pilots, Pangborn and Herndon traveled through thirty-two states, selling rides to any takers while making plans to set a record flying around the world. The first around the world flight, in 1924, had been completed in less than five months by two Douglas World Cruisers; the German Graf Zeppelin sliced that mark down to twenty-one days in 1929.

Then, while Pangborn and Herndon were making final plans, Oklahoma barnstormer Wiley Post and Harold Gatty of Australia in a Lockheed Vega named *Winnie Mae* streaked around the world in eight days, fifteen hours, fifty-four minutes. Pangborn and Herndon set out to break that record.

Pangborn selected a sturdy Bellanca Skyrocket for the job, capable of making longer hops with more fuel on board. They departed New York's Roosevelt Field on July 28, 1931. Bad weather over the Atlantic and in Eastern Europe put them behind *Winnie Mae's* pace. While landing in a rainstorm at Khabarovsk, Siberia, for fuel, *Miss Veedol* slid off the runway and became mired in mud. Their hopes of beating the Post record were dashed.

Hoping to recoup some of their costs, they decided to try for the $25,000 prize money offered by *Asahi*, a Tokyo newspaper, for the first nonstop transpacific flight. Unaware that Japan was in the midst of an aggressive military buildup, Pangborn and Herndon left Siberia for Tokyo on August 8.

Japan was already fighting the Sino-Japanese War (1930–37) and the last thing Japanese authorities wanted was foreign pilots arriving unannounced. The cable the two had sent the US Embassy in Tokyo requesting help obtaining entry papers had not been honored, and, upon landing at Tokyo's Tachikawa Airport, they were put under house arrest.

The flyers were detained most of August and September but they continued to prepare *Miss Veedol* for her transpacific flight. Finally, on September 29 they departed Tokyo for Sabishiro Beach in Misawa City, 250 miles north, the point in Japan closest to the United States.

Despite the militarism sweeping the country, Misawa City remained dedicated to the principle of international responsibility and peace. While Pangborn and Herndon were hosted by city officials, local youths readied the wood-plank runway stretching down the long sloping Pacific beach.

On October 4, just before takeoff, a Japanese boy rushed up to the aviators with a gift of five apples. Then Pangborn firewalled the 425-hp Pratt & Whitney Wasp engine and released the brakes. With no radio, liferaft, or parachutes, *Miss Veedol* was overgrossed by 3,400 pounds. She slowly lifted just above the cresting whitecaps at 100 mph.

The landing gear was dropped over the ocean as planned to reduce weight and drag. They climbed to 14,000 feet without oxygen to top the clouds and ride the tailwinds until weather forced them to 17,000 feet. The cockpit was inadequately heated and their canteens of tea froze; heavy socks were the only protection for their feet as they had adopted the Japanese custom of not wearing shoes.

The struts holding the jettisoned landing gear had not broken clean; a belly landing with them still attached could have been fatal. So at 17,000 feet, Pangborn climbed out onto the icy wing strut in his stocking feet to tear them off.

They finally sighted Queen Charlotte Islands and turned to the south for Mt. Rainier. Seattle, Boise, and Spokane were fogged in. They headed for Wenatchee with its long beach along the Columbia River on which to make a soft belly landing. Pangborn cut the engine on final approach to slide safely home. The Japanese and American connection had been forged during the 4,551-mile journey. They had completed the first nonstop transpacific flight in forty-one hours and thirteen minutes.

The citizens of Wenatchee sent letters and presents to the people of Misawa City thanking them for the hospitality extended to the aviators. One of those presents, sent by the mayor of Wenatchee, was a package of five apple tree cuttings to reciprocate the Japanese boy's gift; these cuttings were grafted onto native Japanese apple trees near Misawa. By 1941, Richard Delicious seedlings and cuttings were being distributed to farms throughout Japan.

Today, an Imperial Navy runway at Misawa AB is 10,000 feet long and the base is home to USAF's 6112th Air Base Wing. US Navy P-3C aircraft are also based alongside JASDF F-1 fighter-interceptors.

In the spirit of warm Japanese and American relations and in commemoration of the contribution of Pangborn and Herndon, Misawa City and Wenatchee signed a sister-city agreement in ceremonies on October 4, the fiftieth anniversary of the aviation first. Eighteen citizens from Wenatchee, as well as political and military figures, arrived in Misawa City to witness the formal agreement of friendship. And, in the US, seven Washington State University AFROTC cadets commemorated the first transpacific flight by sponsoring a flyover, films, and lectures on the event.

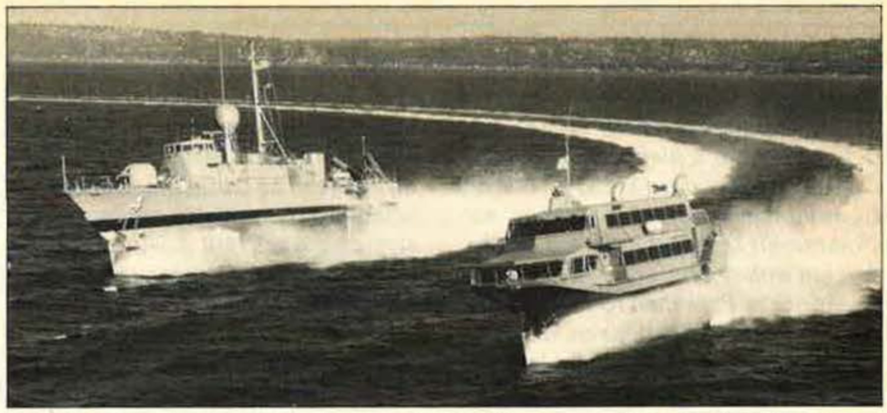
—Capt. Thomas L. Hall, USAF

The experts and their gear are to be formed into "small, fast-moving, and flexible teams." As visualized, a five-person team will be on the move within three hours of notification to provide an on-the-scene commander with "assured, controlled communications, both local and long distance," AFCC officials said.

At the deployment location, a UHF/VHF radio will be the heart of the long-range capability via satellite link with a fixed facility at Scott. Messages are to be routed to the involved major command staff and other agencies via established channels.

On-scene communications will be augmented by a hand-held radio net equipped with a data encryption scrambler. This net will extend the working radius of the base station to twenty miles. The team will also be able to provide ground-to-air and secure teletype and facsimile communications capability.

When not deployed, Hammer Ace teams will join the 1842d Electronic Engineering Group at Scott in testing newly developed equipment and techniques. "This should also pace Hammer Ace capabilities with state-of-the-art advances," AFCC officials said.



Tight turns in Puget Sound demonstrate hydrofoil maneuverability. Aquila, *left, is the second of five patrol missileships Boeing Marine Systems is building for the US Navy. They'll form a squadron at Key West, Fla. At right is a jetfoil recently purchased by Indonesia that is slated to begin operations in home waters this coming March. Jetfoils can hit more than forty knots, even in rough seas.*

★ **NEWS NOTES**—In April 1982 will be commemorated the **fortieth anniversary of the fall of Bataan and Corregidor,** following which thousands of Americans went into captivity. More than 3,000 died in a prison camp at Cabanataun, and a survivors group **plans to dedicate a memorial there** in conjunction with the Republic of the Philippines commemorative event. Contributions can be sent to the Cabanataun Memorial, P. O. Box 13505, Orlando, Fla. 32859.

Maj. Gen. (Dr.) Harry G. Armstrong, USAF (Ret.), has been presented the **International Civil Aviation Organization's highest tribute**—the Edward Warner Award—"for his work as a pioneer in the field of aviation medicine and for his contribution to the safety and comfort of international civil air transport." The only other American so honored was Charles Lindbergh, and then posthumously. Dr. Armstrong had a hand in developing, among other things, the delayed-opening parachute (he jumped with it himself); aircraft oxygen and pressurization systems; and equipment for rescuing crash victims. He retired from the Air Force in 1958 after almost thirty years of military service.

Died: Lt. Gen. Idwal Edwards, USAF (Ret.), former president of the Retired Officers Association whose military career dated back to World War I and who, following the Korean War, helped draw up a code of conduct for US servicemen who became prisoners of war, of cardiorespiratory failure in Washington, D. C., in November. He was eighty-six.

Died: Maj. Gen. Billy B. Forsman, USAF (Ret.), former deputy director of the Defense Intelligence Agency and military attaché to Israel, of cancer at Andrews AFB, Md., in November. The AFA member, a veteran of combat during the Korean War and in SEA, was fifty-three.

Died: Charles B. "Tex" Thornton, of cancer in Los Angeles, Calif., in November. Following service with the Army Air Corps during World War II, he joined Ford Motor Co. as a brain-truster with Robert S. McNamara and eight other "Whiz Kids" and later built Litton Industries into a giant conglomerate, among other acts of financial legerdemain. In October, Mr. Thornton became a recipient of the nation's highest civilian honor—the Medal of Freedom—presented by President Reagan at White House ceremonies. The long-time AFA supporter was sixty-eight. ■

At the invitation of the Senate Foreign Relations Committee, AFA Executive Director Russell E. Dougherty (who served as Chief of Staff, Allied Command Europe at SHAPE, and as Commander in Chief, Strategic Air Command) testified before it on the foreign policy and arms-control implications of President Reagan's proposed strategic weapons modernization program. Because of the high interest among AFA members in those matters, AIR FORCE Magazine here reprints the text of his statement to the Committee, and extracts from his responses to Committee members in the discussion that followed.

"As a nation, we can no longer avoid our individual and collective responsibility for the strategic deterrent forces we acquire, or fail to acquire."

Deterrence Is Everybody's Business

Mr. Chairman, Members of the Committee:

I am honored by your invitation to testify before this distinguished Committee concerning the foreign policy and arms-control implications of President Reagan's recent strategic weapons decisions. But beyond any feeling I may have regarding my personal appearance before you today is my professional appreciation and respect for what you are doing; for implicit in the fact of this hearing by your Committee is the recognition that US foreign policy, arms-control policy, and defense policy are absolutely interrelated and indivisible—and that the strategic forces deployed by our nation are central to all three.

As a nation, we can no longer avoid our individual and collective responsibility for the strategic deterrent forces we acquire, or fail to acquire—deterrence is everybody's business. The decisions we make in selecting the military sinews of our strategic deterrent posture will determine, in large measure, the extent of control and selectivity we will have of our own foreign and arms-control policies, as well as our ability to defend ourselves and our allies from intimidation, coercion, or actual attack.

Secretary of Defense Robert A. Lovett wrote to President Truman in 1952: "The primary purpose of the Department of Defense is, of course, to protect and defend this country. This duty may involve fighting a war. If this becomes necessary, the duty of the Department of Defense is to fight a successful war. . . . The better equipped the Department of Defense is to fight, the better it serves its role of a deterrent to war."

In my judgment, the coherent strategic modernization decisions President Reagan announced on October 2, 1981, went right to the heart of Secretary Lovett's timeless dictum. They reflect consummate understanding of the disabling paralysis that has stymied needed modernization, improvement, and increases in major aspects of our strategic force posture. The President's decisions reflect refreshing common sense in the scope and cohesion of the major actions he intends to initiate, as well as in the sequence in which he intends to take them.

If we are to regain essential strategic momentum, and begin to redress the strategic imbalances that have resulted from our relative atrophy in the face of the Soviets' dramatic strategic weapons programs, our nation must rally around these brave decisions and support them enthusiastically. If we fail to take advantage of these remarkably prescient and brave strategic decisions by this President, there is reasonable doubt that we will have another timely opportunity to redress the rapidly shifting balance of power. Should that balance be lost—in fact or in perception—there is no assurance that we can continue to control the course of our foreign policy, and our ability to influence arms-control (hopefully, arms-reduction) policies and initiatives will become a mockery.

In viewing the long-term impact of President Reagan's decisions, I think it would be useful for this Committee (indeed, for all Americans, and our allies) to reflect on the historical perspective of these decisions—where we are in terms of military and foreign policy responsibilities (to ourselves and the free world), how we got there, what is relatively new and different about our defense responsibilities, and how the world views what we do or don't do about our defense responsibilities.

- Most of us in this room grew up in the "Minuteman" tradition of our country as we went about providing for our security. We were protected by geography, blessed with relatively peaceful borders, able to fight our enemies at a time and place of our choosing, and, when threatened, we did so through mobilizing our resources and manpower for the task—demobilizing almost completely when the task was completed.
- So it was through our history, including World Wars I and II; so it was in Korea.
- It was not until after Korea that

we came to a full realization of the extent to which science and technology had dramatically altered forever our traditional pattern of relying on "Minuteman" security. For the first time in our history we found it necessary to build and maintain consequential, capable military forces in "peacetime."

- In the 1950s we entered an era that was completely new and different for Americans. We embarked upon an era of sustained power projection, but power projection uniquely for defensive, *deterrent* purposes—not for the classic historical role of power projection for coercive, aggressive purposes. Our version of deterrence took a new twist—not only to deter attacks on our nation, but to extend that deterrence to allies and friends throughout the world. Our foreign policies stemmed, in large measure, from this global deterrent we had created.

- Through the mobility and extended range of our air, naval, and ground forces, and through the expanded capability of our weapons and delivery systems, we embarked on what was, for us, an entirely new phase of power projection—deterrence through projected retaliatory power; damage limitation and defense through powerful offensive forces; forward defenses through deployed forces, backed up by long-range external strategic forces for interdiction and retardation; with theater forces, conventional and nuclear, for both retardation and direct defense. We built a believable, balanced force—capable of supporting this new doctrinal concept both in fact and in perception.

- We and our Canadian allies built a respectable defensive environment in and around our continent; in NATO Europe and in Korea we did the same in and around those forward areas of vital interest to us.

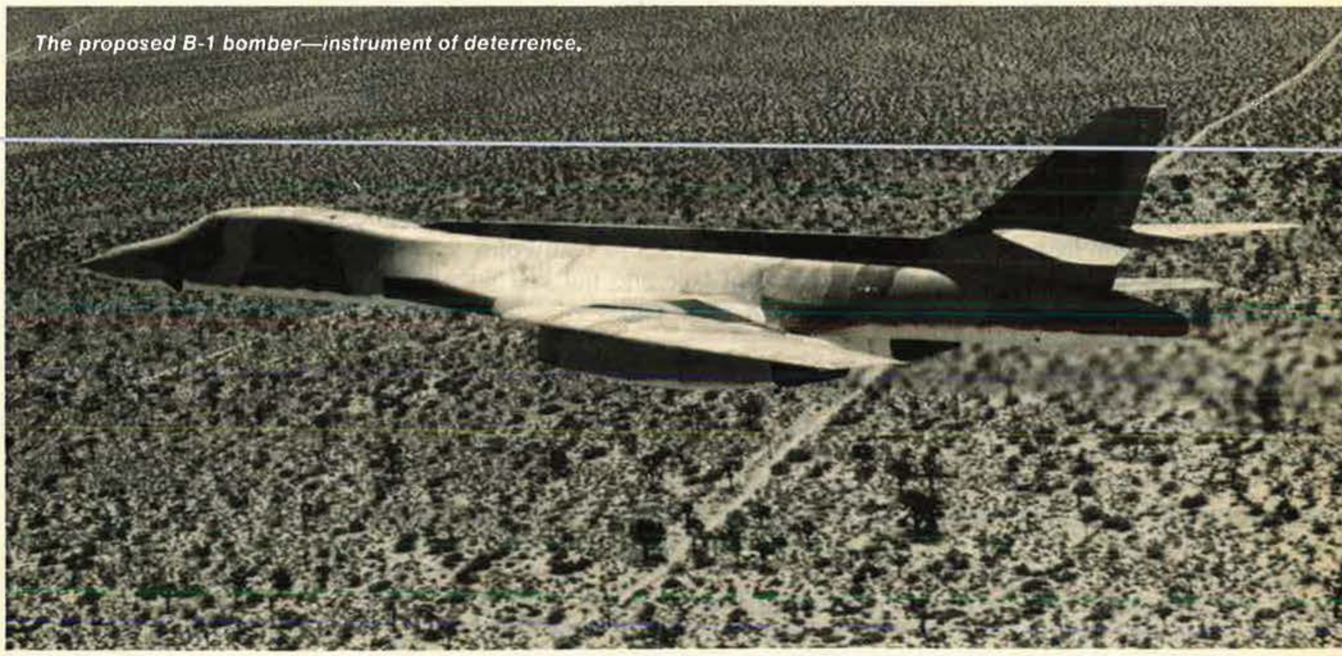
- And, significantly, we maintained an uneven, but remarkable consensus among the prime movers of all aspects of national policy. In foreign, defense, economic, and psychological policies we enjoyed a general blending and cohesion—not "Camelot," by any means, but successful.

- Those of us in military planning roles cheered the recognition that defense policies were now recognized as an integral part of overall national policy. We took pride in our achievements and in being a vital contributor to this essential blending of national policies. We took to heart the admonition of Sir William Butler that: "The nation that will insist on drawing a broad line of demarcation between the fighting man and the thinking man is liable to find its fighting done by fools and its thinking by cowards."

- What happened to that deterrent confidence—that consensus—the stability of national policies that marked those years? In short, we failed to meet the obligation to stay relevant to the threat. We "rested on our oars"—for too long.

- About 1967 or so, while we were preoccupied with Vietnam (a tragic perturbation to our central policy of deterrence) and deflected by myriad pulls and tugs from the essential decision-making and investments needed to keep our strategic offensive and defensive forces relevant, the Soviet Union initiated multiple programs of modernization across the full spectrum of military forces. These Soviet programs exceeded even the most extreme estimates of where they were going and when they would stop.

- For the past decade, we have been progressively falling behind, in fact and in perception—particularly with regard to our strategic forces—until we have now reached this point of serious deficiencies in our ability to control the principal balance of power in our world, much less to handle the spate of diverse incursions, infiltrations, and other hostile actions that abound in this dangerous, untidy world.


The proposed B-1 bomber—instrument of deterrence.

• For too long we have rationalized away, apologized for, and postponed the virile actions essential to maintain an effective deterrent posture with our strategic offensive and defensive forces. We have failed to keep relative the ability of our strategic forces to fight a successful war—ergo, their ability to deter is in question.

The President has stepped up to his responsibilities in a manner that deserves widespread appreciation and support—public, institutional, congressional, and international. The coherence and cohesion of the five-point program are, to me, most important. The President has avoided isolated improvements, for indeed, his comprehensive, across-the-board approach is what is needed to shape a reliable deterrent to major Soviet aggression—or to the Soviets' ability to threaten credibly strategic aggression for purposes of leverage. With the five areas of improvement he proposes, we will have a far more capable and credible strategic arsenal: more robust, flexible, and relevant to any Soviet threat. The stability and confidence that should result from these improvements are directly applicable to more confident foreign policies and to more viable approaches to arms control and reduction.

Hopefully, we will avoid becoming mesmerized into a lack of overall support for the President's strategic program by overly critical focus on any single facet of his decision that may lend itself to endless debate and indecision. In my judgment, the impact of further slippage in this essential strategic modernization will seriously erode our ability to maintain a satisfactory deterrent posture, with the catastrophic impact this will have on our overall national policy—defense, economic, arms-control, and foreign policies. I urge the Committee to support the President and serve the nation in getting on with these improvements.

Sen. Larry Pressler (R-S. D.) asked what would occur if a nuclear war began, and what the scenario might be.

General Dougherty: "Too often I run into people who have a fixed image of how a nuclear war would begin. I do not. And I think it is that flexibility that our nation must have, because truly, however it will begin, it will not be the way we have precanned it and predetermined it. I do not know what the effect would be."

Sen. John Glenn (D-Ohio) reflected on the fact that, at any time, nuclear warheads and components are moving about the United States, so the US already has mobility of our nuclear deterrent. He asked if General Dougherty would comment.

"Certainly," General Dougherty replied. "I agree with you about the mobility, but the mobility that we want isn't just of warheads and boosters and things disconnected. We need the mobility of an operational weapon system in the hands of operational forces to really play any deterrent role and not just an assembly of spare parts."

Sen. Alan Cranston (D-Calif.) asked, "Can you conceive of a circumstance where, under present conditions, in terms of strategic capabilities of both sides, the Soviets would feel they successfully could launch a first strike against us?"

General Dougherty: "I cannot look into their minds and know what provocation is there, either internal provocation, economic or party pressures. I just don't know. But I would not want to bet our nation on the fact that they would reach a level of provocation for whatever reason they might attempt it.

"The total nuclear attack that has been postulated which is required to knock out all of our land-based missiles is very far-fetched. In fact, it is so remote it is difficult for me to conceive of. But then, I have to look and recognize that we are betting our nation, and that technology and resources offer us an opportunity to eliminate that risk, even though it is remote and even though it is miniscule.

"It is a matter of acceptance of risks, and I learned a long time ago that ultimately it is the Congress of the United States and the Administration of the United States that determines what risk we will accept. In my judgment, we are accepting too many right now."

Senator Glenn asked, "Do you favor planning for production of Stealth right now? That is, the Advanced Technology Bomber?"

General Dougherty: "Yes sir, Senator Glenn. I think the President has it exactly right in this. I have been interested in the B-1 for years, as you know, and from the beginning in the advent of Stealth technology. I have no doubt in my mind that an Advanced Technology Bomber can be built and can be put on the ramp.

"But the sequence that the President has adopted I think gives great recognition to the fact that what we really want is a competent, capable military weapon system. We can get that very early on with the B-1, and the B-1B variant that I understand now is being considered will have many of the Stealth technologies built into it. It will be very nuclear-hard. It will have a reduced cross section from the earlier B-1, some say an order of magnitude, but I would say it is probably fifty times less from some perspectives from the earlier B-1 and certainly the B-52.

"But the Advanced Technology Bomber is so new and different that we need to take our time and not make mistakes. It is too valuable a technology to stampede, just to have something on the ramp.

"Very importantly—and I know you know this as well as I do—to develop a military weapon system you have to know how to maintain it, support it, have the training, have the spares. You have to know how to plan for it, how to use its capabilities and how to minimize its vulnerabilities. And it will take us some time to do that.

"Even though an airplane can be built and put on the ramp, we will not have a weapon system for some years. That is why I think the sequencing of these things is exactly right." ■

CAPITOL HILL

By Kathleen G. McAuliffe, AFA DIRECTOR OF LEGISLATIVE RESEARCH

Washington, D. C., Nov. 27

B-1B Successes

The Senate Appropriations Committee voted a surprising twenty-one to seven to fund the B-1B program in FY '82. The lopsided vote was helped through strong final efforts by DoD and USAF officials.

Under Secretary of Defense for Research and Engineering Dr. Richard DeLauer stated flatly that the B-1B was ninety percent as good a penetrator as the Advanced Technology Bomber (ATB) and that, because of its reduced radar cross section, the B-1B could penetrate until 1995–98, depending on Soviet defense countermeasure breakthroughs. Further, the B-1B would force the Soviets to divert some $200 billion from offensive to defensive systems.

However, probably the most compelling argument used in B-1B's favor was a cost comparison with other bomber programs. According to Dr. DeLauer, maintaining an all-B-52 force through the year 2000 would cost $92 billion; an all-B-1B force, $100 billion; an all-ATB force, $112 billion; and a mixed B-1B and ATB force, $114 billion.

ATB Schedule

During debate over ATB vs. B-1B, several members of Congress accused DoD of cutting funds for ATB and deliberately slowing down Stealth technology in order to fund the B-1B program.

Dr. DeLauer countered these charges by stating that ATB is adequately funded in FY '83 and '84 in order to meet all R&D checkpoints and achieve deployment in the early 1990s. Defense Secretary Caspar W. Weinberger reaffirmed this by assuring senators that the ATB technical risk areas had been identified and sufficiently funded. He further said money had been set aside in the out years to fund ATB fully so as to reach the earliest prudent date for full-scale engineering development.

Defense Appropriations

An FY '82 Defense Appropriations Bill is finally within the reach of DoD. With the House approval of its $196.6 billion bill a *fait accompli*, the Senate planned action for its $208.5 billion bill just about two weeks later. The Senate bill, $7.6 billion above the request, departed from tradition and included $4.8 billion to cover the military pay raise authorized earlier this year instead of waiting for a spring supplemental pay bill.

While conferees will meet to iron out differences, congressional pundits predict the House will stall final action until after Christmas, thus keeping the Pentagon operating under a Continuing Resolution Authority (CRA). The CRA, currently extended to December 15, allows DoD to fund programs at the FY '81 level or the budget estimate, whichever is lower, and prohibits new program starts. With the FY '81 level substantially lower than the budget estimate for the current fiscal year, DoD comes out a big loser under the CRA.

MX Concession

Despite rejection of basing the MX in multiple protective shelters (MPS), deceptive basing is not dead.

Allegedly at the insistence of Senate Armed Services Committe Chairman John Tower (R-Tex.), Secretary Weinberger told the Senate that "the Administration intends to explore deceptive basing of offensive missiles and defensive components of the BMD program." He explained that rejecting MX/MPS was *not* a rejection of deceptive basing per se.

Describing this as a "political concession" to the powerful committee chairman, one USAF official said Air Force hopes are raised for final MX deployment in some variation of the original MPS plan.

Window of Vulnerability

The Administration's defense policies continue to be hit by pro-defense members of Congress who argue that early retirement of the B-52Ds and Titan IIs will serve only to widen the window of vulnerability in the mid-'80s. The President proposed earlier than planned phase-out of these programs as a budget-cutting measure.

Sen. Sam Nunn (D-Ga.) said during debate on the defense authorization conference report that without these two systems the weapon megatonnage available during a nuclear war would be reduced by more than thirty percent for the four- to five-year period in which the US is most vulnerable to Soviet strategic nuclear forces. Senator Nunn was backed up by another strong defense supporter, Sen. James Exon (D-Neb.).

Gen. Bennie L. Davis, SAC Commander, told the senators that in terms of absolute numbers strategic capability will decline but phase-out of the systems is not "significant" militarily.

Stall on Big Bird

Most congressional defense experts show little enthusiasm for basing MX on a continuous patrol aircraft or "Big Bird." Although Secretary Weinberger reportedly favors this method, Congress pushed it aside, at least temporarily. The final authorization bill instructs that no funds in FY '82 be spent for R&D of an aircraft launching mode for MX. Several members of Congress contend that inherent survivability and response flexibility problems, as well as high cost, make it less than desirable.

The one-year ban could be renewed in future years, thus squelching any future for MX in an air-launched mode.

Budget Cuts Stopped

Rep. Patricia Schroeder (D-Colo.) again failed to foist on the House an across-the-board cut in defense. Her attempt to slice five percent from the defense appropriations bill followed her previous try to cut $8 billion from the authorization bill by eliminating waste, fraud, and abuse from DoD. Her latest effort followed closely on consideration of the CRA in which Minority Leader Rep. Robert Michel (R-Ill.) urged a five percent cut in every budget account except defense.

Rep. Marge Roukema (R-N. J.) tried another approach by offering a substitute to cut two percent from only the R&D and procurement accounts. It failed by five votes. ■

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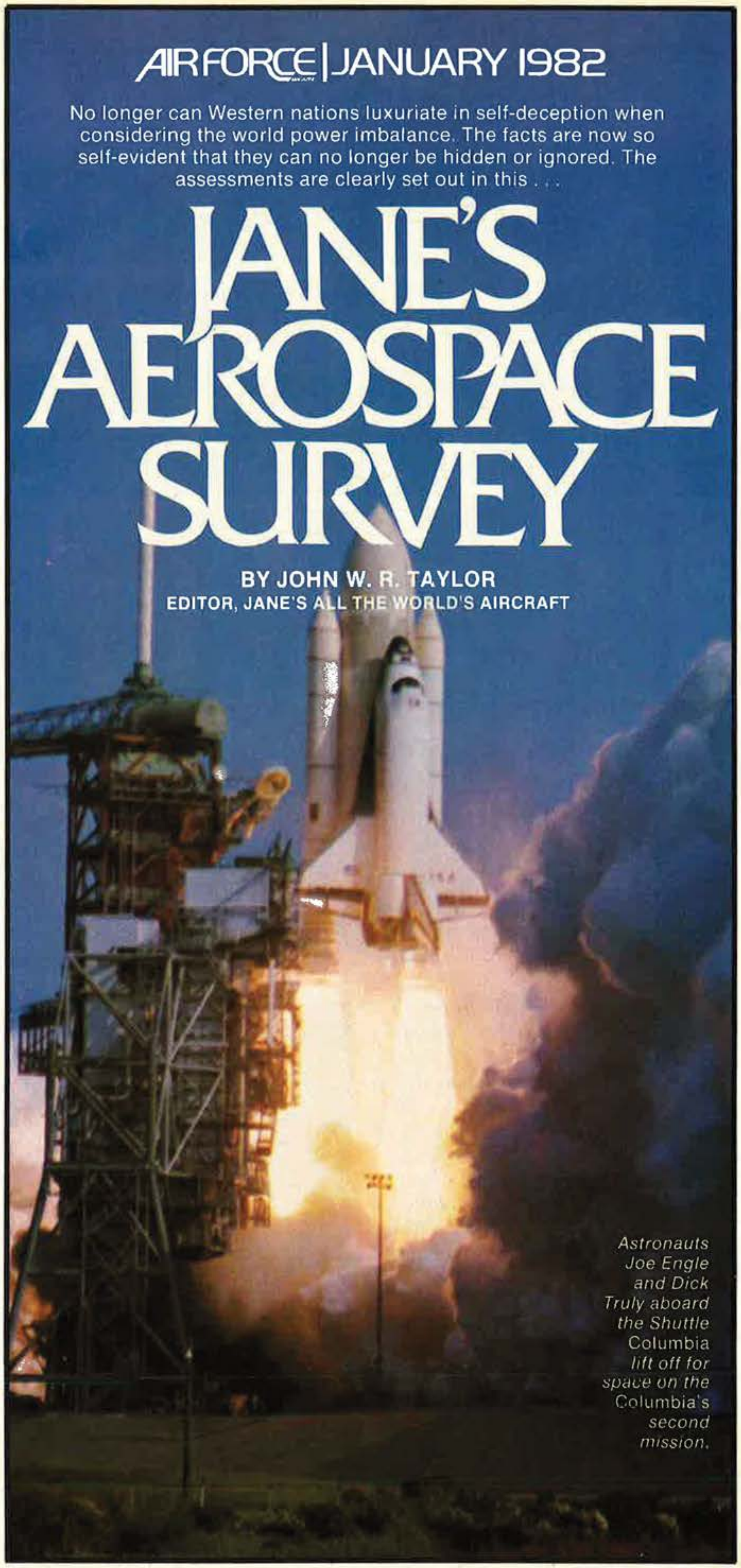
AIR FORCE | JANUARY 1982

No longer can Western nations luxuriate in self-deception when considering the world power imbalance. The facts are now so self-evident that they can no longer be hidden or ignored. The assessments are clearly set out in this . . .

JANE'S AEROSPACE SURVEY

BY JOHN W. R. TAYLOR
EDITOR, JANE'S ALL THE WORLD'S AIRCRAFT



Astronauts Joe Engle and Dick Truly aboard the Shuttle Columbia *lift off for space on the* Columbia's *second mission.*

A DOMINANT feature of the past year has been the continuing buildup of the Soviet war machine. The scale and pace of the buildup are clear to anyone who has taken the trouble to study the document "Soviet Military Power," published recently under the authority of US Secretary of Defense Caspar W. Weinberger. Gone, at last, is all pretense that superior quantities of Soviet weapons are offset by technological backwardness. The latest submarines include the largest, fastest, deepest-diving underwater craft in the world. New-generation SS-18 and SS-19 ICBMs are admitted to be "among the most accurate ICBMs operational anywhere. Together," we are told, "these systems have the capability to destroy a large percentage of the more than 1,000 US ICBM launchers, using only part of their total numbers."

Nobody pretends any longer that the supersonic bombers known to NATO as Backfires have a range too short to launch their nuclear missiles against targets in the US. Such aircraft are in service now, in large numbers. Evidence suggests that highly competent Soviet design teams are developing a new long-range bomber and possibly a strategic cruise-missile carrier, and that their ineffective Tu-126 Moss AWACS aircraft will be superseded by the often-reported rotodome-carrying version of the Il-76 Candid by the mid-eighties.

The modified MiG-25 Foxbat is now known to be "the Soviets' first look-down/shoot-down fighter. Armed with four new AA-X-9 missiles and possibly four shorter-range infrared air-to-air missiles, it will be able to detect, track, and engage targets at very low altitudes."

With nearly 900,000 scientists and engineers engaged full-time in research and development in the USSR—fifty percent more than in the US—the Department of Defense states its belief that:

> During the 1970s, the Soviets have dramatically reduced the US lead in virtually every important basic technology. The United States is losing its lead in key technologies, including electro-optical sensors, guidance and navigation, hydro-acoustics, optics and propulsion. In many areas where the United States

continues to lead the Soviets, their technology has achieved a level of adequacy with respect to present military requirements. . . . [T]he Soviet Union is estimated to have taken the lead in the development of directed energy weapons such as high-power lasers and possibly radio frequency devices. . . . [However,] the United States still leads the Soviets by two-to-seven years in microelectronics, computers and jet engines critical to the development of advanced weapon systems.

The Soviet Su-24 Fencer, counterpart of USAF's F-111 and the Panavia Tornado.

Leadership, by anyone, in military technology is significant only when it is embodied in hardware. There is no need to remind the Kremlin of this. During the single year of 1980, the 135 major Soviet military final assembly plants delivered a huge variety of weapons, including 3,000 tanks, 5,500 other armored fighting vehicles, 150 self-propelled field guns, thirty supersonic bombers, 1,300 fighters and fighter-bombers, 350 transport aircraft, 750 helicopters, 200 new-generation ICBMs, 100 IRBMs, 700 submarine-launched cruise missiles, 175 SLBMs, 1,500 air-to-surface missiles, 50,000 surface-to-air missiles, eleven submarines, and eleven major combat surface ships.

The momentum has not slackened since then. By comparison, the US FY '81 budget procurement (which set an expenditure record for any Western peace or wartime defense budget) allowed USAF a total of only 300 new aircraft, including sixty A-10 Thunderbolt IIs, forty-two F-15 Eagles, and 180 F-16s. The FY '82 budget inherited by the Reagan Administration was even less encouraging, with *total* provision for ninety-six F-16s, thirty F-15s, and four TR-1 reconnaissance aircraft for USAF. Even the overall NATO picture is depressing. The number of fighters and bombers built annually in the Soviet Union is, for example, more than double the entire first-line combat aircraft strength of the Royal Air Force.

The present administrations in both the US and UK were swept into power on platforms that promised, among other things, to strengthen their nation's defenses. But how far have those promises been honored at a time of world recession and other economic problems?

Britain's Impractical Deterrent

Mrs. Thatcher's Conservatives in London seem to have got everything wrong in terms of defense, with the emphasis on false economies, an anachronistic desire to retain the trappings of a military superpower, and an apparent wish to earn the approval of a transatlantic senior partner. The motives could be right, but the consequences are indefensible.

Within days of the launch of HMS *Ark Royal* by the Queen Mother, a decision was taken to put one of the Royal Navy's three new *Invincible*-class antisubmarine aircraft carriers into mothballs, and to plan early retirement in 1983 for the newly modified assault carrier *Hermes*.

Earlier in the year, it had been announced that some RAF Vulcan, Canberra, and Shackleton AEW Mk 2 aircraft were to be withdrawn from service ahead of schedule to reduce fuel and maintenance costs, which are higher for these older types of aircraft. Plans to form a third squadron of Lightning interceptors with mothballed aircraft were dropped, and work on the improved Sky Flash Mk 2 air-to-air missile for the Tornado F Mk 2 was terminated.

In July 1981 came the decree that Britain cannot afford a direct and early replacement for the Jaguar ground attack aircraft, which fills a key role in NATO's front-line force in Europe. Yet, throughout all these parings of an already slender defense effort, the UK government has maintained its stubborn belief in the need for an independent nuclear deterrent, based on a handful of Trident missile submarines. Deaf to the facts that such weapons will simply add to an already excessive US ICBM/SLBM "overkill" force and that there is no conceivable way in which the Royal Navy could ever launch SLBMs until *after* the UK had been devastated, the Trident fleet has remained the cornerstone of an utterly misguided defense policy, its estimated total cost rising from £5,000 million to £8,000 million, with a likely massive supplement if (as seems inevitable) the UK follows America in having improved D-5 missiles instead of the earlier model once specified. Such a sum could be spent in a hundred better ways.

At least President Reagan seemed to begin with all, or most, of the right ideas; but as month succeeded month during 1981 the people on the European side of the Atlantic became increasingly confused and worried.

It is probably true to say that a third world war has been averted for thirty-six highly menacing years only by the "peace through fear" policy of the nuclear deterrent. Unfortunately, so far as the NATO nations of Europe are concerned—and, probably, the non-Soviet Warsaw Pact nations—the nuclear umbrella was shot full of holes by the ill-conceived draft of SALT II.

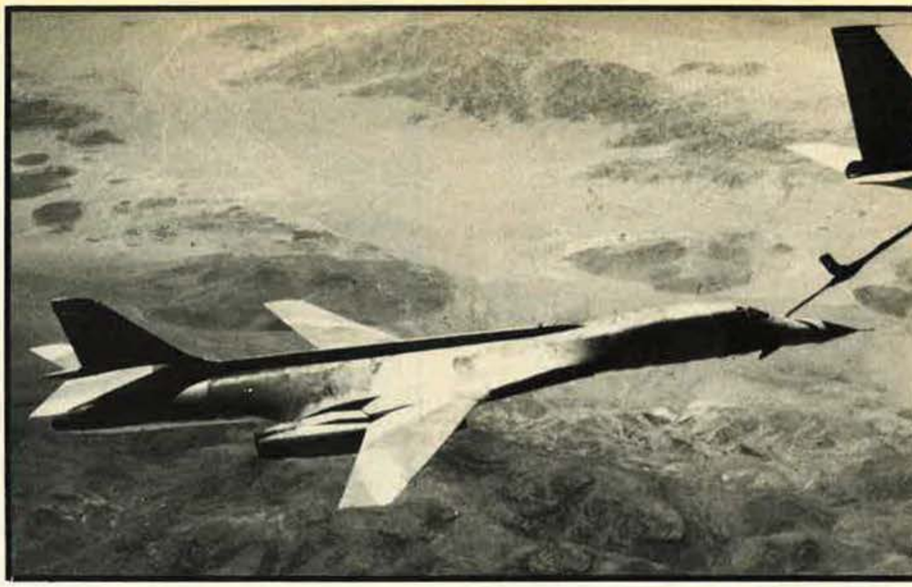
The original SALT I agreement materialized because the US and the USSR were able to speak for the two most formidable military groupings in the world at the initial strategic arms limitation talks. Their mistake was to allow SALT II to authorize an increase in the number of weapons it was supposed to limit, and to leave the junior partners with the feeling that they had been selfishly overlooked. Missiles pointing in their direction were unrestricted by the proposed treaty. Even worse, proposals to base new generations of strategic nuclear weapons within their territory seemed to indicate the superpowers' determination that lesser nuclear conflicts would be conducted far outside the US and Soviet borders.

One result has been a spontaneous wave of protest through Europe—not only in the West but, to a different and significant pattern, on the eastern side of the Berlin Wall. Each successive badly worded or badly reported statement and counterstatement on NATO defense policies by President Reagan and his team appears to have fanned the flames that threaten anarchy, to nobody's benefit, in the East or West.

The Traditional European Battleground

It may be difficult for some folk living in the continental US to understand how great was the impact felt by their European allies when the President *seemed* to imply that America might wage a nuclear war in Europe in hope of sparing the territory of the US. Did not this match precisely the whole concept of the late, unlamented SALT II? Suspicions were strengthened when Secretary of State Haig was seen on tens of millions of TV screens stating, in effect, that one of the last-ditch deterrent tactics envisaged by NATO involved the launch, and explosion over Europe, of a nuclear device.

It was not enough for Defense Secretary Weinberger to deny the existence of any current plan for such a warning shot. Fueled by reports of occasions on which SAC



bombers and missiles had been advanced to alert status, on the basis of completely false warnings, it was easier to accept the comments of Mr. Brezhnev. He stated that the Soviet Union would make no attempt to distinguish a warning shot from the first missile of an all-out attack, but would take immediate retaliatory action. He then added, in an interview reported in the West German *Der Spiegel,* that "if nuclear war breaks out, whether in Europe or in any other place, it would inevitably and unavoidably assume a worldwide character."

Such unambiguous statements of intent show clearly that the nuclear deterrent policy of the past two decades is dead and buried. After Hiroshima, the ability to eliminate with a single warhead any potential target on earth, including a capital city with all its people, seemed the ultimate deterrent. This was logical.

One or two cities might be (and had been!) considered expendable to avert years of major war. Today the US and the USSR have a combined total of 3,976 intercontinental and submarine-launched ballistic missiles. Is there, anywhere among the world leaders of the eighties, a latter-day Hitler or Genghis Khan willing to push a button to launch the first ICBM that would spark off the entire force? Unless the other side was caught completely off guard, which is inconceivable, such a nuclear exchange would erase life from vast areas of his own homeland, as well as that of an enemy.

Because the common people seem more aware of the danger than those who plan the manufacture of neutron bombs and toy with ideas of a limited nuclear war, a quarter of a million men and women gathered peacefully in West Germany in October 1981 to emphasize that they want no additional Pershing strategic rockets in their land, increasing the risk of preemptive attack from the east in any future period of international tension. These, and a similar assembly in London shortly afterward, were not simply the old antinuclear mix of idealists, pacifists, and left-wing socialists. They were much the same cross-section of ordinary citizens as those in Utah who had made so clear their opposition to the shuttling of MX ICBMs around their state, between mostly empty shelters, that the whole absurd proposal of multiple basing has been rejected.

Nobody could have imagined that parallel protests would be allowed in the nations of the Warsaw Pact, on even a relatively small scale, but TV newscasts revealed many thousands of East Germans protesting with equal vigor against nuclear war.

Their professed target was NATO's plan for Pershing IIs and cruise missiles in Western Europe, but the underlying message was the same. With Poland rumbling because its leaders are failing to feed their people adequately, the Kremlin must sense that its own satellite nations are becoming as restless as those of NATO. This offers little

cause for rejoicing in the West. As so-called superpowers, the US and the USSR can speak on behalf of some twenty nations at the START talks. Any weakening of the cohesion among groups making up respectively the NATO and Warsaw Pact alliances might only lessen the chances of eventual, permanent, peaceful coexistence.

There could be no greater incentive for urgent, meaningful, new agreements on genuine strategic arms reduction.

Confirmation that time is running out came in the recent decision of the Socialist opposition to Mrs. Thatcher's UK government to adopt a policy of unilateral disarmament, withdrawal from NATO, and isolation withdrawal from the European Economic Community if it is returned to power in or before 1984. Its support, and that for the international protest movements, will grow if the antiwar factions learn to look wider than their immediate target of nuclear weapons. Revelation during the past year of British/American proposals to attack Germany with anthrax "bombs" in the Second World War—added to references to "Behavior Modification and Biological Warfare" in the "Soviet Military Power" document—reminds us that far more horrible forms of weaponry are under constant study in hidden places. How, then, can the fragile peace of the past three decades be maintained, following loss of credibility of the nuclear deterrent policy?

A B-1 prototype being refueled by a KC-135 tanker. Although requirements for tanker support are growing, and are expected to increase dramatically with the launch of a new bomber program and to fulfill the strategy of long-range rapid deployment, budgetary pressures threaten to terminate the much-needed KC-10 cargo/tanker program. In addition, projected cutbacks in the KC-135 tanker reengining program will only exacerbate the tanker shortage problem.

The Reagan Strategic Program

The best defense plan for the future that has yet been proposed is President Reagan's Strategic Program of September 1981. Attention has been focused mainly on the 100 B-1B bombers, 100 MX missiles, and Stealth bomber that would form the initial and future deterrent heart of the program. No less important are some of the other weapons and systems that would be provided under the $180.3 billion package.

Five additional squadrons of F-15s are suggested, to replace NORAD's vintage F-106 interceptors, plus six to nine more E-3A Sentry AWACS aircraft and over-the-horizon radars to ensure their most effective use. Command and control would receive long-overdue attention under the Reagan plan. Fresh urgency is injected into the Trident D-5 SLBM program; proposals to ensure survival of strategic forces include the early deployment of nuclear-armed Tomahawk land attack cruise missiles on attack submarines, and accelerated development of the concept of air-launching MX ICBMs over water from long-endurance aircraft known as Big Birds.

Whether *all* of these, and other, items in the package are entirely necessary is debatable. At a time when the Soviet Union has such vast nuclear forces, at every level, it may be essential to plan on a scale that would maintain an overkill parity. Eventually, it is to be hoped that START talks between responsible men will recognize that, in the event of any aggression, the threatened elimination of one or two specific targets, which need not be cities, ought to be adequate as a demonstration of intent.

Ten or twenty highly accurate missiles, deployed invulnerably by each of the two superpowers, would be sufficient for this. To render ineffective defensive countermeasures, including evacuation of known target areas, the missiles could be targeted against different places week by week. Supported by reconnaissance satellites and other forms of intelligence, they would also make it possible to monitor and deter nuclear proliferation into the control of less-responsible nations.

On such reasoning, the modest quantities of B-1B bombers and MX missiles proposed by the President make sense. While providing the means to eliminate every major center of population and production in the USSR, they would also move partway toward providing the limited forces that should be adequate to supersede the senselessly massive inventories of the present time.

It is difficult to imagine a time when universal and complete abandonment of nuclear weapons will be practicable, as it would leave the door open to the kind of war that was endured in 1914–18 and in Vietnam. The vital second component of a future deterrent is, therefore, a triservice force capable of absorbing an attack by opposing forces, on any scale short of nuclear, for as long as it would take to stabilize the situation, militarily and politically. This is the area in which NATO is currently least capable of meeting its commitment, which could be ominous for both East and West. Overanxious reaction to a minor fracas might lead all too easily to premature use of nuclear weapons.

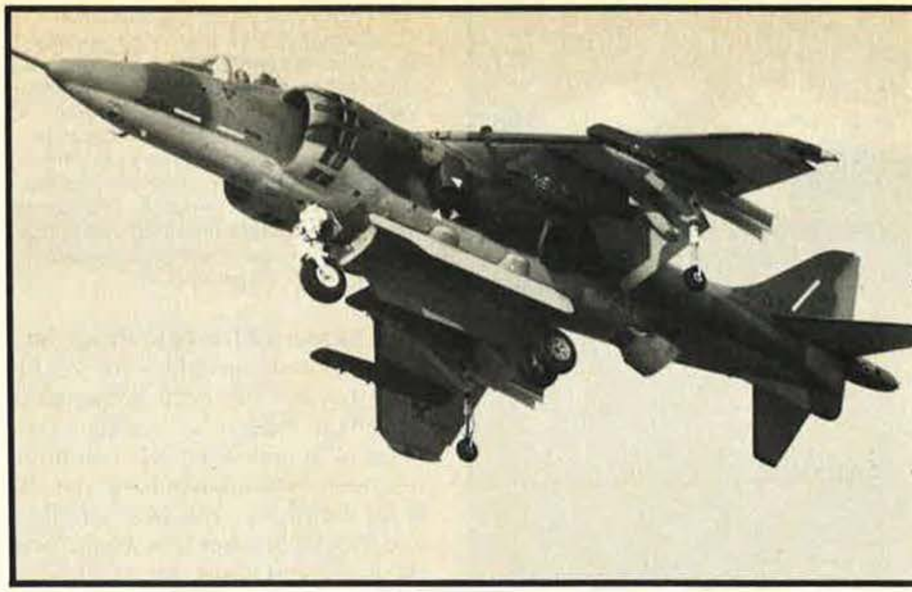
In such situations, the B-1B and its Stealth successor might be especially valuable. On nuclear missions, Rockwell's swing-wing bomber will be able to carry up to twenty-two air-launched cruise missiles, thirty-eight short-range attack missiles, or between twenty and thirty-eight B-28, B-61, or B-83 bombs. It will be equally suitable for nonnuclear roles, armed with thirty-eight Harpoon missiles, 128 Mk 82 bombs, or fifty-three CBU-58 or sixty-eight SUU-65 dispenser bombs. Added to recall capability, this represents a degree of flexibility that no missile can match.

The old SAC B-52s were once in the same league but, even after continuous updating, they would find it difficult to survive in the face of Soviet combat aircraft and SAMs of the eighties. Reversal of President Carter's 1977 cancellation of B-1 production was, therefore, the kind of move for which all believers in peace through a genuine East/West balance of power had prayed. Unfortunately, experience has shown that the pathway from procurement planning to hardware deployment seldom goes smoothly in the US.

When, for example, President Reagan decided to boost his predecessor's FY '81–82 defense budget by $32.6 billion in March 1981, it appeared that this would provide USAF with another sixty A-10s, two E-3As, twelve F-15s, twenty-four F-16s, eight KC-10 Extender flight refueling tankers, and two TR-1s. The Navy seemed likely to do even better, with 159 additional aircraft of ten types, including the first pilot production batch of twelve of the AV-8B Harrier IIs which the Marine Corps regards as its primary requirement.

The euphoria was brief. Just six months after the President's defense boost came an announcement by Defense Secretary Weinberger that the Administration's economic goals could be met only by budget cutbacks, including a reduction of $13 billion in defense expenditure over the next three years. If all the proposals are accepted, production of the KC-10 Extender will be terminated, putting continuation of the entire DC-10 program in jeopardy. Forty of the sixty A-10s added in the spring will be canceled. F-15 Eagle production will be cut back and stretched out. The B-52D fleet and Titan II ICBM force will be retired earlier than intended. The Anglo/American JP233 airfield attack weapon system will be dropped by the US, and cuts made in a whole range of other high technology programs, including those for KC-135 reengining, the Martin Marietta LANTIRN infrared nav/attack system for the F-16 and A-10, the Wasp antiarmor missile, and AMRAAM, intended as the next-generation standardized medium-range air-to-air missile throughout NATO.

When the Reagan Strategic Program was announced shortly afterward, confusion became absolute. If F-15 production is to be cut back and stretched out, from where will NORAD get its five new squadrons? After listening for years to explanations of why the KC-10 is so vital to the success of USAF's rapid deployment and long-range operations, it seemed odd to cancel this tanker at the very moment when a new bomber program is emerging—or is it?



According to the Washington *Post*, the General Accounting Office has implied that "the Air Force dropped items costing billions of dollars when it submitted its B-1 manned bomber program to make it seem much cheaper than it will be." Criticism of both the B-1 and silo-based MX has been fierce. One congressman alleged that the B-1B will be incapable of penetrating the Soviet defense system by 1987. A simple answer to such comments is that the original B-1 had a radar signature about ten times smaller than the B-52; the B-1B signature will be ten times better than that.

Is it presumptuous for an Englishman to emphasize how urgently USAF needs the B-1, that it is a mistake to reduce funding for systems like LANTIRN, and that missiles like Wasp could give the far-outnumbered NATO aircraft in Europe some hope of stopping an assault by an all-weather enemy without the ultimate disaster of going nuclear?

More Sophisticated, or More?

When NATO had an immense technological lead over the Warsaw Pact, the fact that its combat aircraft were outnumbered by two and a half to one caused only modest concern. Some people still draw consolation from the fact that US Navy Tomcats were able to shoot down two Soviet-built variable-geometry fighters over the Gulf of Sidra with apparent ease. However, the aircraft, control techniques, and aircrew confronting NATO in Europe are very different from their Libyan counterparts. It is also thought-provoking that Iraqi MiG-21s, armed with Magic IR-homing missiles bought in France, are said to have shot down an F-14 Tomcat and an F-5 of the Iranian Air Force. The Iranian pilots may have expected the MiGs to carry nothing better than the usual Atoll missiles, but war is full of surprises.

The MiG-21 is, of course, an extremely small, mass-produced aircraft that nobody would rate highly in comparison with a Tomcat; but experience in Red Flag exercises has suggested that superior numbers can be significant. Attempts to restore an East/West numerical balance by building more than 2,700 lightweight, low-cost F-16 and F-18 fighters, as second-line backups for the F-15 and F-14 respectively, have proved an embarrassing economic disaster for the Department of Defense. All that has been learned is that by the time the so-called "minis" have been retrofitted with all the equipment they need for modern combat use, in a period of price inflation, they will be very good fighters but no less expensive than the "big league" fighters that entered production earlier. Put another way, the only sure method of keeping costs to a minimum is to manufacture all the aircraft likely to be required under any program in

Left, the first flight of the AV-8B Harrier II V/STOL combat aircraft. The AV-8B was developed jointly by British Aerospace and McDonnell Douglas for the RAF and USMC. Above, Boeing's new twin-turbofan wide-body Model 767 on maiden flight.

the shortest possible time scale. But, while easing defense expenditure, this will have a disastrous effect on industrial solvency and long-term employment.

Reference was made earlier to the effect that cancellation of a single, numerically small program can have on a major airframe manufacturer. Lacking airline orders for DC-10s for delivery in 1983, at the time this is being written, McDonnell Douglas was relying on Department of Defense contracts for eight more KC-10 Extenders (making a total of twenty) to keep the production line open until an expected surge in new airliner sales in a post-recession decade from 1985. Threatened loss of the military order may force a premature shutdown just as plans were being made to add new fuel-efficient models to the range of DC-10s available to worldwide commercial operators.

In other respects, 1981 was kinder to McDonnell Douglas than to many other manufacturers. Like Canada, Australia chose the F-18 Hornet as its next-generation fighter, adding fifty-seven single-seaters and eighteen two-seaters to an already impressive total of aircraft on order. In the same month, the company's St. Louis plant rolled out the first of four AV-8B full-scale development aircraft, loaded with fourteen 500-pound bombs and two Sidewinder missiles to emphasize its much increased capability compared with the AV-8A.

A memorandum of understanding signed by the US and UK governments seems to promise 340 production Harrier IIs to the US Marine Corps and sixty to the RAF. Unless the budgetwreckers get to work again, this will provide the two allied services with combat aircraft of unique versatility as a step toward ultimate supersonic V/STOL operations.

It would be easy for an Englishman, trained in the design office responsible for the original Harrier, to bemoan the loss of program leadership to a US manufacturer. This is only partly offset by promised earnings of some $3.6 billion from the currently projected program for Britain's aerospace industry over the next ten years. Sadly more significant is a feeling that the whole business might have followed other promising UK aerospace programs into the Whitehall wastepaper basket without the dogged enthusiasm of the US Marine Corps and McDonnell Douglas.

Such beliefs have been strengthened by the events of 1981. After its dismal failure to build on the technological triumph of the Concorde supersonic airliner, the UK seems far from eager to restore the RAF's attack and defensive capabilities with the Tornado. A further stretchout of the production program may now provide the RAF with a total of forty-four aircraft in 1982, instead of the planned sixty-three. Similar budget restrictions may also reduce the number of Tornados delivered to the German armed forces from fifty-nine to forty-two in the same year.

Simultaneous with cutbacks of this kind, UK industry is urged constantly by the government to be more competitive. Little wonder that, in the words of *The Times* newspaper: "The British aircraft industry is in a bitter frame of mind over the loss to the United States of a £300 million contract to supply airborne early warning systems (AWACS) to Saudi Arabia—and has criticised the government for failing to support its bid for the order." An earlier report in the same paper had stated: "Indications from Westminster and Whitehall are that the government has decided as a matter of policy to allow the United States a clear run in attempting to win the order."

This is not the place to compare the merits of the E-3A Sentry and Nimrod Mk 3 AWACS aircraft; both are superb in this vital role. The facts are related here only to emphasize how difficult it is for the UK industry to respond to demands for competitiveness even in a period when its competitors were restrained from selling their product to Saudi Arabia by the deliberations of their own government.

Bearing in mind the difficulties under which defense suppliers work in the UK and US, even under right-wing governments in a capitalist economy, the latest happenings on the other side of the English Chan-

This year's aerospace survey by John W. R. Taylor continues his annual review written for AIR FORCE *Magazine since 1972. It is the most authoritative and comprehensive worldwide analysis available, and a valuable service to our readers. John W. R. Taylor had edited* Jane's All the World's Aircraft *since 1959. Trained as an architect, he became an aircraft designer at Hawker with Sydney Camm during World War II, working on the Hawker Typhoon, among other projects. He is a Fellow of the Royal Aeronautical Society, the Royal Historical Society, and the Society of Licensed Aircraft Engineers and Technologists. His prolific output on aviation matters includes more than 212 books, countless articles, and commentaries for radio and television. He provides the bimonthly "Jane's Supplement" in* AIR FORCE *Magazine, and compiles or edits the galleries of aerospace weapons for the Soviet Almanac and Air Force Almanac issues.*

nel could well cause a shudder of apprehension. Following the election of President Mitterrand, the new French Socialist administration took immediate steps to nationalize some of the major privately owned manufacturers of military equipment, including Avions Marcel Dassault/Breguet Aviation and the military sectors of Matra and Thomson-Brandt. Those familiar with the years of chaos which followed nationalization of the French aircraft industry in the mid-1930s will be grateful for the assurance that there is no intention of changing the identity, autonomy, executive appointments, or programs of these companies.

Together with Aérospatiale, Dassault/Breguet played a major role in increasing the turnover of the French aerospace industry from 20,500 million francs in 1979 to more than 35,000 million in 1980, of which nearly sixty percent came from exports. These exceeded imports by 13,700 million francs, placing aerospace in second position among French exporting industries. In the western world, the French aerospace industry now comes second to the United States in this respect—a remarkable success that owes much to the Airbus and CFM56 turbofan international programs.

Sale of five A310 Airbus transports to Middle East Airlines in November 1981, with options on fourteen more, brought the total of orders and options for the A300/A310 series to more than 500. This may not compare yet with the ever growing order book of Boeing, but it puts the European program very firmly in the No. 2 spot behind the US giant. The scale of leadership established by Boeing in the jet age is so great that statistics are almost beyond comprehension. The 4,000th Boeing jet transport was delivered in July 1981, with well over 500 more (629 on November 1) on order. Those in service had logged a total of 45,301,220,000 miles by November 1, carrying a total of some 3,665,650,000 passengers—equivalent to four out of every five people on earth. There could be no more dramatic indicator of the extent to which air travel has expanded, or of the contribution made by this one manufacturer.

Nor will the future be less challenging. More than 2,100 of the 5,800 western-built jet airliners in service at the beginning of 1981 were at least thirteen years old, and will soon need replacements. Already, Boeing has flown the prototype of its medium-range 211-passenger, wide-body, twin-turbofan Model 767, with the first short/medium-range 178/224-passenger Model 757 poised to follow early this year. Orders for the two new types had reached 309 by November 1.

Identifying an unfilled gap in the market, at around 150 seats, Airbus got in first with the 154/172-passenger A320, on which work was expected to begin at the end of 1981, with a launch order for twenty-five (plus twenty-five on option) for Air France. Below that is the booming commuter level, somewhat overcrowded with hardware on display, but with Shorts's new thirty-six passenger twin-turboprop Model 360 earning the enviable comment from the Swiss magazine *Interavia* that it "is probably about as close as it is possible to get to the elusive 'DC-3 replacement' about which airliner manufacturers have talked for so long."

Many operators recall with nostalgia the simplicity and economy of the original DC-3 era. By comparison, in its mid-1981 analysis of airline results, IATA had no hesitation in referring to the previous year as financially the worst in airline history. During 1980, its members had taken delivery of 300 new aircraft, including 120 wide-body jets. This was the highest annual rate of fleet increase since 1968, in a year when passenger seat occupancy on international scheduled services slipped 2.4 points to 60.9 percent.

Predictions for 1981 suggested a combined loss of some $2.5 billion for IATA members (since reduced to $1.6 billion by increased fares and freight rates). However, it was not all gloom. In the Far East and Southwest Pacific area, traffic grew by 21.8 percent and Latin American operations showed above-average rates of expansion. Safety statistics were also pleasing, with the lowest number of fatal accidents since 1976, equivalent to only 0.24 per 100,000,000 miles flown.

Hit by every kind of problem, from effects of the recession to wrongly timed expansion, the strike by US air traffic controllers, high fuel costs, and cut-throat low-fare competition, Pan American had to ask its worldwide staff to accept an immediate ten percent pay cut and a wage freeze throughout 1982. It had already sold its Intercontinental Hotels group to raise capital, and had introduced fare cuts which added to the troubles of its domestic and long-haul competitors. British Airways sold its London terminal, made savage cuts in its route network, announced plans to reduce its 52,000 employees by 9,000 before June 1982, and offered for sale its entire all-cargo fleet of three 707-320Cs and a 747F, as well as a TriStar 500, two 707-320C passenger airliners, and two undelivered 747-200Bs. Airline after airline reported staggering financial losses—British Airways £145 million for the year ending March 31, Pan Am $217 million in the first six months of 1981, Qantas between A$25 and A$30 million, and Air New Zealand £14 million in 1980–81.

The picture has been much the same, on a suitably smaller scale, for most sections of general aviation. Bellanca has gone; Beech, Cessna, and Piper have all cut back their product range. Yet there are still a few new-generation, advanced technology aircraft like the Lear Fan 2100, last design by the late Bill Lear, with up to ten seats in a sleek graphite epoxy airframe and powered by two 850 shp PT6B-35F turboshafts driving a behind-the-tail propeller. To keep down manufacturing costs, and give work to highly skilled unemployed workers, production is to be centered eventually in Northern Ireland as one of the cornerstones on which it is hoped to rebuild Britain's once-thriving light aircraft industry.

How much things have changed since the halcyon days of wood-and-fabric de Havilland and Miles lightplanes is underlined by the materials, manufacturing processes, and powerplant of the Lear Fan, and by the flight deck of the Dassault/Breguet Falcon 100 which appeared with it at the 1981 National Business Aircraft Association exhibition at Anaheim, Calif., in September. This six-passenger Mach 0.87 aircraft is claimed to be

Bell's XV-15 tilt-rotor prototype aircraft, proposed as the basis to meet future transport, close support, medevac, AWACS, ECM, gunship, and other roles. The XV-15 could be the progenitor of an entirely new breed of aircraft.

the fastest business jet on the market. It will also be the first civil jet of any kind, including airliners, to be certificated with Collins EFIS-85 electronic flight instrumentation, using a panel display of five cathode ray tubes.

Aircraft like the Falcon 100, retailing at $4.2 million, still seem to find a ready market. So do helicopters, which contribute 740 to the 4,774 aircraft fleet of NBAA members. Those readers who are familiar with annual editions of *Jane's All the World's Aircraft,* or our supplements for AIR FORCE Magazine, probably will have noted the increasing number of pages demanded by new products of the worldwide helicopter industry.

The past year has brought a first display of the Soviet Mil Mi-26 Halo, the world's largest production helicopter, at the Paris Air Show. Together with the smaller but oh-so-deadly Mi-24 Hind from the same design bureau, it reminds us again of the advances made by the Soviet aerospace industry. About one-third of the total of 30,000 rotating-wing aircraft deployed with the air forces of 120 nations, worldwide, are of Mil and Kamov design. The other 20,000 originated mainly in the US, France, the UK, Italy, and Germany. Aérospatiale, Bell, Hughes, and Sikorsky, in particular, are setting a pace in high-technology research that could bring huge advances in efficiency, economy, and flexibility during the last two decades of our century.

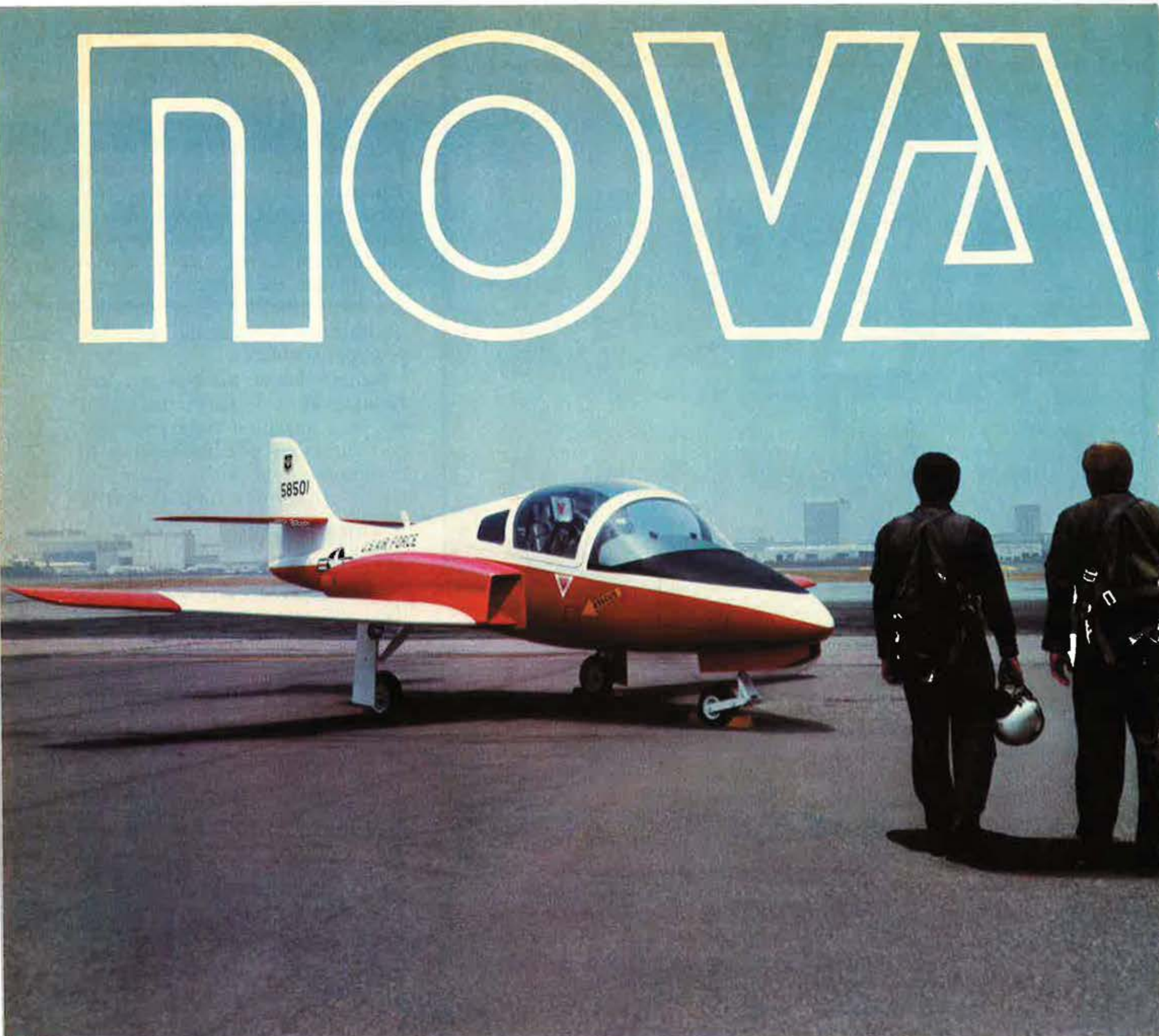
Star of the show at the 1981 Paris Salon was Bell's tilt-rotor XV-15. Like the earlier Bell X-1, which was first to exceed Mach 1 thirty-five years ago, it could well earn a place in history as an aircraft which pointed the way to an entirely new breed of aircraft of unprecedented capability. With conventional helicopters now appearing under a Christmas tree array of night vision sensors, mast-mounted sights, air-to-surface and air-to-air missile pods, heavy-caliber Gatling-type guns, whirling target acquisition radars, laser designators and target trackers, and ECM packs, the future of the army tank on the battlefield and the undefended helicopter above it will become increasingly uncertain.

It has proved far more difficult than most observers realize to bring helicopters to such an advanced standard as combat aircraft. Hughes's AH-64 Apache provides an extreme example of the difficulties simply because it is itself extremely complex and dependent on the parallel development of a variety of new equipment. For this reason, it seems still to be at least two years from initial operational capability, although its development began in 1973. Because we seldom see photographs of Soviet aircraft until they are deployed in large numbers, we tend to assume that their designers and builders achieve miracles in compressing the time taken from concept to squadron use. In fact, the supposed miracles are myths, and we *never* see some of the prototypes that fall below the required standards.

Superb though the UH-60 Black Hawk is in its primary missions, it will be a tragedy if budget or other considerations give precedence to arming this type with weapons on an external stores support system (ESSS) rather than the Apache that was designed specifically for the advanced attack role. There are no such things as low-cost highly effective make-do weapons for an air service that is expected to deter or fight in our time. Those who suggest fitting turboprops in fighters of World War II vintage, or carrying lightweight guns, rockets, and other weapons on powered hang gliders should be offered commissions as pilots in the first squadron to be dispatched to the Central Front in Germany.

The place for World War II fighters is in a museum or air show for buffs. The powered hang gliders, microlights, ultralights, or whatever other name they are given, are playthings for flying enthusiasts who cannot afford anything better. The fact that there are now huge numbers of microlights in use worldwide, of so many varieties that they fill twenty-nine pages of the 1981–82 *Jane's*, shows how well they satisfy their owners—but let us keep them simple, civil, and fun.

Our survey closes with the briefest of references to a craft which is far from simple, only half civil in its purpose, and one-hundred percent serious, though there can be few men and women of spirit who would not wish to be part of the team that made its first flight the aerospace spectacular of 1981. Part aeroplane, part spacecraft, all triumph, the Space Shuttle is "out of this world," and yet can help to make life better for all the world's peoples—provided their leaders enable them to live, rather than die, together. ■



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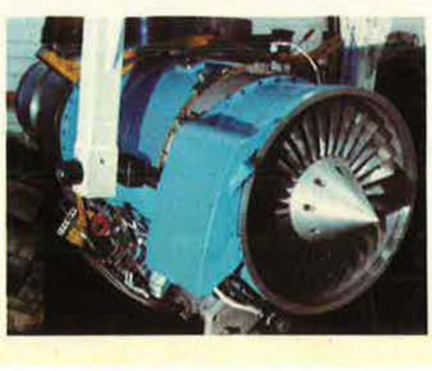

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Tempered by fighting and lessons learned in four wars since the end of WW II, the Egyptian Air Force of today stands ready to face the future with confidence and resolve.

Egyptian Air Force: Ready When Needed

BY F. CLIFTON BERRY, JR., EDITOR IN CHIEF

Editor's note: In the months ahead, AIR FORCE Magazine will devote regular coverage to foreign air forces. We begin the series with the Egyptian Air Force.

The account that follows is based on research and conversations in Washington, followed by a ten-day visit to Egyptian headquarters and bases at the end of October and early November 1981. The cooperation of Egyptian officials was uniformly outstanding and understanding, and is gratefully acknowledged.

* * *

On November 2, 1981, the Egyptian Air Force (EAF) marked its fiftieth anniversary. Flying training actually began in May 1932 at Almaza, a Cairo suburb, using two British Tiger Moth aircraft. Its present strength of 27,000 operates more than 1,200 aircraft, including nearly 400 combat aircraft from more than twenty bases.

The EAF operational units are organized into regiments, a reflection of the period when it had closer ties with the Soviet Union in the 1956–72 era. Generally, each regiment operates a single type of aircraft, such as the MiG-21, F-4E, or Mirage III. Interceptor aircraft such as the MiG-21 are under operational control of the Air Defense Command, but remain the responsibility of the EAF. Pilot training is conducted at the Air Force Academy at Bilbeis *(see below)*. Maintenance and repair training, as well as major overhaul of all aircraft, are carried out at Helwan, the industrial complex south of Cairo.

To appreciate the current EAF situation, some background is in order. During its early years, the EAF was influenced by the Royal Air Force model. That changed as political tensions between the countries increased during the WW II and postwar period, and the EAF broadened its acquisition of aircraft and technical support to a range of other European countries. After the July 1952 revolution, when King Farouk was succeeded first by Mohammed Naguib and then, in 1954, by Gamal Abdel Nasser, this process widened. It narrowed again when Nasser accepted Soviet influence and advisors, whose numbers expanded sharply following the 1956 Suez crisis, eventually reaching a total of 17,000.

After Nasser's death in 1970, his successor, Anwar Sadat, was determined to regain the pride and confidence lost in the defeat of the 1967 Six-Day War. He summarily ejected the Russians in 1972 as part of the process of preparing the Egyptian armed forces for their successes in the 1973 October War. After that, the modernization of the EAF accelerated, encouraged by resumption of contacts with a wide range of foreign air forces and manufacturers.

Ground crew refueling MiG-21 at an operating base. Most of the Egyptian Air Force's MiG-21 aircraft are assigned to interceptor roles. Major overhaul of MiG-21s is performed at Helwan, south of Cairo (photo by Denis Hughes).

At the same time, Egypt began expanding the development of its indigenous military industry, including aerospace. This was assisted financially in the immediate post-1973 period by funds from Saudi Arabia and Kuwait injected into the Arab Organization for Industrialization. Their funding was withdrawn after the Camp David accords, but the infrastructure begun under AOI auspices is in place and expanding slowly all the same.

Unending Alert or Combat

Throughout the post-WW II period, the Egyptian Air Force was in a state of alert or in actual combat almost continuously. Most of the senior officers have fought in four wars: the 1956 Suez case, the 1967 Six-Day War, the War of Attrition (1968 onward), and the 1973 October War. They were defeated in the first two cases, used the War of Attrition to train and prepare for the next time, and scored surprising successes in the 1973 October War. "Surprising" to the outside world, perhaps; especially to the Soviet Union and Israel.

But part of the plan developed by President Sadat and the armed forces' leadership during the War of Attrition required a sudden, sharp victory against Israel, using the EAF to knock out the elements that beat it in 1967. Egyptian officers point out that the military leaders were convinced of the need for Egypt to live in peace. Otherwise, it could never develop into a prosperous and stable country. But, they say, to begin the quest for peace, the Egyptian armed forces had to recover the pride and confidence lost in the disastrous Six-Day War of 1967. In that case, the EAF lost 338 aircraft, most of them on the ground. The aircraft that did go aloft were outfought, both in technology and in tactics.

Looking Ahead

EAF leaders, like those of the other three armed services, are determined to build on the confidence regained in 1973 and on the modernization process now accelerating. While willing to deal with a fairly wide range of suppliers of hardware and know-how, they are also determined to ensure that they never again become the captive of a single nation or military system. Thus, although they operate aircraft from six foreign countries besides their own, the maintenance and repair systems are modified into a uniquely Egyptian mode. So, too, with training. They believe that their training methods were vindicated in 1973, once they threw off the shackles of the rigid and unsuitable Soviet system. Now, they accept training advice from others, but also adapt it to Egyptian needs.

In the case of military manufacturing, the Egyptians intend to expand their own research, development, and production capabilities. Also, they intend to seek export customers for their production. And, where they purchase major items such as aircraft from abroad, they intend to require an appropriate level of coproduction or coassembly in Egypt as a condition of the deal.

Minister of Defense Remarks

The Egyptian Minister of Defense, Gen. Muhammad Abd al-Halim Abu Ghazala, summarized the position of the Egyptian armed forces in discussion with a group of journalists (including AIR FORCE Magazine) in Cairo. The occasion was the opening of the Cairo Military Exposition, with participation by 128 companies, mainly US and European.

General Abu Ghazala said that modernization of the Egyptian armed forces is a turning point for them. To them, the word "military" does not mean war. The goal of Egypt in its military modernization is not to promote war, but to preserve peace in all directions.

He said that a basic requirement in preserving peace is that Egyptian armed forces must be able to face the threats "which come from all directions." Peace and security must be pursued side by side, he said. Egyptian leaders believe that an equilibrium of power is essential. Regarding the Grumman E-2C Hawkeye aircraft, he said he believes that it can do the same job as the E-3A AWACS at a lower cost, and "that's why we asked for it."

On Egyptian plans to expand their arms exports, General Abu Ghazala said that his country hoped to export them for the same reasons as the US, the UK, the French, and others. He noted that they already produce their own ammunition as well as small arms, artillery, certain aircraft (mainly trainers), rockets, and other military items. He said they are discussing with the UK the potential for improving Soviet tanks in their inventory, as well as development of new armored vehicles.

When asked whether Egypt is increasing its arms purchases from abroad, General Abu Ghazala said, "Yes, it is," and he cited discussions with the US, British, and French. He further said, "We have our ten-year plan, which is already well-developed, and we are not changing that. We are moving delivery schedules ahead to receive major items sooner." (Note: That includes the F-16 aircraft.)

The Air Force View

Gen. Mohammad Lotfi Shabana is Commander in Chief of the Egyptian Air Force. In a long discussion in his office at Air Force headquarters, he provided insights into his force, past and future.

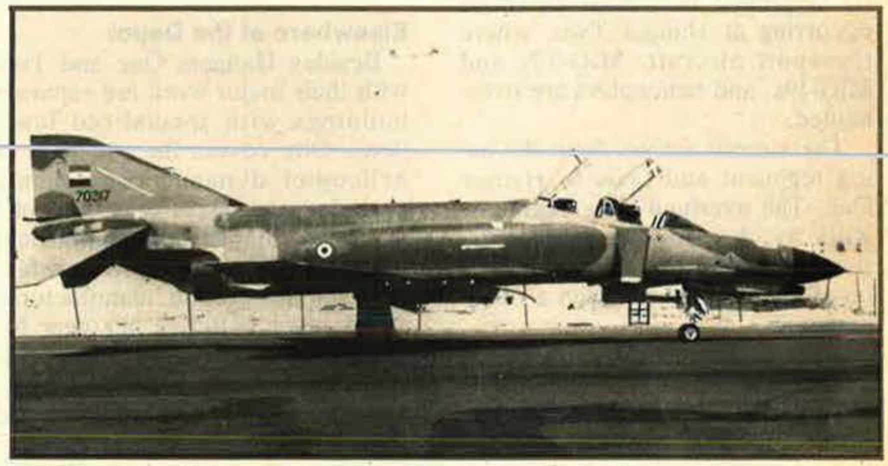
General Shabana and other leaders of the EAF are determined that the combat lessons of the past will not be lost, and that the younger generations of their airmen profit from those lessons. To that end, formal programs of study and wargaming are undertaken. This study goes beyond military history; it also includes speculating on how past battles might be fought with current and future systems and tactics.

During the period when the Russians were in Egypt, they were more concerned with safety than flying. The EAF pilots had very little actual opportunity for operational training. In fact, during those 1955–68 years, it was a crime for an Egyptian pilot to fly low-level. Also during that period, there was no air-to-air dogfight training. During the 1967 War, the Egyptian Air Force learned the hard way that there are other, more combat-effective ways to fly.

Thus, during the War of Attrition (beginning 1968), the EAF began to modify its practices based on the 1967 lessons. It was a slow process; they lost pilots and aircraft but gained valuable experience. They also gained combat experience flying with the Pakistanis and Libyans.

Egyptian engineers designed and installed improvements to the Soviet aircraft they were provided. For example, they modified the MiG-21 to improve its range and payload. For payload, they increased the weapon pylons from three to five. That enabled their aircraft to carry two air-to-air missiles plus three drop tanks, or combinations thereof. On the MiG-17, they improved the payload from one belly tank and two rockets to eight of their own 80-mm rockets, two bombs, and one belly tank.

These "lessons learned" and improvements were put into effect in the 1973 October War. The late President Sadat tells in his autobiography, *In Search of Identity,* how it was done. At 2:00 p.m. on October 6, 1973, 222 Egyptian Air Force aircraft struck simultaneously at essential Israeli targets in the Sinai. In twenty minutes they destroyed ninety percent of the targets. As President Sadat wrote, "It was equally surprising to Israel and the world—both East and West." Earlier Soviet estimates projected Egyptian aircraft losses of more than forty percent in a future conflict, with strike results no better than thirty percent. In fact, the EAF lost five of its 222 attacking planes. The EAF Commander was Gen. Husni Mubarak, who planned and



Above, Defense Minister Lt. Gen. Abu Ghazala outlines Egypt's current defense policies at the Cairo Military Exposition. Above right, the EAF operates thirty-five F-4Es, with thirty of them mission-ready on most days (photo by Denis Hughes). Right, Gen. Lotfi Shabana commands the Egyptian Air Force.

executed the air strikes. He is now President of Egypt.

President Sadat said of these air strikes: "The Egyptian Air Force recovered all it had lost in the 1956 War and the 1967 defeat and paved the way for our armed forces subsequently to achieve that victory which restored the self-confidence of our armed forces, our people, and our Arab nation."

High Readiness Expected

The normal readiness rate goal of an EAF unit is ninety percent daily. For the US F-4E, they usually have thirty of the thirty-five in mission-ready status, or eighty-six percent.

The absolute requirement for low-level penetration was a lesson from the earlier conflicts that was learned before the 1973 War and paid off then. The EAF standard of training is to fly at a height of ten meters above the surface. This requires a high level of skill and confidence, as well as navigational ability and familiarity with potential combat areas. To ensure that units remain familiar with possible combat areas, the regiments rotate regularly among forward air bases for one- to two-week periods.

Differences in maintenance philosophy between the Eastern bloc and Egyptians is significant. Also, the EAF modifications to their Russian- and Chinese-built aircraft have increased the time between overhaul and reduced costs. The Russians normally perform a complete overhaul on a MiG-21 airframe at 600 hours, and its engine at 200. The Egyptians use the same time marks, but repair or replace only as necessary, based on their experience with the parts involved. On some parts, the EAF has extended the service life by a factor of two or three or more over the Russian specifications.

The EAF also differs from USAF in philosophy on maintenance training and skills. They expect their people to have a broad base instead of specialized. While they specialize upon assignment to a regiment and type of aircraft, every maintenance person has received training in the requirements of several specialties beforehand. Each one has a solid basic grounding in radio communications, armament, electronics and electrical systems, engines, and airframes. Although somewhat specialized after assignment to a unit, the result is a mechanic who is able to work across several areas as work load or combat situation demand.

The Helwan Depot

The different Egyptian approach to maintenance can best be seen by visiting the complex at Helwan, south of Cairo, on the east bank of the Nile. There is the EAF's main depot for aircraft overhaul and its maintenance training center.

The depot is a complex of hangars, workshops, and laboratories in an area two kilometers long by one and one-half kilometers wide. It is adjacent to the main runway of Helwan Air Base. The depot is commanded by Gen. Mahmoud Kabil, who has a force of 420 Air Force officers, 2,600 airmen, and 920 civilians.

As mentioned earlier, the Egyptian Air Force melds the best from all the foreign aircraft support systems into a logistic support mode that is uniquely Egyptian. They have found over the years that this works better than trying to cope with the headaches of multiple foreign systems.

Maintenance and Repair

The engineering department of the EAF has four main functions: logistics, plans, main workshops, and maintenance and repair. In each EAF regiment there are maintenance and repair shops handling first- and second-echelon work. For third- and fourth-echelon level work and complete overhaul, aircraft are taken to the main workshops. That is the depot at Helwan.

Hangar One at Helwan is the site of MiG-21 and Su-7 overhaul. At the southwest corner of the complex, its sequence is similar to those occurring at Hangar Two, where transport aircraft, MiG-17s and MiG-19s, and helicopters are overhauled.

The aircraft arrives from the using regiment and taxis to Hangar One. The overhaul crew begins its work by checking the documentation and performing a series of tests on all its systems to reach a rough diagnosis.

Next is disassembly, just inside the hangar door. The aircraft is taken apart into major subassemblies for the next step, which is fault detection. Throughout these steps, the work required is being recorded and priorities established. At their completion, the entire worklist is prepared and repairs begun.

The first stage of repairs begins immediately. Crews on the hangar line start performing "small repairs," that is, work that can be done readily without the need for special parts or tools. These repairs are undertaken while the parts and tools for major repairs are being arranged. Meanwhile, the engine has gone off to a separate hangar where all engines are zero-timed in overhaul. Avionics and accessories such as landing gear also go to separate repair shops to be overhauled. Major airframe repairs occur in Hangar One.

As components are repaired and major work completed, the parts of the aircraft begin coming together again in Hangar One. They are first put into subassemblies, then joined into larger assemblies. The wings, for instance, have been separated from the fuselage and overhauled on a jig of their own, along with the landing gear. They are mated back with the fuselage at this point.

Next step is final assembly, where the entire airframe and its internal components are joined. The engine is reinserted and connected, and ground tests ensure that its controls and instruments work. Finally, the aircraft is turned over to the flight acceptance group. They perform the test flights to validate the work. After that, the aircraft is repainted with the appropriate camouflage paint job and released to its parent unit. The overhaul process for a MiG-21 takes 129 days under current work load. Sixteen MiG-21s are overhauled annually.

Elsewhere at the Depot

Besides Hangars One and Two with their major work are separate buildings with specialized functions. One covers the overhaul of helicopter dynamic components such as gear boxes and transmissions. A complete calibration laboratory is on the depot. A new factory on the ground manufactures 1,000 silver batteries per year for MiG-21s. It came to Egypt via the People's Republic of China, adapted and improved over the Russian original. Other workshops include surface coating for ferrous and nonferrous metals, paint shops, accessories, engine test cells, main stores, and the normal administrative and support buildings.

The limiting factor on overhaul output is skilled manpower. The depot must compete with the heavy industries in Helwan and elsewhere in Egypt for the workers who can earn larger salaries outside the service. But the Egyptian Air Force, like the other services, has set up a system of cash bonuses for productivity improvements. Over the past year, productivity at the Helwan depot has improved fifty percent in key areas, say local officers. One source says that a really energetic and dedicated person can earn cash bonuses as high as 100 percent of his base salary, a true incentive.

Maintenance Training

Training of repair personnel is a major task, and is conducted at Helwan in a complex next to the depot. It was established in 1958, and is the main source for EAF maintenance personnel. Col. Farouk Ahd is the commander.

New students arriving at the center have completed nine years of education. They spend three years in the course, finishing at the high school graduate level.

The thirty-six-month course is divided into six periods. Each period concentrates on a major discipline of maintenance and repair. Concurrently, the student receives a secondary school education. The major disciplines besides general education are radio, armament, electrical systems, engines, and airframes. When the student graduates he is a sergeant in the EAF and has a five-year service obligation.

In the early stages, right after basic military instruction, the student gets into technical training, including the use of machinery and reading drawings. At this stage, under the supervision of instructors, the student makes many of his own tools.

Training devices at the center are all designed and built by the instructors. Their philosophy in all classrooms and training aids is to engage as many of the senses as possible. Also, the location of items in actual aircraft is always shown, as is the role it plays as part of a functioning system.

For example, a simulator representing an Su-7 cockpit stands in an armament classroom. It is actual size, and the switches, lights, control stick, and other indicators are from actual salvaged aircraft. When a student arms a system, the proper lights make the right indications on the cockpit panel. The guns fire with lights, and an actual inert bomb drops into a cradle when triggered on the stick. Instructors can introduce faults into the system, showing the student the indications (or lack thereof) on the panel. Further along in the classroom is the complete circuitry for the armament system, also powered so that faults can be traced and corrected.

Similar training devices are in the classrooms of other major systems. The largest training device at the center is a complete MiG-21, intact except for its skin. It is mounted on a stand so the landing gear can be cycled. Near it, in the engine training section, is a complete Tumansky engine that operates via oil instead of air, so the students can observe its functions. Next to it, another engine has an actual combustion chamber by which students can practice and observe the engine-start procedure and watch the fuel ignite. Over in the aerodynamics classroom, there sits a working small wind tunnel with test airfoil and readout devices. Students can see and learn the effects of airspeed and angle of attack in action.

The end result of this training is about 500 skilled maintenance men produced each year, somewhat "jacks of all trades" and ready to join a regiment. There they will specialize on systems of one aircraft, but will be able to pitch in to work in other specialties if needed.

Top, inside the Helwan Depot's Hangar One an EAF MiG-21 undergoes the complete overhaul process, which takes 129 work days per aircraft. Above, an EAF L-29 (foreground) and MiG-21 (background) on the ramp outside Hangar One, undergoing final checkout before acceptance after overhaul. EAF officers consider the overhauled aircraft better than brand-new ones from the factories of origin.

Academy Produces Pilots

The Egyptian Air Force Academy is located at Bilbeis, about midway between Cairo and Ismailia. Commanded by Gen. Ali Zeko, the academy produces pilots, navigators, and administrative officers for the EAF. The course is now four years, with flying and academic curricula running concurrently.

Actual training of EAF pilots began in 1932 at Almaza, in a suburb of Cairo. By 1948, congestion around Almaza was such that a new location for flying training had to be found.

In 1950, EAF's academy opened at Bilbeis. After 1967, it was dispersed to Upper Egypt and Mersa Matruh, because Bilbeis became a front-line base during the War of Attrition. After the 1973 October War, the academy returned to Bilbeis.

Course length has varied, depending on the situation. When General Zeko entered in 1950, the course was three years. Because of the need to produce aircrews after the 1967 War, the course was shortened to eighteen months during 1967–73, and two classes per year were graduated. Then it was lengthened in stages so that after 1979 the present four-year curriculum was established.

Academy output is set at about 120 new pilots per year. The actual number varies slightly below or above, depending on input and attrition. Because of the rigorous selection process, most attrition occurs in the preparatory schools before a cadet reaches the academy.

Most entering cadets have attended the air force's own prep school. That is a three-year course similar to the last three years of US high schools. During two summer periods in prep school the students have experience flying powered gliders. That works both as a motivational device and screening tool.

First Year Academics

No flying occurs during a cadet's first year at the academy. It is devoted to ground school and academics. The courses are broken into three major groups: flying, military subjects, and academic and cultural. The groupings continue throughout the four years. Under the flying group are such major subjects as aerodynamics, engines, airframes, navigation, mathematics, and science. In the military group, subject categories are drill and ceremonies, tactics, military law, management, topography, field engineering, and physical training. Subjects in the cultural and academic group are English, Hebrew, economics and political science topics, and national security affairs.

Flying begins in the second year at Bilbeis. The Gomhouria aircraft is used. The EAF has about 200 of these Egyptian-built trainers, whose name means "Republic" in Arabic. The Gomhouria is a two-seat, side-by-side low-wing, tailwheel aircraft powered by an internal-combustion engine driving a fixed-pitch two-blade propeller.

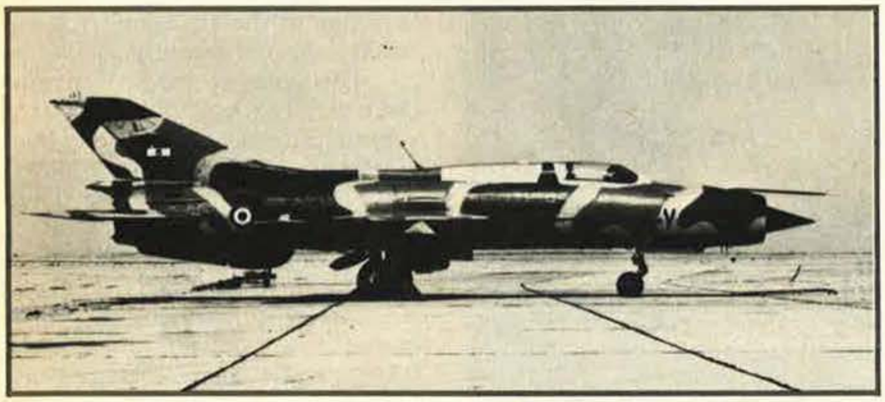
The flying course during the second cadet year takes the student from first flight through instrument checks in 103 sorties totaling between ninety and 100 flying hours. Solo flight is achieved around the twelfth hour. Students are trained in normal flight qualifications, instrument flight, and day and night cross-country flight. They are evaluated by instructors after each flight, by the squadron leader twice monthly, and by the Chief of Flying, a brigadier general, monthly.

For the third year the cadets move south to El-Menya in Middle

Egypt for intermediate flying training and continuation of academics. In that year, they log about 120 hours in the L-29 Delfin jet trainer. (If selected for the helicopter track, they log about 100 hours in the Gazelle helicopter.)

The fourth year comprises advanced flying and academics. It includes tactical maneuvers and formations, plus weapons delivery. This takes place farther south at Draw, in Upper Egypt, where students fly the MiG-17. They amass seventy hours in it before graduation. Thus, when the cadet is commissioned and reports to his operational regiment, he has something like 280 flying hours and knows the basics of tactical flying. The fine points of operational flying are learned in the regiment.

Besides pilot's wings, the cadet at graduation has earned a commercial pilot's license as well as a bachelor's degree.



Above, MiG-21PFS (#807) on the ramp at an EAF forward base (photo by Denis Hughes). Right, a cadet of the Egyptian Air Force Academy mounts an MiG-19 trainer for advanced flying practice, probably from Draw Air Base in Upper Egypt.

Academy Looks Ahead

Traditionally, the Egyptian Air Force Academy has trained foreign cadets. In earlier years this included men from Saudi Arabia, Libya, Oman, Yemen, and other Middle Eastern countries. At the present time, it has students from Burundi, Chad, Nigeria, Somalia, and Sudan. General Zeko, the dean, and other officers visited the US Air Force Academy in February 1981 and have since toured several European academies. They are interested in arranging officer exchanges with those academies. Under their plan, officer-instructors from Egypt would spend a year or two at the other academies, and each of the others would have an instructor at one of the three Egyptian locations for a like period.

Future aircraft plans are aimed at phased modernization. For the immediate future, the Gomhouria will continue as the basic trainer. The intermediate trainer will be a turboprop aircraft produced under license in the EAF factory at Heliopolis. That procurement is in the competitive selection process right now. Six proposals are being evaluated. Instructors from the EAF, under the leadership of Gen. Samir Sharawi, have flight-tested three of the proposed competitors. The other three are for aircraft that have not yet flown. The turboprop aircraft will replace the L-29 Delfins right away and the Gomhouria over the long term.

As replacement for the MiGs in advanced training and weapons delivery, the EAF will use the Alpha Jet E already contracted for. It will be used in two versions. The first will be for training in advanced flying techniques, formation flying, and basic fighter maneuvers. The other, more-numerous version will be equipped with inertial navigation systems, laser designators, and head-up displays leading to a smooth transition into the F-16 and other advanced fighters.

Air Defense Forces

Discussion of the Egyptian Air Force is incomplete without mention of the country's air defense forces, because both forces work so closely together. The air defense forces are Egypt's "fourth service." They have their own air defense academy and senior staff courses, and their own career progressions. Gen. El-Sayed Hamdi commands the air defense forces; his deputy is Maj. Gen. Mostafa Khiry.

The air defense forces were formed in 1968 as a direct result of lessons learned from the 1967 Six-Day War. Primary lesson: the absolute necessity of unity of command in air defense. Such unity did not exist in the 1967 War, contributing directly to Israeli air supremacy in that war.

Air defense assets include some nine squadrons of MiG-21 interceptors, about sixty SA-2 SAM launchers, about eighty SA-3 SAM launchers, a larger number of SA-6 mobile SAM launchers, and hundreds of AA guns in calibers ranging from 23 mm to 85 mm. Some French Crotale SAMs are also in the inventory. Early warning information is gathered by several models of radar, mainly of Soviet origin (but including a brand-new Plessey 3-D system), plus a chain of human observer posts. They are a key element of the system, spotting and identifying low-level penetrators.

In operation, the air defense commanders exercise command and control over all of Egypt's air defense assets. The actual working arrangements are best seen at air defense brigade combined command posts (CCP). AIR FORCE Magazine accompanied General Khiry to the CCP at Inshas, northeast of Cairo.

Entering an Egyptian CCP is a bit like going into the Cheyenne Mountain Complex at Colorado Springs. The position is sunk deep into the ground instead of into the side of a mountain. The protection methods are similar: a series of blast doors set at varying distances and angles, corridors that change direction to attentuate blast effects, living quarters and all services, and staffs who spend long periods in the ground.

Warning information from all sources flows into the CCP from multiple sources, including radar and human observers, and engagement decisions are made there. The information flows first into a warning center where it is compiled, processed, and displayed. Simultaneous displays are created there, in the CCP operations room, and at subordinate battalion command posts. One of them can take over command if the main CCP is out of action.

In the operations room, the air defense commander's battle staff functions side by side with the fighter interceptor staff. In the next room are the fighter interceptor controllers. Engagement decisions are made at the brigade CCP. Once made, firing authority is passed down to battalion commanders, who engage targets entering their zones of coverage.

Air Defense Philosophies

Unity of command is paramount, and has already been mentioned. Another essential element of Egyptian air defense philosophy is that the operations officers are responsible for maintenance. The functions are not separate, but are integrated, with operations officers having direct accountability for maintenance. In addition, they are trained in maintenance and serve in such jobs during their careers. In fact, operations people at air defense units are responsible for their own maintenance through first and second echelons. The Egyptians believe this ensures a higher degree of readiness as well as a more rapid return to service when malfunctions occur.

Extensive use of decoys is a critical element in Egyptian air defense. During the War of Attrition (1968 onward) they created a massive missile belt along the Suez Canal. They cite a statement by then-Israeli Prime Minister Golda Meir. She once referred to the missile belt, saying, "It is like mushrooms; cut one down and another springs up." The Egyptians say she apparently was not aware that more than seventy percent of the targets her forces struck were decoys. At present, more than fifty percent of air defense sites are decoys. Special units serve the decoys, including their preparation and continuing activities for credibility.

Summary and Comment

The EAF and Air Defense Forces are essential elements in maintaining security and supporting the quest for peace. All their senior officers have fought in four wars, and most officers in one, two, or three. They have applied lessons learned from those conflicts and are confident of future success if they must fight.

The Egyptians may have equipment from a variety of countries, but they operate and maintain it in uniquely Egyptian fashion. They are determined not to become captives of a single outside supplier or weapon system. They will expand their military industry, and seek export markets, as well as requiring coproduction on future acquisitions.

Finally, to appreciate the outlook of the Egyptian armed forces, consider geography and the current situation. They see potential threats on the east, west, and south. They consider peace essential to restoring Egypt's economy and spurring national development. They welcome US military cooperation and support in the peace process, but are wary of a smothering US embrace. Egyptian and US officials alike warn against repetition of the Iran model, where overwhelming quantities of equipment and personnel created the seeds for resentment and disaster. ■

Aircraft of the Egyptian Air Force

Fighter or Fighter/Ground Attack	
Dassault Mirage III SDE	45
Dassault Mirage 5	14
General Dynamics F-16*	40
MiG-21/F/PFM/M/MF	95
Attack/Reconnaissance	
McDonnell Douglas F-4E	35
MiG-23BM	18
Shenyang F-6 (Chinese-built MiG-19)	40
Sukhoi Su-7BM	60
Sukhoi Su-20	18
Bomber	
Ilyushin Il-28	5
Tupelov Tu-16	23
Trainer	
Aero L-29 Delfin	100
Dassault/Dornier Alpha Jet*	30
Dassault Mirage III SDD	5
Helwan Gomhouria	200
Helwan HA-200B Al Kahira	20
MiG-15UTI	50
MiG-17	30
MiG-23U	6
Sukhoi Su-7U	20
Yakovlev Yak-11	36

Transport	
Antonov An-12B	16
Antonov An-24	3
Boeing 707 (VIP)	1
Boeing 737 (VIP)	1
Dassault Falcon 20 (VIP)	1
Ilyushin Il-14	26
Lockheed C-130H	17
Helicopter	
Aérospatiale SA-342	64
Meridionali/Boeing Vertol CH-47C	15
Mil Mi-4**	20
Mil Mi-6	12
Mil Mi-8**	80
Westland Commando Mk1	5
Westland Commando Mk2/2B	22
Westland Sea King (ASW)***	6
Special Purpose	
Lockheed EC-130H	2
Grumman E-2C +	4

Notes: * Ordered
** Operated by Army
*** Operated by Navy
+ Planned

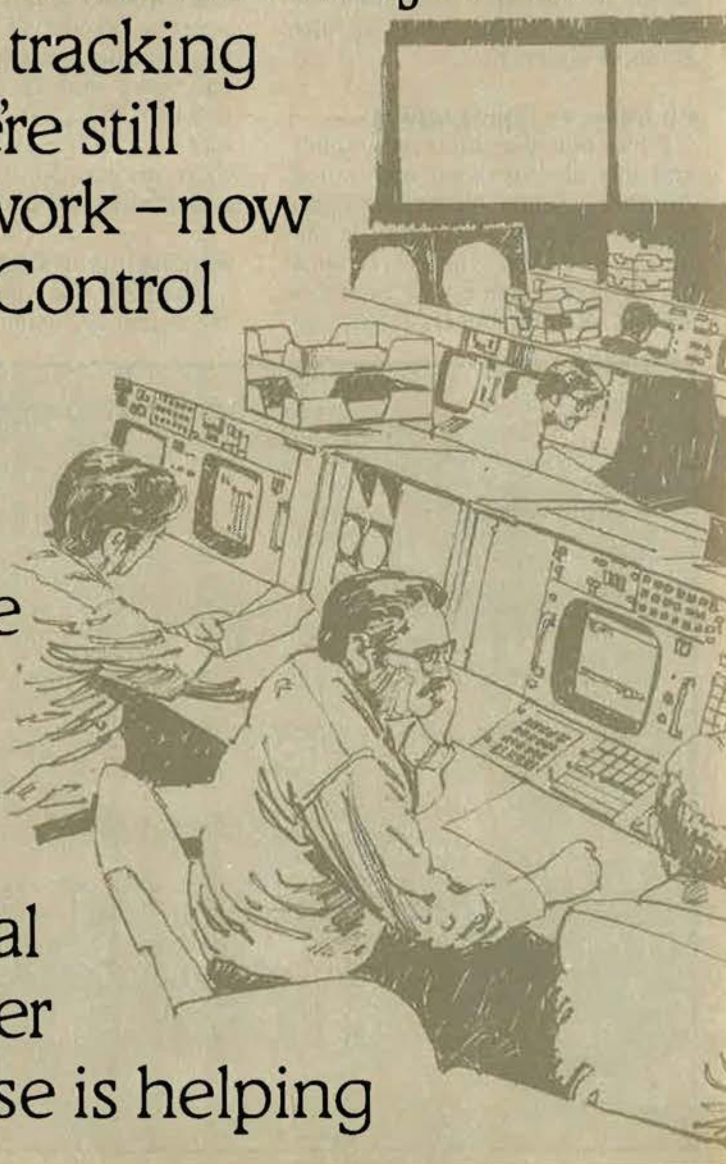
Source: Adapted from *Jane's Pocket Book Air Forces of the World*, ©1981 Jane's, London.

In the Beginning, we

For over a quarter-century, Ford Aerospace has been the company to start things. Important things in every aspect of the Space Mission.

In 1957, we participated in the design and development of the first major U.S. military spacecraft tracking network. Today, we're still servicing that network – now the USAF Satellite Control facility, the largest of its kind.

In 1963, we began building the Mission Control Center at Johnson Space Center, and we've provided total system support ever since. This expertise is helping



THE year is 1935. Three men—one in England, one in Germany, and one in the United States—have reached the same conclusion: The world is ready for a new type of airplane engine.

"Concurrence," an idea that occurs simultaneously to different people, is not unusual in science. In this case, dissatisfaction with the reciprocating engine as an aircraft powerplant is widely recognized. All that is needed is someone to bridge the creative gap between the problem—the limitations of the reciprocating engine—and the solution, the development of an effective gas turbine—a jet engine.

The Englishman is an RAF officer in his mid-twenties. In January 1930, he had applied for his first patent, an ordinary reciprocating engine driving a compressor to produce a jet. Although his patent was similar to one issued years earlier to a Frenchman, the RAF is impressed and sends the young man to Cambridge University for two years. His name is Frank Whittle.

The German is a student of applied physics and mathematics at the University of Göttingen. His first patent is granted in 1934. The German is Pabst von Ohain, also in his mid-twenties.

The American has a head start. In his mid-thirties, he is already chief of structural research at the Douglas Aircraft Co. in Santa Monica, Calif. He has helped build the world's first successful all-metal dirigible. His name is Vladimir Pavlecka, and he has been working on a gas-turbine engine since 1933.

First Steps

In England, Frank Whittle enlists the aid of two former RAF officers who arrange a meeting with two investment bankers, Sir Maurice Bonham-Carter and Lancelot Law Whyte.

In Germany, graduate student Pabst von Ohain takes his problem to a professor at the University of Göttingen, R. W. Pohl. Pohl is a personal friend of airplane builder Ernst Heinkel.

In the US, Vladimir Pavlecka turns to Douglas, for whom he has already helped develop the concept of light metal airplane structures.

Whittle's RAF friends show his designs to M. L. Bramson, a widely respected consulting engineer, who arranges a meeting with Bonham-

When the first Luftwaffe jet fighters slashed through Eighth Air Force bomber formations late in World War II, they stunned the aviators who had to fight against them. No propellers, very high speeds, and a surprise. US development of jet engines had lagged. In the UK, developments were much further along, but operational aircraft were not in the fray.

The Great Jet Engine Race... And How We Lost

BY LEE PAYNE
Illustration by Leslie Dunlap

Carter and Whyte. The two are interested in projects considered too speculative for conservative investment firms.

Lancelot Whyte meets the twenty-eight-year-old Whittle on September 11, 1935.

"The impression he made was overwhelming," Whyte recalls. "I have never been so quickly convinced, or so happy to find one's highest standards met. . . . This was genius, not talent.

"Whittle expressed his idea with superb conciseness: 'Reciprocating engines are exhausted. They have hundreds of parts jerking to and fro, and they cannot be made more powerful without becoming too complicated. The engine of the future must produce 2,000 hp with one moving part: a spinning turbine and compressor.' "

In Germany, even though his airframe company has never built an aircraft engine, Heinkel hires the young von Ohain.

In the US, Douglas sends Pavlecka's proposal to engine manufacturer Pratt & Whitney, who forwards it to MIT. The MIT and Pratt & Whitney engineers agree: Even if the engine worked, which it won't, there would be nothing useful for it to do. They are unanimous in their disinterest of the jet engine.

In March 1936, Power Jets Ltd. is formally incorporated. Whittle, still an RAF officer, is chief engineer. The Air Ministry, after examining Whittle's proposal, determines that his engine will never have military value but allows him to spend six hours a week working for the new company.

In October, a Power Jets bid for an Air Ministry research grant is turned down and work continues with private funds. Though Whittle would prefer to build and test each engine component separately, suitable test equipment does not exist and it would be too expensive and time-consuming to build. They decide to build the entire engine all at once.

Von Ohain begins work at Ernst Heinkel Flugzeugwerke in February 1936. Heinkel's engineers have doubts but decide to build a simple demonstration engine out of sheet metal.

At Douglas, Pavlecka has not been idle. In 1936 he designs the company's first pressurized fuselage for the DC-4; develops the first tricycle landing gear ever used on a large plane; invents a self-sealing fuel tank; and switches Douglas from extruded sections to rolled sheet metal sections, thus making Douglas the first company to adopt today's industry standard.

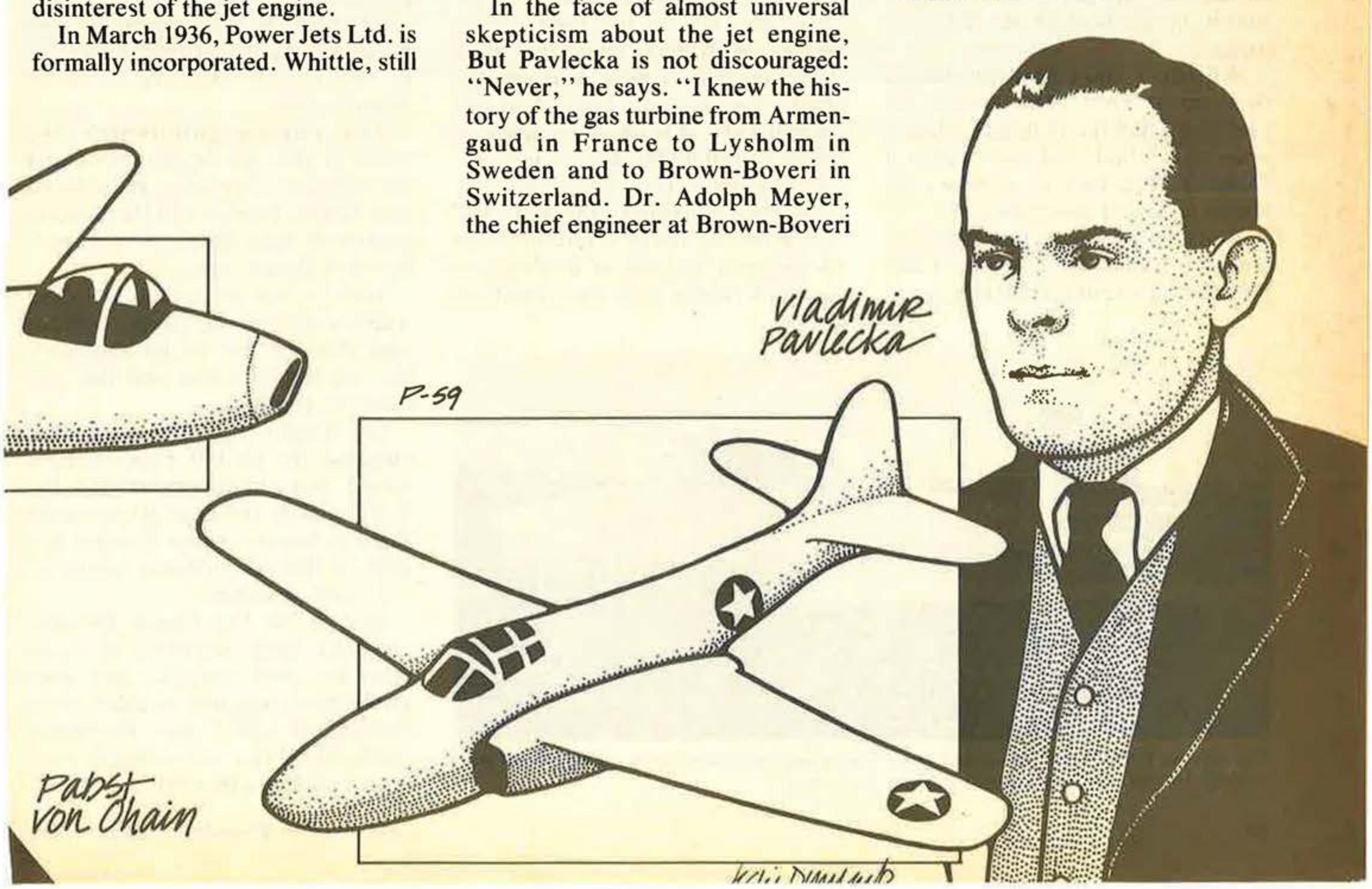
In the face of almost universal skepticism about the jet engine, But Pavlecka is not discouraged: "Never," he says. "I knew the history of the gas turbine from Armengaud in France to Lysholm in Sweden and to Brown-Boveri in Switzerland. Dr. Adolph Meyer, the chief engineer at Brown-Boveri had been a guest in my home, though he didn't believe the gas turbine could ever be made light enough to fly. I knew the history. The experts at MIT and Pratt & Whitney didn't and this meant they would miss out on the beginning of this new industry. I knew I was right."

Early Advances

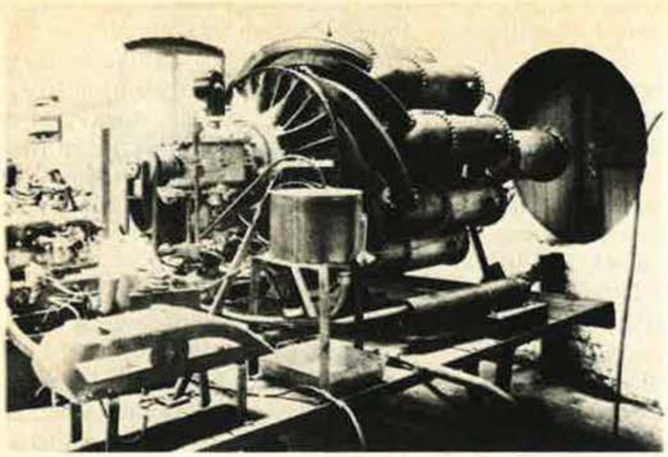
In March 1937, the world's first jet engine roars into life—in Germany. It has taken von Ohain and three assistants eleven months and $20,000. Their simple demonstration engine develops 550 pounds of thrust, more than enough to silence doubters.

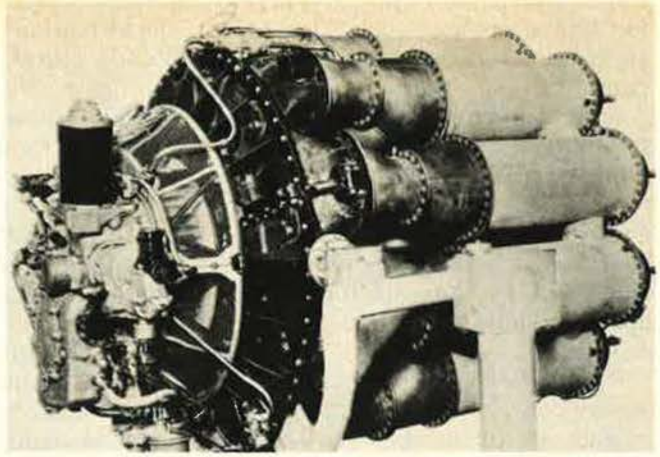
Work begins immediately on a flight engine and on an aircraft for it.

A month later in England, Whittle's engine faces its first test. Built by the British Thomson-Houston Co. at a cost to Power Jets Ltd. of $30,000, it works. Though its output is less than the 1,100 pounds of thrust Whittle hoped for, the fact that it even runs is encouraging.



Below, the three main players in the development of jet engines, and the first jet-powered aircraft: Frank Whittle and the Gloster E28/39, Pabst von Ohain and the He 178, and Vladimir Pavlecka and the Bell P-59.





Left, the first experimental engine built by Frank Whittle, after having been rebuilt twice, in an unused foundry at Lutterworth. Right, the production version of Whittle's engine, the Welland. (Photo courtesy Rolls-Royce Ltd.)

Though financing remains a problem, the government finally agrees to contribute $5,000 and allows Whittle to work on the project full time while drawing his RAF salary. But the government shrouds the entire project in military secrecy, making it even harder to interest investors.

In the US, Douglas is building the world's largest airplane, the B-19, featuring Pavlecka's tricycle landing gear and self-sealing fuel tank. The company is uninterested in the jet engine. Meanwhile, Pavlecka and his staff invent flush riveting, a major breakthrough in reducing drag.

Whittle's improved engine is fired up in April 1938. It runs for four and a half hours before coming apart; it is rebuilt and tested again in October. The lack of money continues to hinder development.

Von Ohain tests his first flight engine at midyear. Designed for 1,800 pounds' thrust, like Whittle's, it too falls short and the job of reworking it begins.

A second German jet engine has been under development since 1936, also in strict secrecy. The second jet is also being built by an airframe company, Junkers Flugzeugwerke A.G., with no previous engine experience. Even after the Junkers Airplane Co. merges with the Junkers Motorenbau GmbH, the project is kept secret from the new firm's engine division. Herbert Wagner, chief of airframe development, feels the engine division is overly cautious and conservative. Wagner sets up his own engine works. With thirty designers under the direction of Max Mueller, the Junkers jet is ready for its first test in mid-1938. It works but cannot be made to run under its own power.

At Douglas, Pavlecka invents the internal hexagonal stop nut, still standard on today's aircraft, and develops a method of hydropressing with rubber pads that remains a master tool in airplane fabrication. Even though three jet engines have been built and tested, few in the US believe the idea is feasible.

The Gloster E28/39 was the world's second jet-powered aircraft to fly. Its first flight was on May 15, 1941. (Photo courtesy Gloster Saro Ltd.)

Moving Into High Gear

By 1939, Europe is slipping toward war and the British government's Director of Scientific Research finally becomes convinced of the Whittle engine's practicality. The government agrees to fund further development, including a flight engine and a plane for it. The Gloster Aircraft Co. is asked to begin work on an airframe.

The German government has also begun to take the jet engine seriously and its Air Ministry steps up organization.

The engine companies are ordered into jet development and the airframe companies are ordered out. BMW, Bramo, and the Junkers engine division agree to begin preliminary design work.

Junkers has no objection to the transfer of jet development to its engine division but its jet engineers do. All but two quit and half are hired by Heinkel.

On August 27, 1939, a Heinkel airplane, the He 178, powered by a single von Ohain engine, the He S-3b, makes the first jet-powered flight in history. Ernst Heinkel has proved that an airframe company can build an engine.

And in the US, former Douglas engineer John Northrop plans to start his own company and asks Pavlecka to join him as chief of research. "I will," says Pavlecka, "but only if you will seriously consider building a jet engine."

"What's a jet engine?" asks Northrop.

Pavlecka explains his theory and tells of the illustrated lecture he has been giving. "When do we start?" Northrop asks.

Pavlecka joins the Northrop Aircraft Co. in September 1939. Work on America's first jet engine gets under way on January 2, 1940.

Early in 1940, England begins to awaken to the state of her military unpreparedness. In January, Air Vice Marshal Sir Arthur Tedder gets his first look at the Whittle bench engine. Though the first flight is yet to come, he orders Gloster to begin designing a jet-powered fighter. By year's end, with the government now finally providing financing, Power Jets grows from fifteen to 134 employees.

The Germans, on the other hand, enter 1940 with complete confidence in a short, successful war. The General Staff sees no need to push new technology.

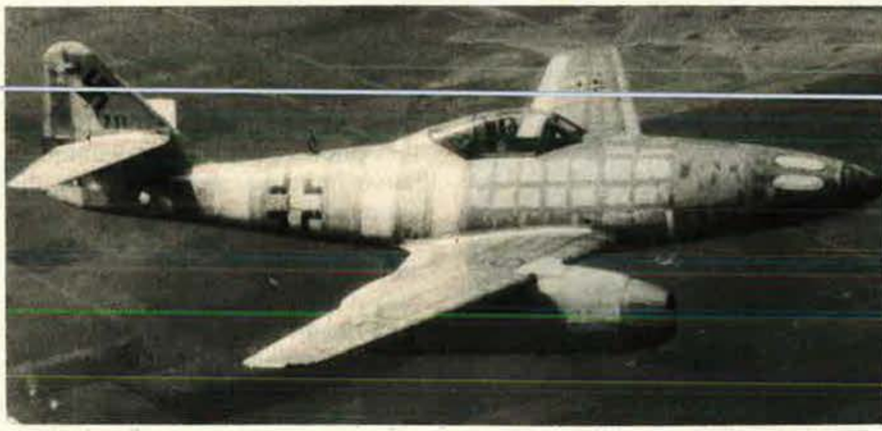
Ernst Heinkel ignores the General Staff. Builder of the world's first rocket-powered plane, he continues to test the first jet plane, which has an engine better than the airplane. The He 178 is directionally unstable at high speed and flies wheels down because the mechanism to raise them won't work. Even with these problems, the first flights attain speeds of more than 300 mph, close to that of the best propeller-driven fighters.

Heinkel begins work on a new twin-jet fighter, the He 280, and two new engines, a refined version of von Ohain's and a new axial-flow jet designed by the former Junkers engineers.

Junkers, with only two jet engineers left, decides to begin from scratch and design the simplest and easiest jet possible, even at the cost of lower performance. This engine, designated the 004, is first tested in November 1940.

At Northrop, Pavlecka and his twenty-man staff also start anew, first with thermodynamic principles and cycles, then with the design of turbines and compressors. By March 1940, they have enough technical data to make a presentation to the Powerplant Section of the Navy's Bureau of Aeronautics. They choose the Navy first because Mr. Friedner, the Section's civilian engineer, is an advocate of jet power. But Commanders Ricobata and Spangler, the Section's two engineering officers, demonstrate no interest in the subject. Following the presentation, Commander Ricobata asks how they expect the Navy to fly fire-spitting airplanes from the carriers' wooden decks.

The presentation to the Army Air Corps's Powerplant Division at Wright Field in Dayton is no better. Here, not even one person is familiar with the subject. Pavlecka meets with Maj. Donald Keirn and four of his civilian engineers. The engineers understand little of what Pavlecka is talking about. In Europe at this time, thermodynamics is a highly developed science. In the US it isn't even taught at Caltech. Despite Pavlecka's labors, the engineers conclude that it is nonsense. Northrop must continue jet-engine development without government assistance.



The Me 262, the most numerous jet-powered aircraft of the war. Powered by two 1,984-pound-thrust Junkers 004B engines, the Me 262 achieved top speeds of 541 mph, seventy mph faster than any other aircraft in the sky. (USAF photo)

Getting Airborne in Britain

Whittle's W-1 flies on May 15, 1941. With 850 pounds of thrust, his engine drives its Gloster E 28/39 at 334 mph at 5,000 feet and 338 mph at 20,000 feet. At low altitudes, it is faster than Britain's best fighter. Though the Whittle engine has slightly less thrust than von Ohain's first flight engine, the W-1 at 623 pounds weighs 162 pounds less than von Ohain's He S-3b. Pound for pound, the two produce almost the same thrust.

With this success, the government begins to plan for quantity production of Whittle's engine and the Gloster Meteor. Power Jets continues its research while a production contract goes to the Rover automobile company. In November 1941 the government also sets up the Gas Turbine Collaboration Committee to speed development by all parties.

After the Power Jets successful test flights, Vickers and de Havilland begin work on jet engines of their own.

A month later, Gen. Hap Arnold, Chief of the US Army Air Corps, visits England. He and his assistant, Maj. Donald Keirn, attend a demonstration flight at Gloster. The E 28/39 is waiting, with pilot aboard. "Where are the propellers?" General Arnold asks. "There are none," his British host replies. "It's a jet." "What's a jet?" asks Arnold.

Major Keirn knows. He had it carefully explained to him nine months earlier. He hadn't believed it then. He believes it now.

During the plane's two flights, General Arnold is astonished. He orders Keirn to fly two Whittle engines back to General Electric aboard a B-17. America enters the jet age.

In June 1941, a week after the first Whittle engines arrive in the US, Northrop is awarded a $483,600 joint Army-Navy contract. Not, however, for a jet engine. Still with visions of flame-spouting jets burning their carriers to the waterline, the Navy insists on a huge 2,500-hp turboprop engine, a jet with a propeller on one end. It is a far more difficult concept, already discarded in England and Germany. And while the whole engine is to be designed, the contract calls for the construction of only the compressor.

"I couldn't believe it," recalled Pavlecka. "Still, to build a compressor was better than nothing. We started to work." Meanwhile, he invents the Heliarc welding process.

In Germany, Heinkel's new He 280 twin-jet fighter is flown with two of von Ohain's He S-8 engines, but the plane suffers from serious tail flutter.

Germany's engine companies are now working on several jet and turboprop projects and the shortage of qualified engineers has become a serious problem.

In England, two of the first Rover-built engines are installed in a Meteor in July 1942 for taxi tests but are unreliable and haven't enough thrust to get the plane off the ground. By midyear, however, new metal alloys become available both from the US and in England. These allow construction of turbine blades that can withstand the high temperatures inside the engine for more than twenty-five hours before replacement.

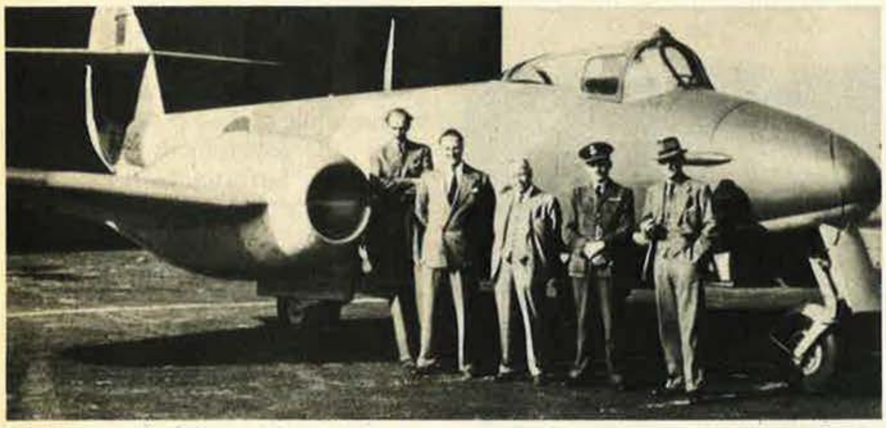
The Junkers Effort Pays Off

By the end of 1942, Germany has two 1,900-pound-thrust engines. Heinkel bench tests its new He S-30 in October but the Junkers effort to produce a simple engine in a short time has paid off. Its 004A makes its first flight on an Me 262 on July 18. It weighs 1,870 pounds and produces 1,848 pounds of thrust.

Now the German Air Ministry must decide which of the two is best for full production. While the Heinkel engine is six months behind, it achieves the same thrust while weighing only half as much. Junkers wins, a decision Heinkel believes is more political than technical. The Air Ministry refuses to allow Heinkel to continue development of the He S-30. Instead, he is to start work on a completely new 3,500-pound-thrust engine.

Germany, short of both nickel and chromium, is having worse problems with metal alloys than the British. The Americans have developed cobalt-based steel for their turbine blades. Above 1,350 degrees, it is superior to any other steel, but Germany has little cobalt. Forced to improvise, the result is the Junkers 004B. When completed, it weighs 1,650 pounds yet includes no nickel or cobalt and only five pounds of chromium. Built of inferior metals, its combustion chamber must be replaced after twenty-five to fifty hours of flying time. It is, however, good enough to become the only production jet to fight in the war.

At Northrop, Pavlecka and an assistant, Fred Dellanbach, build a small test axial compressor. At 1,800 rpm it tests out at ninety-three percent efficiency, and they begin building the large compressor, which, of course, they won't be able to test.



The twin-engine Gloster F.9/40, which finally went into production as the Gloster Meteor. The engine pods were placed in the wings so that development of the airframe could proceed while engine size was finalized. Pictured are (from left): John Crosby-Warren and Michael Daunt, test pilots; Gloster General Manager Frank McKenna; Frank Whittle; and Gloster Chief Designer W. George Carter. (Photo courtesy Gloster Saro Ltd.)

In June 1942, Squadron Leader Whittle visits the US to look at GE's version of his engine. He is also asked by Washington to examine Northrop's work.

"He was very taciturn and very nervous," Pavlecka recalls. "We showed him everything we were doing. He made very few comments. Then he said, 'You have all our reports from England, don't you?'

"I said, 'No, we don't have any reports.'

" 'You're lying,' he said. 'We gave those reports to your government for people like you to use to build on what we have already done.'

"When I finally convinced him that we had received no information at all on Power Jets research, he went right to the phone and called Major Headon, the British military liaison in Washington. I don't know what Headon told him but, after that phone call, Whittle wanted to leave immediately. We never did get any of his reports."

Three months later on October 2, 1942, at Muroc Dry Lake in California, a Bell P-59A powered by an American-built GE version of the Whittle engine makes its first flight. In a year of testing it will attain a top speed of 404 mph at 35,000 feet.

Highest Priorities

By 1943, the jet engine finally rates the highest priorities, and the British government makes the first adequate test facilities available. Vickers, de Havilland, and Armstrong Siddeley get access to the steam turbine in an electric power station in Northampton while the government builds a 6,000-hp facility at Whetstone for Power Jets.

By midyear, Rover has raised the thrust of its Whittle engines from 1,100 to their originally hoped-for design rating of 1,600 pounds. Meanwhile, on March 3, 1943, the Gloster Meteor makes its first flight powered not by Whittle engines but by two de Havilland Goblins. Starting back in 1941, with access to all Power Jets's hard-won knowledge, de Havilland has completed the Goblin in two and a half years. It is cleared for flight at a thrust of 2,000 pounds.

With the crucial work on their famous Merlin reciprocating engines completed, allowing the Spitfires and Hurricanes to outperform the German fighters in the Battle of Britain, Rolls-Royce is now ready to take on jet development. It has been working with Power Jets for more than a year through the Gas Turbine Collaboration Committee. Now they formally assume Rover's mass-production interests and on June 12, 1943, the Meteor is finally flown with Whittle engines, now named the Welland.

By 1943 the German Air Ministry wants jets—now!

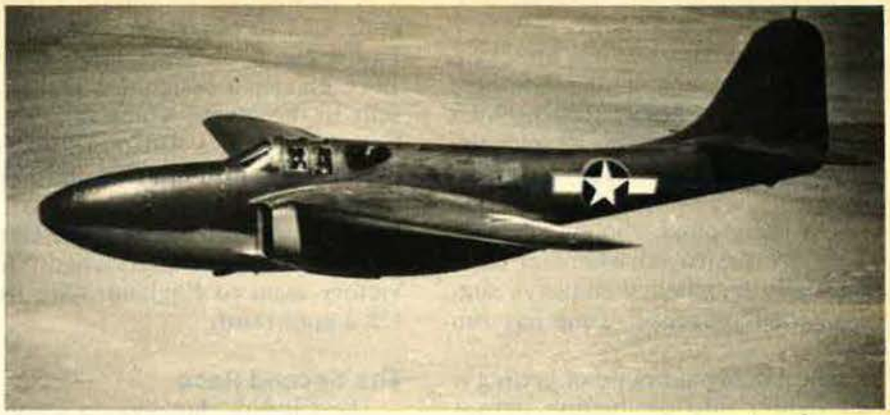
Production of the Junkers 004 that first flew in July 1942 is ordered. A production model, the 004B, has been under design since before test of the 004A development model. Now, before test of the 004B, its factories are being built.

BMW is only slightly behind Junkers with the 003. Begun in 1939, it has twenty-two pounds less thrust than the 004 but is easier to maintain.

The Air Ministry orders BMW to continue 003 development. Both BMW's 003 test engine and Junkers 004B production engine make their first flights in October 1943, in the Me 262.

In the US, with no data on British research, his jet turned into a turboprop, and forced to build a 2,500-hp compressor with no engine to put it in, Pavlecka leaves Northrop and joins Lockheed, which has just received government funding to build a slightly more rational project, its L-1000 jet engine. Lockheed's design work was begun at the end of 1940 by Nathan Price, a former steam engineer. Though Lockheed engineers have been discussing it with the Army since 1941, it isn't until May 1943 that they are informed that similar work has long been under way in England and the US and that British jets have been flying since 1941. The only reason the Army informs Lockheed of these facts now is that they want an airframe for de Havilland's Goblin engine.

Lockheed starts to work on the XP-80 jet fighter and the Army agrees to finance their jet, the L-1000. Lockheed thus joins Northrop and Bell in learning that the jet age is already at least two years old. Most other US aircraft companies have yet to hear anything about it through official channels. Only the steam turbine builders—GE, Westinghouse, and Allis-Chalmers—have had access to the government information. All three have been working on gas turbines for ships. GE is building Whittle engines and has begun the design of its own 4,000-pound-thrust engine, the I-40. Westinghouse has completed work on a small Navy booster jet. And Allis-Chalmers has the Army contract to build de Havilland's Goblin.



The Bell P-59 was America's first jet-powered aircraft to fly. Powered by a General Electric-built version of Whittle's Welland engine, the P-59 eventually attained a top speed of 404 mph.

Deliveries of the Welland, Whittle's Rolls-Royce-built engine, begin in May 1944. Rated at 1,600 pounds' thrust, it weighs only 850 pounds and drives the Gloster Meteor at a sea level speed of 410 mph. The flying squadrons start to receive the planes in July 1944 and fly them against V-1 flying bombs.

Rolls-Royce continues to upgrade the Welland in a series of engines named the Derwent. They also begin work on a completely new engine. First run in October 1944 and rated at 4,500 pounds of thrust, it is called the Nene. Scaled down to 2,600 pounds of thrust and installed in a Meteor IV, it is called the Derwent V and establishes a world speed record of 606 mph on November 7, 1945. It is the first British plane to fly faster than Germany's Me 262.

In Germany, BMW's 003 goes into production early in 1944, with the 100th engine built by August. It flies mainly in Heinkel's He 162 of which sixty are in service before war's end.

A Formidable Weapon

But Germany's chips are on the Junkers 004B, in full production in March 1944. In the Me 262 twin-jet fighter, it makes a formidable weapon with a top speed of 520 mph at sea level and 541 mph at 26,000 feet. It is close to 100 mph faster than Britain's Meteor-Welland combination and seventy mph faster than the best conventional Allied fighters.

The 004B requires only 700 man-hours to build, compared to the more than 3,000 hours for a conventional engine. The problem is aircraft shortages. Flying officers have been urging the Air Ministry to change Messerschmitt's factories from conventional Me 109s for nearly a year before Me 262 production finally begins in the spring of 1944. But then Hitler orders the Me 262 changed from a fighter to a bomber. Göring and the Air Ministry are dumbfounded but have no choice. After extensive design studies and production alterations, Hitler reverses himself. But the damage has been done. Full-scale production is delayed until the fall of 1944.

In spite of constant Allied bombing, 5,000 004B engines and 1,400 Me 262 fighters are built before the war's end.

Lee Payne is a California native, presently the Chief Photographer of the Orange Coast Daily Pilot *in that state. His book,* Lighter Than Air, An Illustrated History of the Airship, *was published in the US by A. S. Barnes & Co. It led to an introduction to Vladimir Pavlecka, one of the major contributors to modern aviation, and Payne's development of this article about the concurrent achievements in jet engines in three countries—the UK, Germany, and the US.*

Could the Me 262 have made a difference? In January 1945, a squadron of German jets attacks a flight of twelve American bombers protected by a fighter escort. Not a single bomber escapes despite the best efforts of the American fighters.

On the ground, though, the Me 262s are destroyed wherever their specially lengthened runways suggest their presence. Time has run out.

The US has no hope of getting a jet fighter into production before war's end. GE's I-40 is certified at 3,750 pounds of thrust and is test flown in Lockheed's XP-80 on June 10, 1944. With speed of more than 500 mph, it goes into production after the war as the P-80A Shooting Star, but is nearly 100 mph slower than the Rolls-Royce-powered Meteor.

Lockheed's L-1000 engine has basic design flaws and won't start. Northrop's Turbodyne turboprop becomes the first US turboprop engine to run with a propeller in December 1944. John Northrop had hoped to use it to power his Flying Wing, but the engine has become obsolete and never flies.

Frank Whittle started with two goals. In one, the creation of the jet aircraft engine, he succeeded admirably. In the second, the founding of a major industrial concern based on his creation, he failed. Without the war, Power Jets Ltd. might well sit today at the pinnacle of the aerospace industry with patent control over half of jet technology. Instead, its knowledge was shared with GE and the entire British aircraft industry, its production interests were taken over by Rolls-Royce, and its research facilities were nationalized in 1947 and absorbed by Britain's National Gas Turbine Research Establishment. At that time its best people quit, and Power Jets Ltd. ceased to exist. Frank Whittle has to settle for a tax-free $400,000 and a knighthood.

Both Ernst Heinkel and Pabst von Ohain continue work in the aircraft industry, with Heinkel in Germany and von Ohain in the US. Though their 1939 jet was the first to fly, they were outmaneuvered by Messerschmitt and Junkers, due mainly, Heinkel believes, to better Air Ministry connections.

A production turboprop engine continues to elude everyone until Pavlecka, back with Douglas in 1947, creates a design that Douglas sells to the Navy, which sells it to General Motors's Allison Division, which builds it as the T-39 and T-40 for the Lockheed Electra.

So who won the race? The Germans, but they were scratched. The victory went to England, with the US a poor third.

The Second Race

There is now, however, a second race which, many feel, the US has already won by a wide margin. They say we now stand alone, the world leader in jet technology. Right? Wrong, in Pavlecka's opinion.

According to that engineering genius, we're only ahead at the three-quarter post. The Japanese and Europeans are close on our heels, and the outcome is still in doubt.

The problem, Pavlecka warned before his death in June of 1980, is what caused the US to come in last in the first jet race. "The problem," according to Pavlecka, "is America's commitment to technology. We haven't made it yet.

"American industry is still committed to short-term profit at the expense of long-term progress. If a new product can make our managers look good on the balance sheet in a couple of years, they'll go all out for it. But if it won't pay off for ten years or more, forget it. They will have moved on to other companies by then. What's good for the country and the future seldom helps next year's profit statement. You don't believe it? Look at steel, at shipbuilding, at textiles, television sets, and automobiles. Come back in ten years and look at chemicals and maybe even semiconductors.

"Japan made her commitment to technology years ago. Europe is working on it now. Tamotsu Harada of Japan's Electronic Industry Association was recently quoted as saying, 'We are looking twenty to thirty years ahead, but the US idea of long-term is two to three years.' That's the problem."

As for Vladimir Pavlecka, he spent the ten years before his death developing the contrarotating gas turbine but was unable to interest anyone in it. He also developed a more efficient wind turbine, now being tested in California, and returned, finally, to his first love, the metal dirigible he helped build for the US Navy back in 1929. He designed a modern, pressurized, all-metal airship that can carry as much as a 747 over the same distance while burning seventy percent less fuel. He put together eighty-seven slides and a lecture that he gave to anyone who was interested. Most people didn't believe him, but he was used to that. ■

The first American production jet fighter was the Lockheed P-80 Shooting Star. Powered by GE I-40 engines with 3,750 pounds of thrust, the P-80 still proved almost 100 mph slower than the Gloster Meteor. (USAF photo)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Like all propulsion specialists since the advent of the jet age, the engineers and scientists at the Air Force Wright Aeronautical Laboratories are working to build an engine that will outperform its predecessors. Their efforts in a variety of fields, including metallurgy, fuels, engine design, and electronics, are aimed at producing a more powerful, more efficient, and more durable engine.

Wizardry at Wright-Pat

BY CAPT. PHIL LACOMBE, USAF, CONTRIBUTING EDITOR

THERE'S no magic in making a jet engine. No spells or incantations chanted over a heap of machinery can instantly produce engines capable of catapulting more than 41,000 pounds of F-15 into the air in fewer than 1,000 feet of runway. Rather, making a jet engine like the F100 requires a lot of hard work by many people in and out of uniform on a number of different projects.

"It's an evolutionary process," says Col. George Strand, Director of AFSC's Aero Propulsion Laboratory within the Air Force Wright Aeronautical Laboratories, or AFWAL, at Wright-Patterson AFB, Ohio. "Little pieces add up to significant improvement and new engines—better than the ones that preceded them. But these engines couldn't have been built without the experience gained from their predecessors."

Building on the past is a sound process. At AFWAL's Aero Propulsion and Materials Laboratories, building on the past now means not only making engines more powerful than before, but making them last longer and cost less. Though the engineers, scientists, and designers still talk about higher thrust-to-weight ratios, they refer increasingly to more durable engines, reduced maintenance, lower life-cycle costs, and improved capability to predict the life span of engine components. These latter subjects aren't new to engine design, but the added emphasis is.

Dr. Walter Reimann of the Materials Lab's Metals Branch describes the new emphasis as a recognition that maintenance now accounts for two-thirds of the life-cycle cost of an engine. Previously, acquisition costs were two-thirds of life-cycle cost. "Durability, conservation of materials, total costs, and the widespread use of strategic materials are making repairability and maintainability more important to engine design," he says. Dr. Reimann, the Materials Lab focal point for all propulsion-related programs, notes that "performance is still our No. 1 goal, but we now talk about cost-affordable performance."

The experience of recent years with increased maintenance costs on engines that were designed to the limits of available technology, component life spans that didn't measure up to predicted life spans, and spiraling fuel costs have resulted in the new emphasis on durability and fuel efficiency throughout the engine development community.

Col. James Nelson, Deputy for Propulsion of AFSC's Aeronautical Systems Division (ASD), says, "It takes some time for durability problems to appear in the field." When the problems do appear, ASD can sometimes solve them using technological developments that have occurred since the engines went into service. ASD's Component Improvement Program, for example, has made steady advances in F100 engine durability. In fact, Colonel Nelson predicts that F100 engines will reach a 4,000-cycle maintenance schedule by the mid-1980s, compared to the current requirement for engine core overhaul after 1,350 cycles. Other engines have also been upgraded with new technology, resulting in fuel savings and longer life spans.

The Aero Propulsion and Materials Labs are hard at work on the next generation of aircraft engines and on continued improvement of existing powerplants. Improved durability and increased fuel efficiency are essential considerations early in the labs' design programs. According to Colonel Strand, "There are big payoffs for doing it right the first time—avoiding unexpected costs later, and going to Congress for money to fix something. For that reason, in the last eight years, we have placed greater emphasis on understanding durability and structural design."

In the past, Colonel Strand says, engine manufacturers would build an engine and run it until it failed and then fix it and run it again. Today, AFWAL is developing what Colonel Strand calls "better rules and tools for design analysis and failure prediction." The difference is apparent in the approach to design analysis. There's a new attitude: "When we test an engine to the point where we have predicted a component failure and the component doesn't fail, we used to consider the test very successful. Today we don't. We consider it a shortcoming because our prediction was wrong—it is essential that we develop the capability to predict failure accurately."

Attempts to design durability and fuel efficiency into an engine are complicated by the nature of engine acquisition. Engines are designed to fit the aircraft being developed—that is, they are designed to fit the requirements dictated by the aircraft and its mission. Consequently, engines often require the very newest technology in order to perform as required. Further, the relatively long engine development lead time and the small number of actual engine buys limit the availability of engine performance data.

The result, according to Colonel Strand, is that engine designers are under a lot of pressure in pushing development programs to test performance expectations and ensure the accuracy of life-cycle cost predictions.

At AFWAL, developing engines for the next combat aircraft also means keeping costs down. An integrated approach is used. New materials with potential application to engine components, new engine designs, electronic control techniques, and a variety of other projects are blended together in various test programs to select those components offering the best cost-affordable performance.

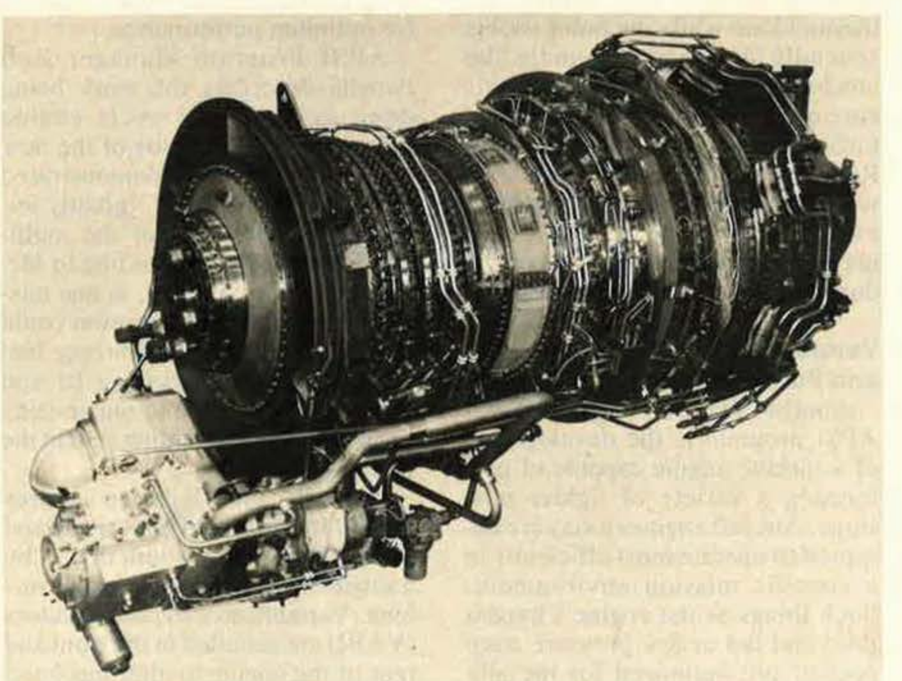
Some of the most significant projects in the Materials and Aero Propulsion Labs are described below.

New Material for Jet Engines

The Materials Laboratory's various propulsion-related projects received approximately $20 million this year. Though the lab could use much more, says Dr. Reimann, it is already developing several important projects—both in-house and through development contracts with civilian companies.

One way to increase engine performance is to raise the temperature level within the engine. In addition, if the engine is made of materials that can withstand higher temperatures for longer, the engine life span can be extended as well. Ten years ago, AFWAL began developing a new group of metals called Directionally Solidified metals. These are metals with the grain running in a single direction to provide increased strength and greater temperature tolerance. Following development of these metals was the development of single crystal airfoils, in which the whole airfoil is a single crystal with no grain boundaries at all. Dr. Reimann estimates these metals will allow engine designers to increase operating temperatures by 150 to 200 degrees Fahrenheit. He indicated that engine components made from these materials may enter service within three to five years.

To further strengthen engines, the lab is also developing a process to produce Rapid Solidification Rate (RSR) materials. Essentially, these are amorphous structures developed by cooling the alloys so quickly (at the same time as they are being processed for use in powdered metallurgical casting) that very strong but incompatible alloys don't have a chance to segregate. RSR technology may even provide the means for alloying plentiful, but incompatible, elements with no loss of strength, resulting in conservation of strategic materials. Parts made from RSR materials will be ready for testing in engines in about three to five years, according to Dr. Reimann.



The Advanced Turbine Engine Gas Generator Program's core engine features forty-five percent fewer parts than its predecessor and is four times as durable.

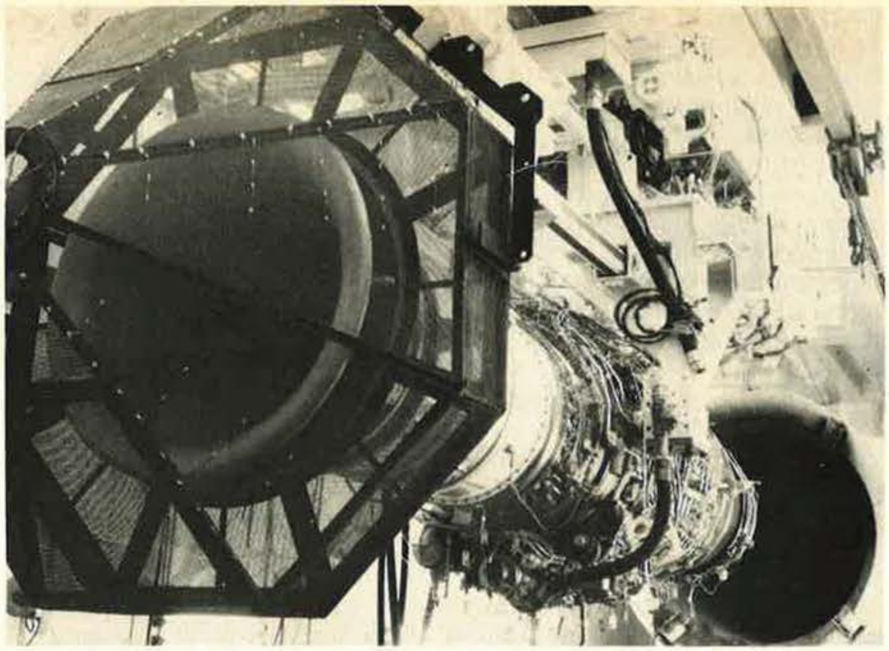
Another manufacturing improvement being developed within the lab is the fabrication (as opposed to casting) of turbine blades. Fabricating blades allows the use of strategic materials to be limited to those blade portions that require them. In addition, more complex and effective geometric cooling patterns can be built within the blades to further increase their life span. These new techniques are expected to be ready for application to engine parts in five to seven years.

Also being developed for the lab by the engine industry is a process to cast large engine structures, such as frames, rather than fabricate them. These structures require only 400 pounds of metal for casting and machining compared to more than 1,000 pounds required when fabricated structures are produced separately. In addition, these castings have a demonstrated cost savings of twenty percent.

Another process, called Directionally Solidified Eutectics, offers the possibility of building even stronger engine components. Essentially, this process involves setting intermetallic fibers into a nickel matrix and offers strength increases for engine parts similar to those provided by composite fiber materials to aircraft structures. Dr. Reimann suggested that this new technology may begin testing in two years, although it is still ten years away from application.

Still other materials are being developed by the lab for specific engine purposes. New thermal barrier materials to coat engine blades and vanes, for instance, may allow higher temperatures to be used without having to change the basic blade composition. Carbon-carbon composites are also being developed. These very strong, nonmetal materials may provide new strength to even the hottest engine components. The lab is also working with titanium aluminide alloys, which have a lower density than nickel and may offer a lighter but still durable engine material.

Another application being developed in the lab stems from an in-house idea to use enamels as damping materials in the hot sections of engines. Previous damping applications involved elastomeric materials used only in relatively low temperature areas, like the TF30 guide vanes of the F-111. Engineers in the Materials Lab, along with university researchers, realizing that damping for high-temperature parts would reduce the life-cycle costs of some engine components, researched a method of using specific enamels that become elastomeric at high temperatures. The procedure has already proven successful at 2,000 degrees Fahrenheit.



The GE-23 Joint Technology Demonstrator Engine (JTDE) developed for the Air Force and Navy has two sets of variable-area bypass injectors (VABI) to provide the ability for reconfiguration in flight, thus ensuring efficient operation at various altitudes.

Building an Engine from New Materials

Though these new materials provide the means of increasing the durability, strength, and power of new engines, they remain just ideas until engines are actually built. That's the purpose of the Aero Propulsion Laboratory's Advanced Turbine Engine Gas Generator (ATEGG) Program and Aircraft Propulsion Subsystem Integration (APSI) Program.

ATEGG, which began in 1965 as an engine capabilities testing program, is now developing new, more durable engine cores with increased performance capabilities. APSI is the follow-on program that adds fans and other components to the ATEGG-developed engine cores.

The ATEGG engine cores consist of advanced combustors, compressors, and turbines. Under the APSI portion of the program, these cores are built into demonstration engines to test further the performance and durability of the various components, as well as to evaluate engine design techniques developed in the two complementary programs. Three of the contractors—General Electric, Pratt & Whitney, and Detroit Diesel Allison—are developing engines for transonic/supersonic applications, while Teledyne CAE is developing small to mid-size aircraft engine designs. One of the ATEGG-developed cores has already undergone initial life testing, according to ATEGG Program Manager Dick Quigley. That core engine, developed by GE and the lab for the Air Force and the Navy, is used in the GE-23 Joint Technology Demonstrator Engine (JTDE).

The GE ATEGG core includes a dual-wall combustor designed to significantly increase cycle life. The combustor's inner wall is lined with floating shingles that handle the thermal load while the outer wall is specially designed to handle the mechanical load. In addition, this core engine also features advanced turbine blades of metals known as Rene 80 and Rene 150. The tests were successful, and Mr. Quigley estimates that the ATEGG core may be capable of four times the durability of existing engine cores.

Variable Bypass Ratio and Fuel Savings

Another feature of the ATEGG/APSI program is the development of a turbine engine capable of performing a variety of fighter missions. Aircraft engines today are designed to operate most efficiently in a specific mission environment. Such things as the engine's bypass ratio and fan or low pressure compressor are optimized for the altitude and speeds expected of the aircraft. High-flying, fast reconnaissance, and air-superiority systems, for instance, have a low bypass ratio fan and compressor in front of the engine core.

On the other hand, transports, having a greater requirement for fuel efficiency, use large high bypass ratio fans in front of the core engine. The goal of the engineers in the APSI program is to show that it is feasible to develop and mechanically reconfigure an engine in flight for optimum performance.

APSI Program Manager Bob Panella describes the work being done as "variable cycle engine technology." The value of the new technology, already demonstrated in the GE-23 JTDE, is "greatly improved performance of the multi-mission aircraft," according to Mr. Panella. "For example, in one mission the engine configuration could be changed from maximizing fuel efficiency while cruising to and from the battle zone to maximizing thrust but still preventing stall in the combat area."

Basically, the GE design features a split fan capable of both single and double bypass operation, driven by a single-stage variable-pressure turbine. Variable area bypass injectors (VABI) are installed in the front and rear of the engine to alter mechanically the bypass ducting on demand and to achieve the various bypass ratios required. The result of the design is an advanced engine with ten individual control variables (compared with the traditional five in the F100 engine).

The technology being developed through the ATEGG/APSI programs promises significant improvements in durability. To measure the engine's performance and ensure the accuracy of life-cycle predictions, the test engine was outfitted with 1,000 channels of instrumentation. Test results indicate that the core will be four times as durable as existing cores with forty-five to fifty-five percent fewer parts in the whole engine, and will achieve a seven to ten percent fuel savings. Tom Sims, Propulsion Branch Chief within the Aero Propulsion Lab's Turbine Engine Division, estimates that the technology demonstrated by the ATEGG and APSI programs may result in reducing engine life-cycle costs by as much as twenty to thirty percent.

Electronic Engine Control

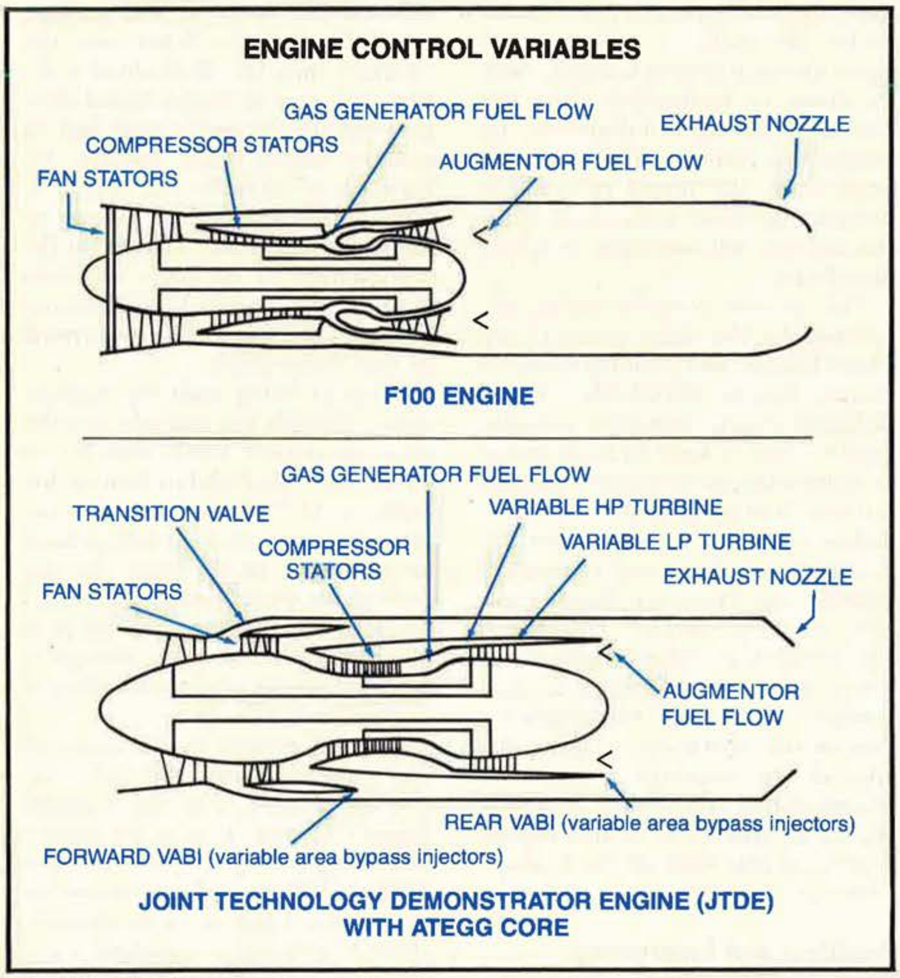
With the GE-23 having twice as many control variables as the F100 engine, the need for accurate, rapid control of the engine becomes even more critical. The control tasks involved have become too complex, and the computational burden too large, for traditional engine controls. To counter these difficulties, the Aero Propulsion Laboratory is exploring the use of solid-state electronics for engine control. Les Small, technical area manager for engine control and diagnostics, notes that "commercial solid-state electronics provide a more compact, lighter, less expensive, and more capable alternative."

Currently, military engines such as the F100 have supervisory electronic control systems that trim or fine-tune electrically and hydromechanically controlled sensors to monitor engine functions. Within this limited application of engine control electronics, sensors are even tied to an onboard diagnostic computer. AFWAL efforts are now directed toward Full Authority Digital Electronic Control (FADEC) for electronic control of all functions. FADEC interfaces with other aircraft electronic systems to evaluate the flight environment at all times, determine the appropriate engine control outputs required, and make those outputs through a series of electrohydromechanical interfaces to control fuel flow and other engine variables. In addition, the FADEC concept calls for a digital data link.

State-of-the-art electronics are already being used by NASA in a Digital Electronic Engine Control (DEEC) program on an F-15. Mr. Small emphasizes that these tests and the technology in use are strictly initial efforts and are limited by such state-of-the-art problems as a system reliability less than that desired. Control applications are further limited by conventional, single-loop, control-logic design techniques and acquisition costs of $250,000 and up.

Nonetheless, the operational potential of FADEC-equipped aircraft is so significant that FADEC is included in a major AFWAL-wide initiative to develop functionally integrated, electronic control systems for aircraft. FADEC, when integrated with other aircraft control systems, will reduce engine life-cycle costs because the more efficient management of controls will result in fewer thrust deviations and engine cycles required for low-altitude missions. Further savings will result from the lighter FADEC-control hardware. AFWAL authorities also anticipate a reduction in the size of the airframe itself, and increased combat lethality and survivability of weapon systems resulting from more effective integrated control capabilities.

At the Aero Propulsion Laboratory, the developmental work on FADEC control systems is still in its initial phases. The direction of the research and development effort is aimed at an immediate goal, as well as a longer range one. The first is the development of dual-channel electronic control architectures that are now being designed. Currently, the project's engineers have rejected other alternatives for



The GE-23 JTDE compared to the F100 engine now in service. There are ten engine control variables, compared to five on the conventional engine. Movable bypass ducting and other factors make electronic engine control a must on such engines.

a variety of reasons—triplex or quadraplex systems, for instance, provide a high degree of reliability but become too expensive, according to Mr. Small. To achieve the degree of reliability required, Mr. Small indicates, "We have to design it into the system. During the design stages, this can be accomplished efficiently—ensuring that acceptable levels of reliability are reached." Only when the required level of reliability demands additional redundancy will it be provided.

Mr. Small estimates that dual-channel electronic controls with advanced multivariable logic and an acceptable level of reliability will be available in about five years. But, he stresses, that isn't the end of the development. The second goal of the program, a follow-on system, is already being worked on. Called an integrated fault-tolerant control system, it would be fully integrated with the aircraft and all other aircraft control systems to provide the most effective, reliable, and efficient management of aircraft controls possible. Mr. Small estimates that this technology should be available before the turn of the century. "We are making all the right moves," he says, "to ensure that we design what we need. In fact, in three to four years we should be able to develop the integrated flight and engine control technology required for a short takeoff and landing fighter aircraft."

STOL Engine Developments

One of the benefits of current fighter aircraft like the F-15 is their ability to take off from short runways. This is especially significant in launching combat missions following an enemy attack. However, landing still requires significantly more runway than takeoff. With this in mind, two APL engineers, Harlan Gratz and Ron Glidewell, and a Royal Air Force exchange officer, Squadron Leader John Blackman, have been examining thrust-reversal systems to reduce the landing roll of fighter aircraft.

Under the direction of the Aero Propulsion Lab's Turbine Engine Performance Branch Chief, Jack Richens, the group studied various means of reducing landing roll. "Drag chutes, runway engagement barriers, and other systems can reduce landing roll," says Mr. Richens. "Our studies are looking at thrust reversal as another option." Thrust reversers are the most effective systems on wet and icy runways.

The group has two separate programs operating at the same time. The first, the Approach/Landing Thrust Reverser (ALTR) program, involves designing and testing an engine-mounted mechanical thrust reverser. It is designed to balance the takeoff and landing distances. At present, Phase I (system trade studies and concept selection) has been completed. The group is now entering Phase II, wind-tunnel testing on an F-15 model, to evaluate the overall impact of the selected thrust reverser concept.

The advantages of the group's thrust-reverser design aren't just a reduction in landing roll. Squadron Leader Blackman says, "The thrust reverser will be deployed on approach, allowing the aircraft to make its final approach and landing under full military power." He notes also that aborted landings will be easier to accomplish since the aircraft is already at full power. To ensure that control surfaces remain unaffected, the thrust reverser is designed to vector thrust away from the aircraft, left and right, at a balanced rate.

The second program being developed by the same group is the Short Takeoff and Landing Exhaust Nozzle Engine (STOLEN). Three different thrust vectoring exhaust nozzle systems have been designed to replace the static nozzles used on current transonic and supersonic fighter engines. The three-year-old program is attempting to reduce takeoff and recovery runway requirements to 700 feet. To counter the control problems that result when the engine nozzle is cocked toward the ground, the engineers plan to use canards on the front portion of the fuselage. For wind-tunnel testing, the group is configuring nozzle models to fit on a Highly Maneuverable Aircraft Technology (HiMAT) aircraft.

Auxiliary and Emergency Power Development

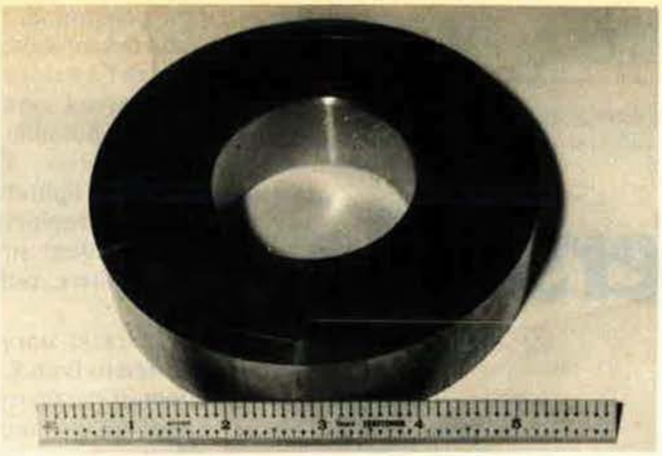
In another part of the Aero Propulsion Lab, the Aerospace Power Division is developing new designs for auxiliary power units, jet fuel starters, emergency power units, and generators. Among their most significant developments is the Super Integrated Power Unit (SIPU). Dr. Buryl McFadden, a division engineer, had the idea a few years ago to build on the auxiliary power unit and jet fuel starter system, using gas turbines.

The idea, according to Dr. McFadden, was to combine a jet fuel starter and an independent gas generator in such a way that the system could be used to restart an engine or provide emergency power independent of altitude and temperature. "The need is obvious, on aircraft like the F-16 with its fly-by-wire control system," Dr. McFadden says. "If you lose electrical power, for whatever reason, you can't control the aircraft."

Essentially, the system that Dr. McFadden designed uses single-shaft gas turbines not only for auxiliary power but for engine start as well—similar to the system used on the B-1's engines. What puts the "super" into Dr. McFadden's design is its use of stored liquid oxygen and the aircraft's own fuel to achieve engine starts quickly, regardless of altitude and temperature. This is accomplished by using liquid oxygen as an oxydizer for the combustion of jet fuel. Previous start systems typically used stored hydraulic pressure or an air turbine to start the engines.

SIPU is being built by Rocketdyne. Though the contract for the developmental work was let in 1978, Dr. McFadden began his work in 1975. Since this was unsponsored research, resulting from his own idea, he attributes the success of the project and its obvious application to fighters "to the people in the lab. I was lucky enough to work for people who were willing to commit resources to it."

Another project in the same lab that benefited from the same encouraging attitude is the Variable Speed Constant Frequency Generator being managed by the lab's Dr. William Borger and developed by the General Electric Co. In the past, aircraft generator systems were large and required the use of a constant-speed-drive device to translate the varying aircraft engine



A section of the variable-speed constant-frequency generator rotor, showing the rare-earth permanent magnets.

speeds into the steady speed required by a generator. The generator constant-speed-drive system is costly, requires frequent maintenance, and has limited reliability resulting from fluctuations caused by the aircraft's attitude, gravitational forces, and other factors.

Building on the work previously done to produce a variable-speed constant-frequency generator system, Dr. Borger's program built a similar device but raised the power output to 60 kVA. The system incorporates a new permanent magnet generator in place of the conventional generator. The permanent magnet generator was made possible by the development of samarium-cobalt magnets in AFWAL's Materials Lab. Rare-earth magnets are up to six times stronger than conventional ones.

Permanent magnets, developed initially in the 1960s, provide the means to achieve higher speeds in the generator rotor to attain greater electrical output from smaller generators. The power from these generators is then fed to an electronic constant-frequency converter located elsewhere in the aircraft. Gravitational forces, engine power settings, aircraft attitude, and other factors that caused power fluctuations and failures in previous constant-speed-driven generator systems will not affect this system.

The system has already been tested, and results indicate that the permanent magnet, solid rotor generator is ten to twenty percent more efficient. Though Dr. Borger can't estimate life-cycle savings from the permanent magnet generator system, he indicates they will be considerable.

In addition to the obvious value of this new generator for providing the high electrical power levels necessary to operate avionics and other aircraft systems, reversing the generator's electrical flow by connecting 400 Hz of external AC power into the generator allows it to function as a starter motor. In fact, the lab and GE recently completed a test on a TF34 engine of the New York Air National Guard's 174th Tactical Fighter Wing at Syracuse. Using the generator as a starter motor, the TF34 was started ten seconds faster than possible with the conventional starter system.

The Variable Speed Constant Frequency Starter-Generator is slated to be field-tested for a year aboard two A-10s at Nellis AFB, Nev., this year. Not only will the test program evaluate the generator's capability, it will include use of the system to start the A-10s' engines as well.

Other Programs

The development work at the Material and Aero Propulsion Labs isn't limited to the programs described above. A number of other programs promise additional improvements in engine technology in the future, and some, like the alternative fuels program in the Aero Propulsion Lab's Fuels Branch, even offer significant advances beyond the immediate aerospace applications.

Dr. Herb Lander, Technical Manager for Alternative Fuels, indicates that the Lab has developed technical information about the suitability of domestic shale oil for meeting future Air Force jet fuel requirements. Shale oil processing studies have been completed and indicate that this source is the most viable option. In fact, interest in the Lab's program is increasing as anticipated cost of shale-oil-derived and petroleum fuels approach equity. The impact of the Lab's leadership in this area is especially noteworthy since the US has more rich shale-oil reserves than the total oil reserves in the Middle East. What's next? Dr. Lander says an entire Air Force base will be operated on shale-oil fuels in several years. A logical transition program is being concluded—it will lead to the first commercial use of synthetic jet fuel in this country.

On another front, the Aero Propulsion Lab is developing a replacement for the satellite solar cells now in use. Using multiband-gap cells, Jim Reams, Director of the Aerospace Power Division, anticipates "an increase in sunlight conversion efficiency by seven percent (to twenty-two percent) with every percentage gain translating to about $15 million in life-cycle cost savings." In a related area, a nickel-hydrogen battery is being developed with twice the energy capability of the nickel-cadmium batteries now in use. In this area, every pound of battery weight savings is worth about $20 million in life-cycle cost savings.

The list could go on and on. The contributions made by the Materials and Aero Propulsion Laboratories—as well as other parts of AFWAL—to the next generation of jet engines are too numerous to mention. But they are there—providing the technology to upgrade continually the weapon systems already on line today, and pointing the way toward better aircraft in the future. Aircraft with engines that are not only more powerful, but are also more durable, more easily maintained, have fewer movable parts, contain common core parts, are versatile enough to perform varied missions more efficiently, use less fuel, and are more reliable than their predecessors is a big order for the men and women at AFWAL and at the commercial development facilities working under AFWAL contracts. But there's no doubt about how far they've come or how optimistic they are about the future. ■

US engine manufacturers and the Air Force have a wider range of choices for powerplants in future designs because the range of technology encompasses small as well as large turbine engines.

Small Is Versatile

BY STEVEN L. THOMPSON

BIGNESS is seductive. As an engineering ethos, sheer size has been as attractive to aviation designers and system planners as it has been, until recently, to automotive engineers and marketers.

Size connotes strength, suggests reliability, and allows room for error in manufacturing. With the breakneck pace of aircraft development since World War II demanding capabilities that stretched the limits of available technology in airframe and powerplant design, engineers have usually gone upscale in search of the performance desired by military planners. The results have been spectacular: transport planes like "aluminum overcasts," fighters with breathtaking speeds and acceleration, and strike aircraft of awesome delivery capabilities.

But the results of Big-Think in aircraft also have had less desirable effects. Capacity was mistaken for desirability. Engines and airframes advanced exponentially in cost. Fuel efficiency plummeted as power and weight requirements crept ever upward. Audio, visual, and infrared signatures pinpoint our aircraft like neon signs. In short, in aircraft as well as automobiles, too much bigness has simply become too much.

This trend has not gone unnoticed. It wouldn't be speculation to correlate the trends in engine design and manufacture with a general, industry-wide kindling of interest in expanding the meaning of "mission efficiency." In the past, the term might have applied mostly to the actual mission of a given piece of hardware itself; now, in both military and business aircraft, it means far more. It means that the whole system surrounding the hardware, from drawing table to maintenance shed, must be scrutinized to ensure as much efficiency as possible. Not surprisingly, this has resulted in less design-office pounding on doors marked "Breakthroughs" and more backtracking to explore heretofore bypassed areas of refinement.

Powerplants are central to this activity, because it is around powerplants that mission capability is defined. You cannot expect to loft a certain weight a certain distance along a certain track without a powerplant to do the job. Gas turbines, as the latest matured propulsion systems for aircraft, are still most often chosen for the job. But now that the first phase of jet development is over (in which "unkunks" plagued the industry, in the form of contracts being placed for as-yet unbuilt engines whose unkunks were "unknown dollars chasing unknown problems"), the cutting edge of technology isn't being used to carve out ever higher Mach numbers, it's slicing off the undesirables that came, willy-nilly, with the first phase: weight, fuel inefficiency, cost, complexity, difficulty of maintenance, egregious signatures, and, of prime importance now, strategic-materials reliance.

Search for Efficiency

With few exceptions (such as the USAF's Advanced Turbine Engine Gas Generator program, or the joint Navy/USAF Aircraft Propulsion System Integration project, explained elsewhere in this section), the impetus for this search for efficiency came first from commercial aviation. The reasons are clear. Because they feel the instant impact of any cost, from fuel to environmental constraints to frowning corporate bean counters daily challenging a bizjet's *raison d'être*, commercial operators constantly seek the lowest possible costs and highest efficiencies. Thus the trend to smaller, lighter, simpler turbofan engines replacing older turbojets was evident in replacement programs there, rather than in the military.

At least until recently, that is. Listen to Ivan E. Speer, Vice President of the Garrett Corp.'s Aircraft and Aerospace Group: "That's starting to change. The tendency to smaller vehicles with more fuel efficiency, more weight efficiency, and less cost is starting to drive Air Force requirements right down into our ball game."

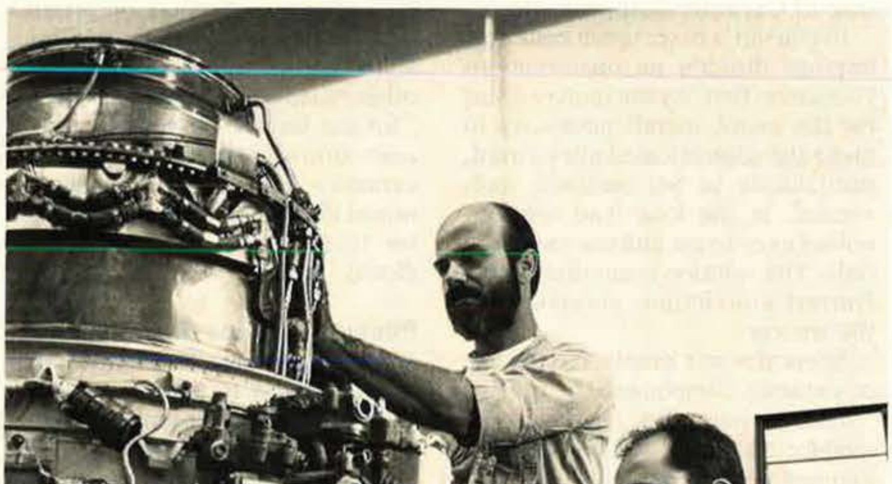
That "ball game" is the development and manufacture of small turbofan engines. It's a game Garrett doesn't play alone, of course; a handful of other US companies is on the field, too. Avco Lycoming's Stratford Div. joins with its ALF502 two-shaft geared turbofan, chosen to power the Canadair Challenger, British Aerospace BAe 146, and as the F102, the NASA Quiet Short-Haul Research Aircraft. Teledyne CAE builds a whole family of small turbines, from the circa-1,000-pound-thrust J69, to the J100 group (2,700-pound and 3,050-pound versions) and the 660-pound J402, which is used for Navy missiles and the Boeing variable-speed training target.

General Electric's venerable J85 turbojet has powered everything from Cessna A-37s to Northrop F-5Es, and a subsequent development of the engine—the CJ610—is used in bizjets like the Lear 25 and IAI Westwind 1121. Further refinement of the CJ610 turned it into the CF700 fanjet, a circa-4,000-pound thruster for bizjets, or, thanks to its swivelling capability, as a VTOL military engine. Pratt & Whitney showed up in the class with its JT12 engines for both first-generation Lockheed JetStars (USAF C-140s) and Rockwell Sabreliners (USAF T-39s). And, finally, in the really small range, Williams Research Corp.'s engines—all in the sub-1,000-pound class—power RPVs, drones, and cruise missiles.

Each of these companies has chosen a different combination of engineering and marketing strategies to enter and compete in the small-jet bourse, but none came into it in quite the oblique way of Garrett—or, to be fair, with Garrett's meteoric rise to success. *Jane's* introduction to the company in its 1979–80 Yearbook says that Garrett "has been called the world's largest supplier of small gas turbines. Development of the first small Garrett turbines began in 1946, and the division claims to have produced over 70 percent of the total of gas-turbine units with power ratings from 60 to 2,500 hp built in the United States and Europe."

John C. "Cliff" Garrett formed the company in 1936 with fewer than a dozen employees. His original intention was to market aircraft tools, but in 1939 he founded AiResearch to design, develop, and produce air-related products, beginning with an oil cooler and cabin-pressurization system. Lessons learned quickly prepared the company for building a wide range of aircraft ground equipment, including a ground-start cart for the hard-starting early jets of the postwar years.

Because Garrett built the turbine for the APU, by the mid-1950s its expertise in small-turbine technology was, according to industry analysts, second to none. This achievement did not stem solely from Cliff Garrett's prewar work; it also derived substantially from Garrett's acquisition not only of data from World War II German gas turbine research, but also the active participation of several men who had done the research. In 1958, Ivan Speer, hired as an engineer in 1946 and by then head of the Phoenix division, turned corporate attention to the possibility of using Garrett's small-turbine technology in a prime propulsion unit, using the core of the APU as a foundation.



Garrett Turbine Engine Co. mechanics Ted Moore and José Salazar assemble the company's 3,000th TFE731 small turbofan engine. The TFE731 is in worldwide service with fifteen different business jets and two military aircraft.

First Paying Customer

The result was the first Garrett turbine engine, the TPE331. It was designed initially to fit into the then-most likely market—helicopters. The 331's first paying customer was the US government. The Air Force and Navy found Speer's arguments that the 331 was the perfect engine to power the COIN aircraft, then being touted as a "brushfire" air-power panacea, persuasive enough to install it, as the T76, in all versions of the OV-10 Bronco. Likewise, when Mitsubishi entered the business-twin market in America, it chose the 331 as its powerplant. Subsequently, the engine found its way onto the wings of Rockwell, Cessna, Swearingen, and enough other aircraft to give Speer and Garrett confidence in the idea of building propulsion engines around APU sections.

He next applied the notion to a DC-10/747 APU and produced the TFE731, a two-spool geared fanjet in the 3,500-pound-thrust class. And, at almost the same time, an engine tagged the ATF3 was also built and tested, intended as a more powerful stablemate for the 731, but having some important differences. Like the famous Rolls-Royce RB.211 engine, it was to be a three-spool engine, but using reverse-flow burning and exhaust mixing. As such, it was the first three-spool engine to run in the USA and was the first in the world to combine its unique features.

Like the 731, though, its immediate goals were, first, to replace the aging bizjets of the time, and, second, to power the new, second-generation jets. But times were tough, and the severe downturn in commercial and general aviation in the last months of the 1960s and early 1970s forced Garrett to focus marketing attention on just one engine. It chose the TFE731, which quickly found customers; first Dassault-Breguet installed it, in 1972, on the new Falcon 10, then Lockheed JetStars, Lear 35/36s, Citation IIIs, Falcon 50s, HS 125-700s, IAI 1124s, Rockwell Sabreliners, and even the Spanish CASA 101 trainer/light-attack fighter found themselves powered by 731s.

The first use for the ATF3 was, again, by the Air Force. Garrett installed an engine in a Teledyne/Ryan Compass Cope high-altitude RPV and engaged in "developmental" flights, in the process setting some records, including flying more than twenty-four hours, unrefueled, at altitudes in excess of 55,000 feet. First commercial use of the engine was again with a Falcon order, this time to power the Coast Guard's HU-25A medium-range surveillance aircraft.

Experience gained by this rapid growth has led, inevitably, to the forging of strong views at Garrett on the entire matter of working with minijets. As the man who is credited with the inspirations for most of the experience, Ivan Speer articulates those views clearly.

One of his strongest observations is that building new engines by evolutionary means is by far the best method. "An all-new engine," he says wryly, "is a sporty course. Even the military is recognizing that if you can do the job by an evolutionary application of later technology, you've got a better starting point." Conventional wisdom suggests that it requires up to 1,000,000 hours of flight and a decade to mature advanced fighter engines.

In the Garrett view: "The same infinite wisdom would apply [to our engines], but we'd hope to do it by applying the *last* 1,000,000 hours and thereby get something that's reasonably mature for less time and money." Speer will then pull out a chart and demonstrate graphically the familial relationship of one product to another, like an anthropologist tracing an ancestor tree. Using known components in new designs is hardly unique to Garrett, but the care with which Speer outlines the growth of this unit to that shows that, at the very least, the oft-stated desire to save money is no mere platitude.

Costs clearly occupy a lot of Speer's attention. Garrett has just completed a huge expansion of its Phoenix plant, and "feeding that hungry monster" of production capacity demands that the question of costs never be far from any Garrett project engineer's mind. Because Garrett primarily services the volatile bizjet market, this cost-consciousness drives an imperative that neatly converges Garrett's interests and the military's—the reduction of reliance on strategic materials.

Use of Ceramic Components

In Garrett's case, those materials impinge directly on operations in two ways: first, by the money spent for the exotic metals necessary to make the sophisticated alloys used, particularly in hot sections, and, second, in the long lead time required even to get and use the materials. The solution is another strong Garrett conviction: ceramics are the answer.

Speer doesn't simply see the use of ceramic components to replace "strategic-impacted" parts as desirable; he makes it clear that it's demanded by economics. As a result, Garrett is working closely with Ford on an automotive powerplant with heavy use of ceramics, and, on October 30, 1981, the company released details of fifteen hours of cyclic testing of a T76 turboprop equipped with a ceramic-bladed turbine. This is an indication of just how seriously Garrett—and Defense Advanced Research Projects Agency (DARPA), which funded the project—takes ceramics.

The problem is, says Speer, that ceramic development for this application is much like small-jet work itself; you wind up doing all the basic research and development yourself. In small jet design and production, this means overcoming the considerable theoretical and practical difficulties of scale, such as the much different air masses being moved, higher rotational speeds and inertial loadings, and manufacturing tolerances and techniques, which must be much tighter to ensure efficiency. In ceramics, he says, it means the supplier "just wants to deliver the powder," leaving the problems of forming and sintering to the user.

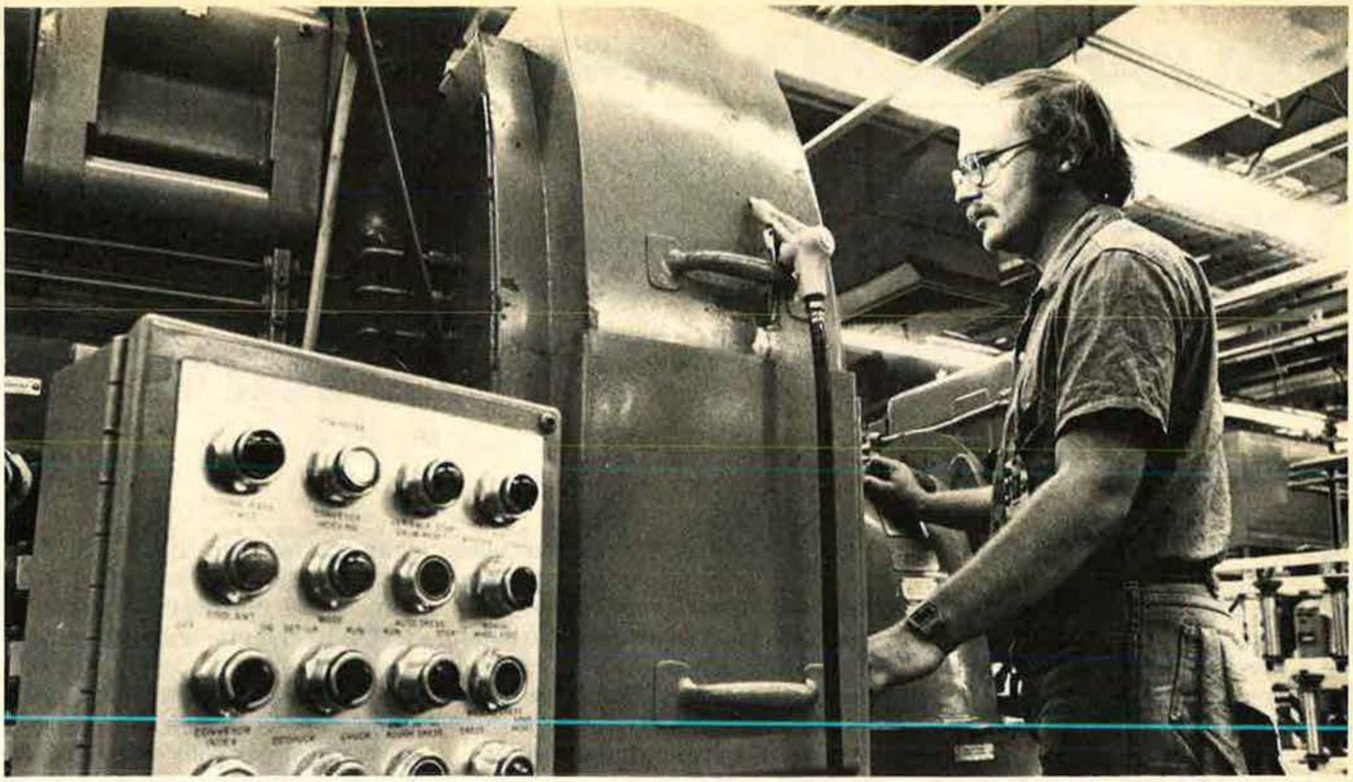
So far, despite the success of the T76 ceramic engine, the stubborn inelasticity of the silicon carbide or silicon nitride blades once they're formed is holding up progress. In order to relieve stress or to change blade shape, a diamond grinder must be used—not a spectacularly cost-effective method of production. However, work in ceramics will continue at Garrett, if for no other reason than, as Speer puts it, "for gas turbines to hack it in low-cost aircraft, they'll have to use ceramics. The cost of materials has raised the cost of engines much faster than any of the indices predicted."

Pitching for Blue-Suit Business

The transference of this cost-consciousness to military work results in Ivan Speer's conviction that such low-cost turbines would find an instant military use in expendable powerplants, like those used for RPV or drone missions. That Air Force R&D people have made the same connection is clear when Speer mentions that Garrett has participated in "more than fifty" technology projects for the Air Force over the years. With this history of close contact, with the ATF3 and 731 still looking for new customers, and with ceramics work at Garrett's Torrance, Calif., facility so promising, it would seem strange if Garrett were not pitching heavily for blue-suit business. And so, of course, it is.

Not only has Garrett already proposed to power the tanker/transport/bomber (TTB) companion trainer (in Learjet, Sabreliner, or Falcon forms), but as this is written, the Phoenix Div. is preparing its response to the request for proposal for the NGT, or Next Generation Trainer. In addition, much of Gar-

*Steven L. Thompson's article, "LaserCom: The Green Dragon Awakens," appeared in the July '81 issue. He is a pilot and aerospace writer whose work includes novels (*Recovery, *Warner Books, 1980, and its sequel,* Countdown to China, *scheduled for release later in the year) and editorial consultation in various magazine fields. He is a member of the American Aviation Historical Society. His third novel,* Dancer, *involves Grumman SA-16s and the 1956 Hungarian Revolution.*



Keith Duckworth, a Garrett machine operator, uses a Curvic Grinder to put curvics on TFE731 engine parts. Curvics, which look like gear teeth, are mated to their counterparts to ensure accurate radial and axial alignment of the engine.

rett's corporate imaging recently has been aimed at acquainting potential military operators with the charms of its experience and engines, along with its success stories in the military genre, from OV-10 to the Spanish CASA 101.

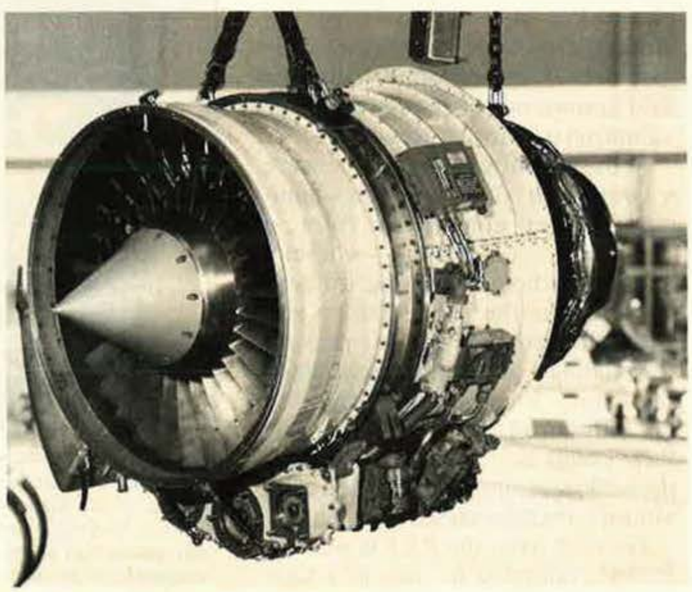
Beyond trainers and unmanned vehicles, though, it's hard for some military aviators to see much of interest in this small-jet world. And it's easy to understand that attitude; after all, historically, the military need was always for more, not less, engine. But in evaluating the activity in this engine class, it's important to keep in mind that the Soviet Union has no equivalent to it, or indeed to the depth of experience at Garrett, GE, Pratt & Whitney, Avco Lycoming, Teledyne, and Williams Research.

The closest thing to a bizjet the Soviets use is the Yakovlev Yak-40, powered by Ivchenko AI-25 engines of 3,300 pounds' thrust. How good is that engine? Ivan Speer smiles and deftly comments with the aerospace engineer's classic "no comment" comment about Soviet equipment: "Where they have to be good," he says, "the Russians build good. Otherwise, it's pretty agricultural stuff." Additional comment comes in another form: when a company called ICX decided to market the Yak-40 in the US, the engines chosen were Garrett's.

The Soviet Union also has no need to develop the techniques of overcoming costs and strategic materials burdens which now occupy American engine makers' attention—and thus, conceivably, will not develop without great effort the evolutionary refinements in design and fabrication that market forces are pushing Ivan Speer and his small-jet colleagues toward.

There may be, as the big-is-best lobby contends, no clearly visible military advantage on the horizon right now as a result of this activity, but there's one more historical lesson to keep in mind. A nation fights in the air with the engines it knows how to build, rather than those that exist only as lines on a drawing table. In that connection, the sharp divergence of Soviet and US experience in the world of small jets could have dramatic importance. ■

Garrett's Ivan Speer headed the company's effort to build a prime powerplant from its Auxiliary Power Unit turbine cores. An obvious success—the TFE731 is a two-spooled, geared turbofan built on the DC-10/747 APU core.



The key to the development of vertical and short takeoff and landing aircraft is not their design so much as that of their engines. In this article, a noted British expert in the field explores the subject of . . .

V/STOL Propulsion: Past, Present, and Future

BY W. J. LEWIS

In one raid in 1945, 284 German aircraft were destroyed on the ground. Since then, there has been an interest in vertical/short takeoff and landing (V/STOL) fighter aircraft by several countries, as the ability to operate from damaged bases and dispersed sites is self-evident. This interest has waxed and waned over the years and has led to research programs both in the US and Europe.

The engineering community first gave consideration to V/STOL when it was realized that the gas turbine engine, with its high thrust to weight ratio, made the proposition possible.

A large range of propulsion/lift concepts have been studied with varying degrees of success. Some were adaptations of existing engines, while others required completely new designs. For several reasons, only one system is currently operational: the Rolls-Royce Pegasus engine that powers the British/USMC Harrier/AV-8A.

For progress beyond the AV-8A and the upcoming AV-8B, the services have to accept the need for high-performance V/STOL aircraft, and realize that any cost penalty is worth paying to achieve the flexibility and mission productivity the aircraft would provide.

One key issue may be whether a conventional engine can be adapted to provide V/STOL capability, thus reducing development costs, or whether a special engine is necessary.

Lift Engines

The first engine to be designed specifically for V/STOL was the Rolls-Royce RB108. A contract was awarded in 1954 and, at the same time, the firm of Short Brothers and Harland was commissioned to build a research aircraft, the SC1, to demonstrate and study the principles of jet V/STOL; four RB108s were intended to provide lift and one propulsive thrust.

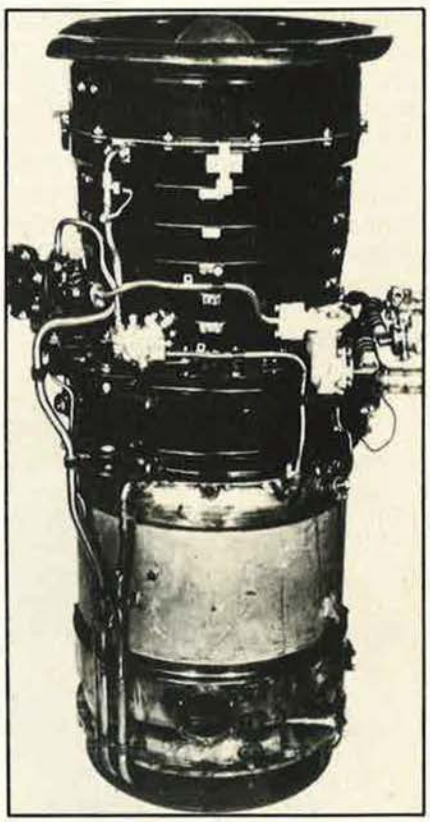
In the US, the emphasis was on using existing engines with modifications to permit operation in the lift mode. Earlier work was with tailsitters and, for example, in the Ryan XV-13 a Rolls-Royce Avon having a deflecting nozzle system and compressor bleed air for control at low airspeeds was installed. The first successful flat riser, the Bell X-14, also used existing engines—a pair of Armstrong Siddeley Vipers fitted with deflecting nozzles.

The RB108 was a single-spool turbojet with an eight-stage axial compressor, an annular combustion chamber, and a two-stage unshrouded turbine. A pressure ratio just over 5:1 was found to be the best compromise between fuel consumption and thrust to weight.

Some features of the engine were a composite air intake, an aluminum, welded compressor rotor, a "total-loss" oil system—whereby after use the lubricating oil was ducted into the jet exhaust—and spring-loaded bearings (to prevent "brinelling" damage in flight when the engine was shut down). Up to ten percent of the compressor airflow could be "bled off" through the hollow mounting trunnion for an aircraft reaction control system.

Derived from the RB108 was the RB145, intended for use in a German aircraft, the EWR VJ-101C. This aircraft was built to provide data for a definitive Mach 2 V/STOL interceptor and had a total of six engines.

The design called for two pairs in wingtip pods, which could swivel through ninety-four degrees from the horizontal to slightly forward of the vertical, and two engines mounted vertically in the fuselage



The first engine designed purely as a lift engine for V/STOL aircraft was the RB108, with a thrust of 2,300 pounds and a thrust-to-weight ratio of over 8, more than twice that of the best, contemporary conventional jet engine.

behind the cockpit. The wingtip engines had afterburners.

The next lift engine in the Rolls-Royce family was the RB162. This doubled the thrust-to-weight ratio of the RB108 from about 8 to 16:1.

The engine was approximately four feet long (or high) and just over two feet in diameter. It produced 4,100 pounds of thrust.

A one-eighth larger version of the RB162 was developed for the German/Italian VAK-191B aircraft, which had a composite propulsion system comprised of RB162-81 lift engines and one RB193 lift/cruise engine. The RB162-81 incorporated a number of design improvements and had a thrust of 6,000 pounds.

In 1965, the US took another look at V/STOL technology to determine whether an advanced V/STOL fighter might have defense applications similar to those of Europe. Germany and the US agreed to conduct a study of high-performance V/STOL fighters entitled "Advanced Vertical Strike" (AVS). USAF decided that turbojet lift engines would be required under the theory that a high thrust to volume was necessary.

The Detroit Diesel Allison Division of General Motors was chosen to proceed with studies.

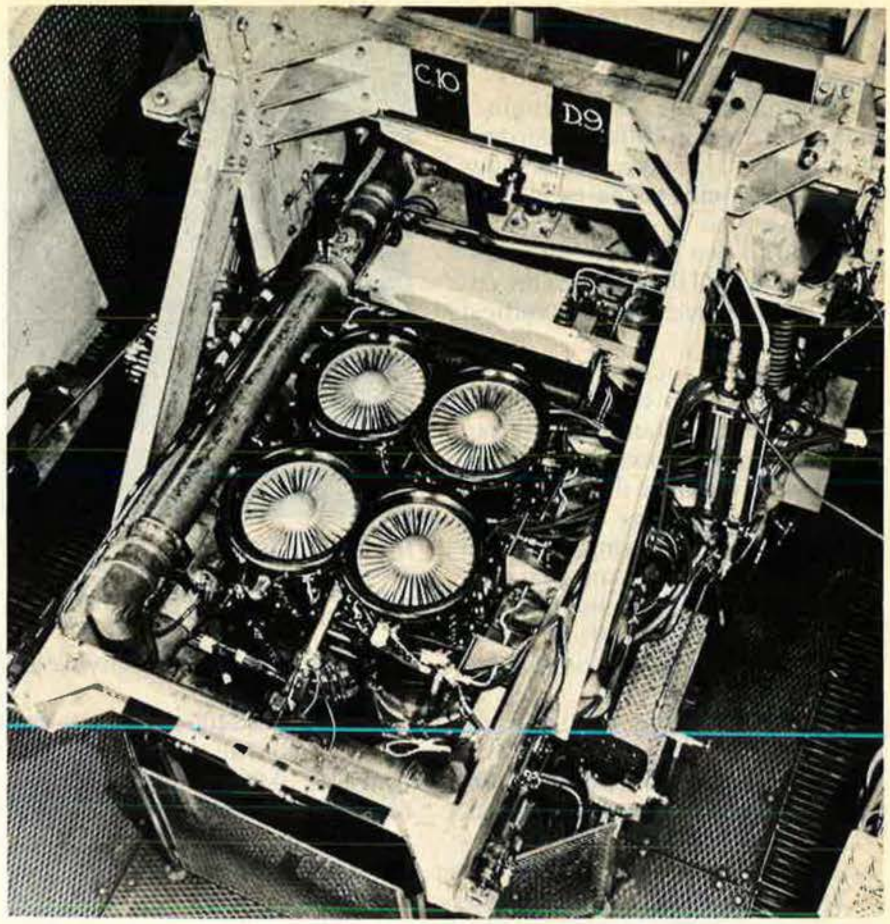
Meanwhile, Rolls-Royce was proceeding with plans for an advanced lift engine, the RB189, intended to have a thrust-to-weight ratio of more than twenty. The company was brought into the US/German project.

The partnership between Rolls-Royce and Allison led to the XJ99 engine, successfully demonstrated in 1968.

The XJ99 was a two-spool engine with contrarotation of the spools. Compared to the RB162, turbine temperature was increased and weight and volume reduced by keeping to a minimum the engine's length. The XJ99 was less than forty-eight inches long with a diameter of about twenty-seven inches. It weighed nearly 450 pounds and produced 9,000 pounds of thrust.

Vectored Thrust Engines

In 1956, a retired French engineer, one Michel Wibault, approached his Air Ministry with an idea for a vertical takeoff ground attack aircraft, the Gyroptère.



Shown above is the installation of four RB108s in the SC1. The engines could be rotated about a horizontal axis through an angle of thirty-five degrees to assist the takeoff and landing transitions. The RB108 engine first ran in 1955.

Its propulsion unit was based on the Bristol Orion turboprop engine, which had a high power "free turbine" that could be harnessed to drive a set of four centrifugal compressors.

The casings of these "blowers" could be rotated to direct the air either downward or backward. Suitably arranged around the center of gravity of a small aircraft, the device would provide thrust for both lift and propulsion.

Wibault was advised to approach the directors of the Mutual Weapons Development Program, or MWDP, in Paris, an organization with access to American resources. This agency suggested that Wibault consult Bristol Aero Engines.

The company's Technical Director at the time was Dr. Stanley Hooker (now Sir Stanley Hooker), and Wibault's idea struck him as an attractive alternative to the Rolls-Royce lift-engines. It would allow Bristol to compete with Rolls-Royce's VTOL designs, without duplicating the rival efforts or infringing on its patents.

The immediate conclusion was that the Wibault design could be improved, in that the four centrifugal compressors and two gearboxes were too heavy. It was suggested that use should be made of two stages of an axial compressor that was being developed for the Bristol Olympus turbojet.

The air from this two-stage "fan," still driven by the Orion through the gearbox, could be taken to two swivelling nozzles, giving either upward or forward thrust. Bristol's first revised version of the Wibault design was called the BE48.

Another analysis of the system determined that the gearbox—and its weight—could be omitted if the fan could be driven directly from the power turbine.

This led to the BE52 in which the compressor and turbine system designed and tested for another Bristol engine—the Orpheus—was used with three stages of the Olympus compressor driven by a two-stage turbine on another shaft.

Originally, the BE52 engine, proposed to the Hawker Aircraft Co. for the P1127 project, had rotating nozzles only at the front. The next stage was to bifurcate the jet pipe and fit two more rotating nozzles—so that all the thrust of the engine became available for vertical lift.

In order to reduce gyroscopic effects, shown to complicate control of the Ryan tailsitter, the fan and compressor spools were made to rotate in opposite directions.

The design change dictated replacement of the Olympus-derived fan, and a larger two-stage fan was designed to feed air to the front rotating nozzles and also "supercharge" the high-pressure compressor.

Since the high-pressure compressor no longer needed its own separate intake, the frontal diameter of the engine could be reduced, simplifying installation in the aircraft.

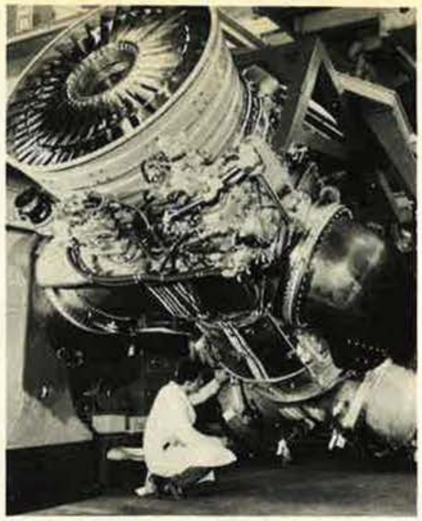
The engine had become a "turbofan," at a time when this new species of engine was just beginning to appear in commercial aircraft. It was now known as the BE53.

The MWDP had agreed to cover seventy-five percent of the initial development cost, with Bristol providing the remainder. Dr. Hooker recalls that the term "vectored-thrust" was first used by Dr. Theodore von Kármán, chairman of AGARD, when he was asked to evaluate the BE53 on behalf of MWDP. *(For Dr. von Kármán's contributions to US airpower, see May '81 issue, p. 60.)*

Two other vectored-thrust engines have been designed and built. The first of these, the Bristol Siddeley BS100, was intended for a supersonic V/STOL aircraft—the Hawker Siddeley P1154.

It was essentially a scaled-up Pegasus with appropriate redesigns for supersonic flight. These included thrust augmentation by burning fuel in the bypass airflow, called plenum chamber burning (PCB), for takeoff and landing as well as supersonic flight.

The second engine was the RB193, a lift/cruise engine for the German VAK-191B and a joint development by Rolls-Royce and MTU in Germany.



The BS100, shown here in final assembly, was designed to have a thrust of 36,000 pounds and a thrust-to-weight ratio of about 8.

Like the BS100, it was a two-spool turbofan with a nominal thrust of 10,000 pounds. One main feature was the ability to bleed off as much as twenty-two percent of the HP compressor flow for aircraft control.

The Present

The BS53, redesignated the Pegasus in 1961, has gone through several design revisions, each aimed at increasing thrust or overhaul life.

Since first run of the Pegasus 1 at 9,000 pounds' thrust, this has more than doubled—to 21,500 pounds. That is the thrust of the Pegasus 11 currently in service with the US Marine Corps, the Royal Air Force, the Royal Navy, and the Spanish Navy.

Thrust growth has been achieved without increase in engine carcass size, to some extent made possible by using short-time ratings needed only for short or vertical takeoff.

One of the toughest mechanical problems solved was that of blade vibration.

The short, high offset bifurcated intake common to the P1127, Germany's Kestrel, and Harrier aircraft introduces a perturbation at the fan face, and the twin-nozzle layouts on the bypass air and on the core exhaust also introduce vibration on the back of the fan and on the LP turbine.

Because of this, the early versions of the Pegasus were very limited in their operational performance; the problem was overcome by fitting "snubbers" on all three fan stages and wire lacing on the LP turbine.

Currently under development are several refinements to increase time between overhauls and reduce maintenance costs.

In addition, a new fan has been tested that will increase thrust by nearly 2,000 pounds, without an increase in the engine's size.

This has been achieved by reblading the fan to increase airflow by four percent and pressure ratio by fifteen percent.

Further thrust enhancements are possible, but become increasingly costly if retrofit capability in the Harrier and AV-8B is to be maintained. The constraints are to remain within the existing engine carcass geometry and to keep the thrust ratio between the front and rear nozzles roughly equal.

Future Developments

Although the AV-8B now seems established as the next step for subsonic STOVL aircraft, there are several options in the longer term. Some questions to be answered:

- Will new engines be designed specifically for V/STOL or will costs dictate adaptations of conventional takeoff and landing aircraft (CTOL) engines?
- Can the cost and complexity of multiengine systems, such as a combination of lift engines and lift/cruise engines, be tolerated?
- What are the in-flight performance requirements?
- Will the field requirements demand vertical takeoff and landing (VTOL), short takeoff and vertical landing (STOVL) or short takeoff and landing (STOL)?

A propulsion system concept evolving from the Pegasus engine in the AV-8B can be identified as

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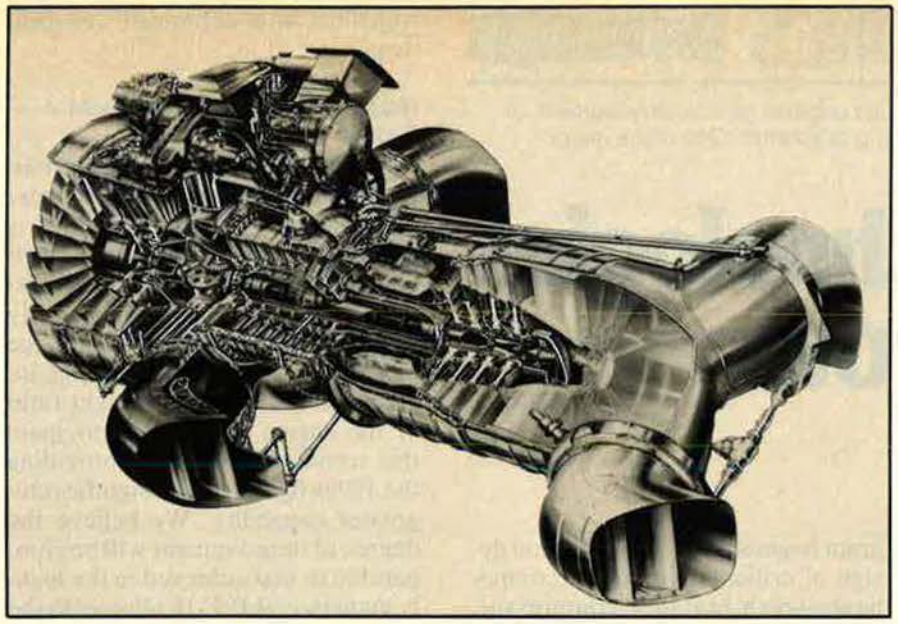
W. J. Lewis is Assistant Chief Engineer for Advanced V/STOL with Rolls-Royce Ltd. A graduate of the University of Bristol with a bachelor's in science, his experience in the field of vertical lift dates back to 1956 and work on the earliest development of the Pegasus engine. Mr. Lewis has written extensively on the subject of V/STOL propulsion.



Compared to the first Pegasus, the Pegasus 11 shown here has an additional fan stage, an additional stage plus variable stators on the HP compressor, and a second HP turbine stage. The lift thrust is 21,500 pounds, achieved by use of a fifteen-second rating together with water injection. The thrust-to-bare engine weight is about 7.

meeting possible future requirements.

This would be to augment the thrust of a vectored thrust engine by means of burning fuel in the bypass airflow—for example, plenum chamber burning (PCB) as proposed on the BS100 engine.

The thrust boost available by this method depends on the engine cycle and the PCB temperature, but with realistic cycles and temperatures a thrust boost at sea level, static conditions of fifty to sixty percent are possible.

The basic engine cycle parameters—overall pressure ratio and turbine entry temperature—need to be little different on a vectored thrust engine than those for an engine for a CTOL aircraft.

The main difference is that the vectored thrust engine will have a higher bypass ratio. This will provide as much thrust as possible from the front nozzle system to ease balancing in the hover and, at very low speed, when the aircraft is supported by the jet thrust. Also to avoid, as far as possible, is the need to augment the core exhaust flow by afterburning, as this would increase both complexity and weight.

The need to keep the thrust line forward during hover makes it desirable for all bypass airflow to be exhausted through the front nozzle system.

Thus, there is no cooling airflow for the core exhaust system, as would be required for a conventional mixed turbofan engine. However, this may imply the need for special materials for the core engine, jet pipe, and nozzle system, and also for insulation to protect the aircraft structure.

An advantage of the separate exhaust systems for the vectored thrust engine is that cycle variability can be achieved very simply by use of a variable area nozzle on the core exhaust flow.

This has already been used on the Olympus 593 engine in Concorde to provide better intake/engine airflow matching, to maximize engine thrust for a given turbine temperature, and to minimize fuel consumption at part throttle subsonic cruise conditions.

The final major difference between the CTOL and V/STOL engine will be the need for the latter to supply large airflows for reaction controls to provide aircraft stability and control at low speeds.

High-pressure air is desirable as it reduces the cross section area of the ducts taking the air to the wingtips and the rear of the fuselage. Thus, it is likely that the bleed position for this air will be at the HP compressor delivery station.

Care will also be needed to ensure that the sudden demand for bleed air for aircraft control does not adversely affect the combustor and the temperature distribution at entry to the turbine.

An alternative to the vectored thrust engine is to use lift engines, in addition to a conventional afterburning engine that has some form of thrust deflection to provide additional lift for takeoff and landing.

The future lift engine is likely to remain a turbojet, having a very high thrust per unit of airflow—the best method for keeping weight and, particularly, volume low. However, this will result in very high jet temperatures, in the order of 2,400 degrees Fahrenheit.

In conclusion, then, it would seem that the best form of protection for aircraft parked on the ground is dispersal, and the surest way of operating dispersed aircraft is to give them a V/STOL capability.

This can be done by adapting a conventional engine or by developing a special V/STOL propulsion system, as in the case of the Pegasus for the Harrier/AV-8A.

Supersonic and high levels of inflight maneuver performance may be achieved by means of thrust augmentation, and one way of doing this is with PCB on a vectored thrust engine. ■

Likely Parameters for Advanced Vectored Thrust and Lift Engines

	Vectored Thrust Engine	Lift Engine
Thrust per lb/sec of Airflow	80–100	90–100
Bypass Ratio	1.0–1.5	0
Fan Pressure Ratio	3–4	–
Overall Pressure Ratio	20–25	6–8
Combustor Outlet Temperature	3,000–3,300°F	3,100–3,500°F
Exhaust Jet Temperature	2,400–2,800°F	2,300–2,500°F
Thrust: Bare Engine Weight	12–14	23–27

AIRCRAFT ENGINES

USAF aircraft of the 1990s will be powered by engines now in development, or for which the new technologies are beginning to emerge. One of the major developers looks ahead to the . . .

Turbine Technologies of Tomorrow

BY FRANK W. McABEE, JR.

A NEW era of supremacy for allied tactical air forces began in the mid-1970s when the F-15 and later the F-16 entered the US Air Force inventory. As Gen. Alton D. Slay, then Commander of the Air Force Systems Command, told US senators, "The F-15 and F-16 are, beyond any doubt, two of the highest performing fighters in the world, if not *the* two highest performing fighters in the world."

By the end of 1981, two years after General Slay's testimony on Capitol Hill, approximately 680 McDonnell Douglas F-15s and 585 General Dynamics F-16s were in service with free world air forces. By the mid-1980s, an estimated 925 F-15s and 1,550 F-16s will be deployed worldwide.

Long Development Process

But the qualitative advantage in tactical airpower provided by these aircraft and other advanced types in service today is not guaranteed to last indefinitely. Historically, there has been a new fighter in development when the previous one reached the midpoint of its life, but this is not the case today. The typical life of a high-performance fighter aircraft system is about eighteen to twenty years, so we will need a replacement for the F-15 as early as 1992 if we are to retain our technological lead. That may seem a long way off, but to achieve a 1992 introduction via a competitive flyoff of prototype aircraft, a new fighter program will have to start in 1984. Moreover, high-technology engines require a longer development period than the fighters they power. To be prepared for a prototype program beginning in 1984, the final design of critical core engine components—high-pressure compressor, combustor, and compressor-drive turbine—should start in 1983. This leaves just one year to blend together various advanced aerodynamic and materials technologies now available to make the powerplant for our 1990s fighter a truly superior system that is totally consistent with its mission requirements.

Despite our time constraints, I am confident the propulsion industry will be in a position next year to initiate development of an engine vastly superior to today's F100 (F-15 and F-16), TF30 (F-14, F-111, and A-7), F101 (B-1), F404 (F-18), and RB199 (Tornado). US engine makers will be ready because of the extensive ongoing industry and government research and development programs conducted independently of production engine programs.

The US Air Force, in conjunction with industry, is presently determining requirements for the Next-Generation Fighter and its propulsion system. As in the past, engine technology improvements that have been substantiated by individual component tests will be available to provide significantly improved aircraft capability. Pratt & Whitney, for instance, began component rig tests of its next-generation compressor, combustor, and turbine in 1981, in preparation for demonstrator core engine tests early in 1982.

Let's look at some of the propulsion system improvements being explored for the Next-Generation Fighter and show how they might translate into enhanced capabilities.

Increased Thrust-to-Weight Ratio

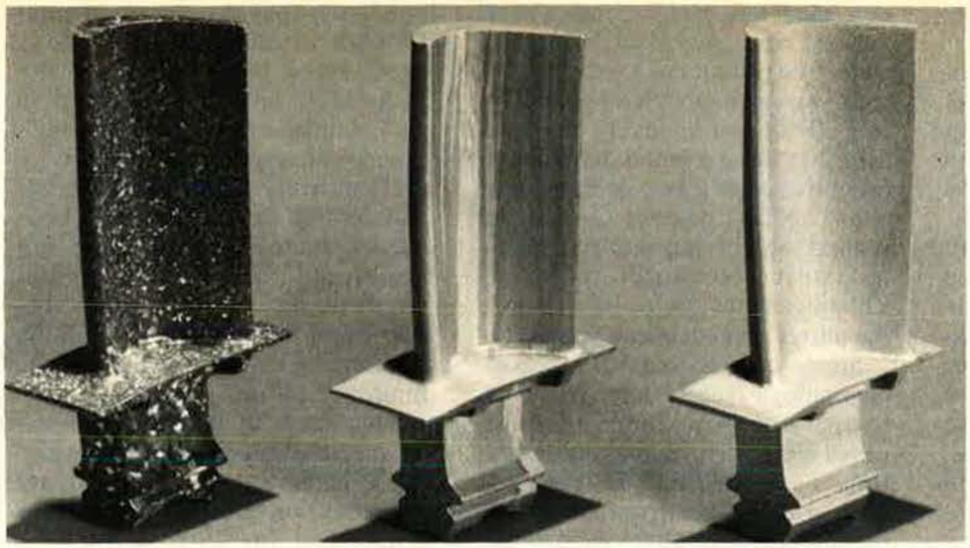
Improved fighter maneuverability expressed in terms of turn rate, acceleration, or rate of climb is directly related to the ratio of available engine thrust to the total aircraft weight. This ratio has nearly tripled since the 1940s, due in large measure to the corresponding increase in the thrust-to-weight ratio of the engine itself. We anticipate this trend will continue, providing the 1990s fighter with a significantly greater capability. We believe the degree of improvement will be comparable to that achieved in the highly maneuverable F-16 relative to the previous generation F-4 fighter, but it will likely take a different form.

Increased thrust-to-weight ratio capability can provide increased supersonic maneuverability and persistence, vertical takeoff and landing (V/STOL) capability, smaller and less expensive aircraft, or some combination of all these features. Increased aircraft thrust loading ratio at the same or slightly lower propulsion weight fraction has been the historical approach to engines with improved capability. If this approach continues, the next generation of engines will reach a thrust-to-weight ratio of 10:1 and provide rate of climb increases greater than thirty percent at Mach 0.9. This also equates to turn rate increases of twenty percent at Mach 1.2. Improvements in other aircraft performance measures, such as a forty percent reduction in acceleration time and a takeoff distance reduction of thirty percent, will also be achieved.

Because of the higher thrust-to-weight ratios of advanced technology engines, it is also possible to design much smaller aircraft with the same capabilities as today's best systems, but with fifteen to twenty percent lower gross takeoff weight. With this approach, cost would be reduced and survivability would be improved.

Effective V/STOL Aircraft

Alternately, highly effective subsonic and supersonic vertical and short takeoff and landing systems can be designed using the new tech-



Advances in turbine airfoil materials over the years have permitted the higher temperatures needed for increased performance and fuel economy. The turbine blade at left was casted using conventional methods; the blade in the center was casted in a columnar grain, an improvement over the conventionally casted turbine blade. Development of new casting techniques will produce turbine blades such as the one depicted at right, made up of a single crystal of metal and extremely resistant to the effects of high temperatures at rotational speeds.

nology. Advanced, lightweight engines will minimize the weight penalty and, in effect, will provide V/STOL capability in tomorrow's supersonic aircraft without compromising the performance or size of today's conventional takeoff and landing systems.

Subsonic V/STOL operation carries the additional burden of requiring more thrust for takeoff than is required for conventional operation. Larger engines will be needed to provide the necessary lift thrust, making engine weight even more significant. In addition, these aircraft are more sensitive to fuel consumption than supersonic V/STOL aircraft. The lighter weight and increased efficiency of the advanced engine will provide the weapon system with the capability to perform the subsonic V/STOL role effectively.

In addition to benefiting the air-superiority fighter and supersonic and subsonic V/STOL systems, an advanced engine can provide significant improvements in supersonic cruise capability. At Mach 2.0, seventy-five percent more thrust is available with an advanced nonaugmented engine than with a current nonaugmented engine. This means that, for a fixed thrust level, augmentation levels can be reduced or eliminated for supersonic cruise operation. This results in significant reductions in cruise specific fuel consumption. If a fighter can be designed to cruise supersonically without augmentation, reductions in specific fuel consumption on the order of twenty-five percent are available relative to current engines, which would require partial augmentation to perform this leg of the mission. At higher thrust levels the advanced engine will require less augmentation, resulting in specific fuel consumption reductions of twenty-five to thirty percent.

Thrust-Vectoring Systems

Besides a higher thrust-to-weight ratio, the 1990s engine will probably feature rectangular exhaust nozzles with thrust-vectoring capability. Thrust vectoring or reversing involves deflecting engine exhaust gases to achieve better takeoff, landing, and maneuvering characteristics.

Advanced tactical aircraft with thrust vectoring/reversing could operate from bomb-damaged airfields. These aircraft would take off and land in distances of less than 1,200 feet. Because of the high thrust-to-weight ratio of advanced aircraft, short takeoff distances present less of a problem than short landing distances. Thrust reversing can dramatically shorten landing roll for these aircraft. Studies show that landing distances for the F-15 are reduced by sixty percent on a dry runway and by seventy-five percent on a wet runway with thrust reversing.

Thrust vectoring is also an effective means of decelerating an aircraft in flight over a wide portion of the flight envelope. Deceleration capability is increased by a factor of four (in Gs) at Mach 0.8 for a reverser-equipped F-15 compared to a baseline F-15 equipped with speed brakes. This capability would clearly improve the combat effectiveness of an advanced fighter.

This next-generation engine will not achieve these performance improvements at the expense of acquisition cost, durability, or reliability. In fact, concurrent improvements are forecast in each of these critical parameters. Estimates based upon a hypothetical engine design using advanced technology indicate that engine acquisition cost can be reduced by more than twenty-five percent, and engine maintenance cost will be reduced more than fifty percent. These improvements, together with the enhanced performance, will provide significant system life-cycle cost benefits.

Higher Operating Temperatures

The most significant contribution toward achieving our goal of a 10:1 thrust-to-weight ratio engine will

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come from increasing the engine operating temperature. Generally, higher operating temperatures provide higher overall performance. The effect of the higher temperatures and heat load on turbine airfoil durability must be offset by a combination of improved materials, more efficient cooling schemes, or additional cooling air. Increased coolant levels, however, result in efficiency losses. Recent breakthroughs in materials and cooling technologies allow us to increase simultaneously the temperature capability and the cooling effectiveness of advanced airfoils. This permits significant increases in turbine inlet temperature.

Engines developed in the 1950s, such as the J75 and J79, have uncooled turbine airfoils cast from nickel-base superalloys. The advent of cored casting technology in the 1960s enabled internal cooling of the turbine airfoils such as those used in the TF30 engine. Increasingly sophisticated cored castings, combined with directionally solidified alloys, have been responsible for the increased temperature capability of such present-day fighter engines as the F100.

Improved Turbine Materials

The trend toward higher operating temperature is ensured by the ongoing development of both single crystal and rapid solidification rate (RSR) powder process alloys. Single crystal technology involves turbine blades or vanes composed of just one superalloy grain, or crystal, and is the product of more than fifteen years of research and development. RSR is a relatively new process that freezes liquid metal into a fine powder at a rate of cooling of about 500,000 degrees Celsius per second. Solidifying alloys at such a fast rate is successful in establishing a homogeneous composition before the alloys' elements can segregate.

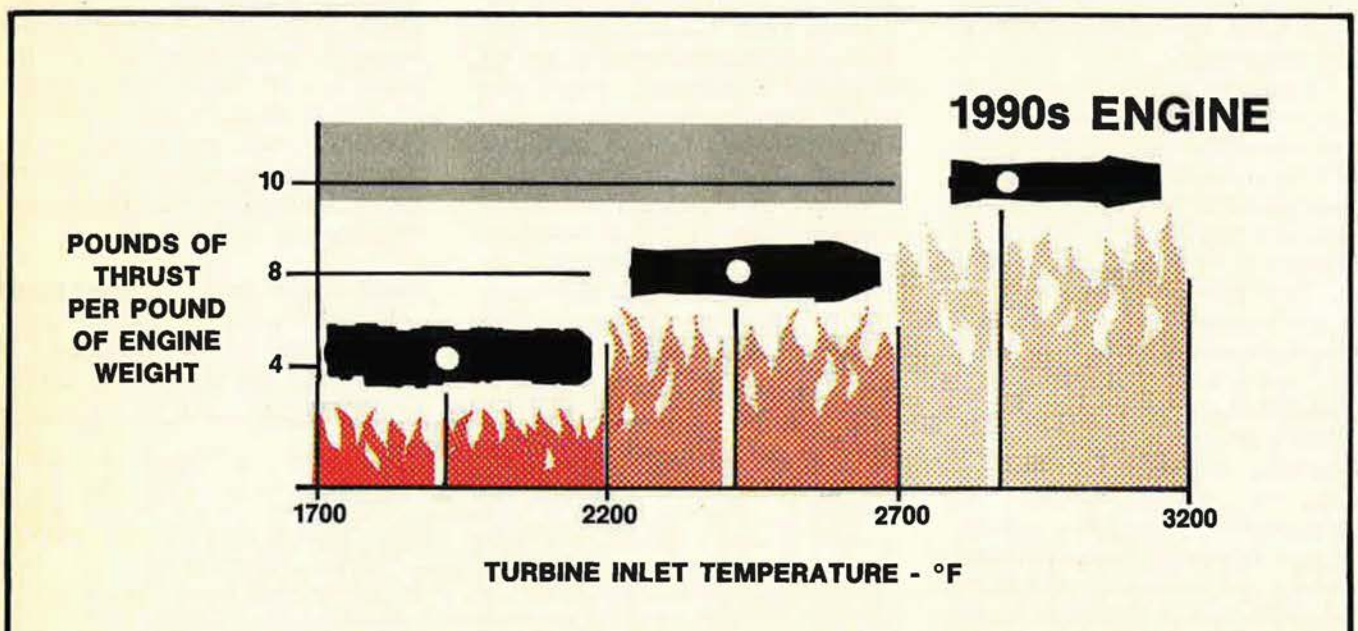
Single-crystal and RSR nickel-base alloys feature improved high temperature resistance to traditional airfoil distress modes (oxidation, cyclic thermal fatigue, and stress-rupture) relative to the directionally solidified alloys used today. Single crystal alloy castings have already been certified for commercial engines and are being proposed for derivatives of the F100. The next generation of high-pressure turbines for fighter and transport engines will feature extensive use of single crystal cast turbine airfoils.

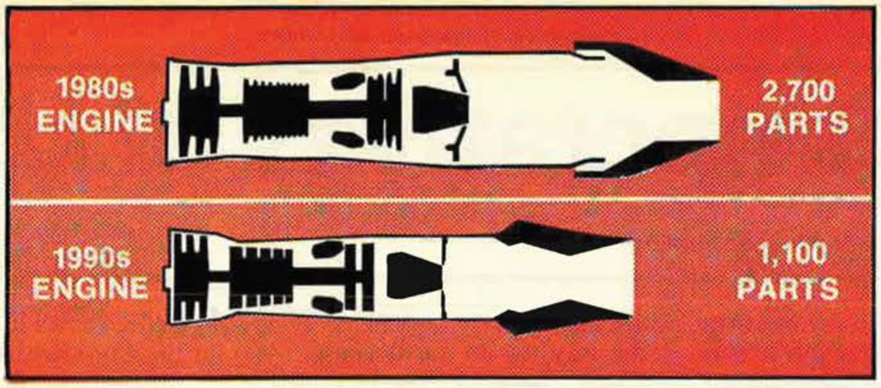
Parallel with alloy developments, advances have been made in the sophistication of the internal cooling configurations that can be cast into the airfoils, thereby providing more efficient cooling for the next engines. Alternatively, the development of multipiece bonded casting and bonded wafer sheet construction techniques have advanced to where these techniques represent viable airfoil fabrication methods. In addition to the increased cooling flexibility afforded by multipiece construction, the recent breakthrough in materials technology represented by the RSR powder process is best implemented in cooled turbine airfoils by using multipiece construction techniques.

Historically, improved materials and cooling capabilities have been used to increase performance, not improve durability. The greater emphasis on operational and support costs for the Next-Generation Fighter engine will demand that the improved future capability be used to enhance both durability and performance. Pratt & Whitney is striving to achieve a threefold increase in hot section durability for military engines of the 1990s while still achieving a twenty-five percent increase in thrust-to-weight ratio relative to the F100 engine.

Fewer Engine Parts

To reduce the cost of the next-generation engine, we are using a combination of aerodynamic, material, and structures technologies to lower dramatically the total number of engine parts. We believe the Next-Generation Fighter engine will have approximately 1,100 parts. This represents a sixty percent reduction relative to the F100 engine with its 2,700 parts. Despite increases in the price of some components such as turbine airfoils, the drastic reduction in the total number of parts enables us to forecast a twenty-five percent savings in acquisition cost alone. This trans-





lates into a six percent reduction in the overall cost of ownership of the propulsion system.

In seeking to reduce engine parts, a major effort has been made in the compression system. We anticipate reducing the total number of stages in the high-pressure compressor from ten in today's F100 to five in the advanced engine. Although our advanced technology five-stage compressor has sixty percent fewer parts (854 as opposed to 1,818), it has demonstrated a four percent increase in efficiency over the current F100. The high gas path axial Mach number, low aspect ratio, and high rotational speed of the compressor contribute to a higher pressure ratio per stage and permit fewer stages. In addition to lowering cost, fewer parts reduce engine weight and greatly simplify engine production and maintenance.

Similarly, the two-stage high- and low-pressure turbines that drive the F100 high compressor and fan will be replaced with advanced, high-work single-stage turbines. This reduces the total number of rows of turbine airfoils from eight to four since each stage is composed of a stationary and a rotating row of airfoils. In addition to cutting the number of stages in half, the number of airfoils per row will be reduced. Our target is a seventy percent reduction, from 492 to 154, in the number of turbine airfoils.

Trend Toward Electronic Controls

Another important contribution to improved engine reliability, as well as reduced cost and weight, is the development and application of advanced microprocessor technology in engine controls. Where today's engines are controlled by a mixture of electronic and hydromechanical computers, advanced powerplants will use digital electronic controls. Eventually all hydromechanical components, with the possible exception of the hydraulic pumps and actuators, will be replaced by electronics. This new control system will be produced and maintained at a lower cost, incorporate comprehensive fault detection, provide significant improvements in reliability and durability, and provide more accurate control of all engine variables. A digital electronic engine control was successfully flight tested on a NASA-owned F-15 in 1981, paving the way for both near- and far-term implementation of these advanced controls.

Lightweight Materials

The development of exhaust nozzles, which provide thrust vectoring and thrust reversing capabilities in addition to the traditional function of jet discharge area control, will greatly enhance the capabilities of advanced fighters. To offset any increase in nozzle weight associated with such advanced capabilities, a rectangular two-dimensional nozzle system fabricated from a new lightweight, high-temperature carbon-carbon composite material is under development. Application of carbon-carbon results in a considerably lighter system because of the material's higher strength-to-weight ratio. Weight reductions made possible by materials of this type will account for about one-quarter of the twenty-five percent improvement in the thrust-to-weight ratio of the next generation of engines.

Other reinforced composite materials such as graphite epoxy and graphite polyimide are also being developed in parallel with new, lightweight metallic alloys like RSR aluminum and titanium aluminum. While the use of composites is limited to minor parts in today's engines, carbon-carbon composites are being used in airframe components. For example, the wing leading edges and nose cap of the Space Shuttle and the brake shoes of the F-15 and F-16 fighters are fabricated from carbon-carbon.

Orderly Development

The low risk of incorporating the large number of advanced technologies required for the next-generation engine is made possible by the extensive development and demonstration programs currently under way. Great progress is being realized in the Advanced Turbine Engine Gas Generator (ATEGG) and Joint Technology Demonstrator Engine (JTDE) programs. In the government-sponsored ATEGG and JTDE test vehicles, new technology is tested in a real engine environment. Performance, durability, and structural data are acquired. As a result, a new engine with improved performance, durability, and reliability can be developed confidently and more rapidly for the next generation of tactical aircraft.

The prototype engine program, which may begin in late 1984, will be founded upon the technology established by the ATEGG and JTDE programs and provide sufficient additional durability and performance test hours to transition the technology to full-scale development in late 1988 with minimum risk. The resulting advanced technology engine will be ready to enter operational service in 1992.

As an engine manufacturer, we are constantly incorporating proven advanced technology into current engines to improve performance, energy efficiency, maintainability, reliability, and durability. Throughout the remainder of the 1980s we will be concentrating on implementing technology advances into upgraded versions of current production engines and their derivatives.

But culmination of today's advanced technology efforts will come in the 1990s when the new engines, embodying the best features we can devise, become a reality. ■

The all-important topic of strategic force modernization was probed in a timely and comprehensive fashion by ranking Defense Department and Air Force experts at a national Air Force Association symposium aptly titled . . .

The New Imperatives of US

BY EDGAR ULSAMER, SENIOR EDITOR (POLICY & TECHNOLOGY)

"THE Air Force, over the next five years, is going to be faced with the toughest management job it ever tackled. Several key programs of the highest priority will have to be handled at the same time. . . . And industry [involved in these strategic force modernization programs] can't afford any slip-ups because this may be your last chance." That is how the Under Secretary of Defense for Research and Engineering, Dr. Richard DeLauer, summed up the central findings of the Air Force Association's national symposium entitled "The New Imperatives of US Aerospace Power," held in Los Angeles, Calif., November 12–13. He pointed out that the Air Force carried the lion's share of the five-pronged $180 billion strategic force modernization package and is even involved in the development of the Navy's D-5 SLBM. This package, he stressed, is based on an ironclad presumption that there will be no cost growth, and that "makes it tough."

"The Air Force, over the next five years, is going to be faced with the toughest management job it ever tackled."

Gen. Robert T. Marsh, Commander of Air Force Systems Command, said that the cost of failing to manage the strategic force modernization program adequately is "almost unthinkable. We will have denied our country the ability to respond to a growing threat. We would be responsible for putting the nation in a position of strategic inferiority."

The warning flags, he explained, are already up in the form of such measures as an amendment by Sen. Sam Nunn (D-Ga.) "calling for reports to Congress and constraints on obligation of funds whenever program costs grow beyond fifteen percent of original estimates. The signal is very clear; Congress expects nothing but impeccable stewardship of the defense dollars so painfully appropriated in the light of other national priorities. Should Congress see evidence of cost growth in Air Force programs, we may anticipate corrective actions including program redirection and cancellations."

In a similar vein, Gen. Lew Allen, Jr., USAF's Chief of Staff, told the some 700 industry executives and civic leaders attending the symposium that "we in the military fully recognize the importance of a strong, healthy economy. Throughout the Department of Defense we are aggressively seeking economies and efficiencies in the way we do our business. And, at the President's direction, the Defense Department has reduced its previously planned budgets for this year and next by some $27 billion.

"We made these reductions not because the threat had diminished: Clearly it has not and not because our needs are less. Rather, we cut fully justified programs solely to meet reduced federal spending objectives. But even these reductions are being criticized by some as too small. In view of recent economic estimates, the threat of future reductions now jeopardizes vital defense programs."

Dr. DeLauer added that Defense Secretary Caspar W. Weinberger "fought his heart out" to contain the budget cut at the $27 billion mark: "There was a large difference between what the Office of Management and Budget said had to come out and what the services and the Secretary felt ought to be kept in. He wouldn't take 'no' for an answer and refused to compromise."

The Imperative of Strategic Force Modernization

The pervasive importance of the President's strategic force modernization plan stems from the fact that "the challenge is most serious and the need to strengthen our forces most evident in the area of strategic nuclear forces. As a result of the steady expansion and modernization of Soviet strategic forces, there has been a dramatic shift in the strategic balance. The momentum of Soviet programs has begun to tilt that equation significantly in Moscow's favor," General Allen told the AFA meeting.

This country, he explained, "faces the ominous prospect of substantial strategic inferiority unless we undertake the appropriate corrective actions promptly. . . . The President's program is designed to fulfill these objectives. We must proceed with it quickly; we must proceed with it resolutely." Restoration of US strategic strength is essential to deny the Kremlin any prospect of success in nuclear conflict, thus deterring Soviet aggression and coercion, and "to provide a sound basis for the negotiation of equitable arms limitation agreements."

"In view of recent economic estimates, the threat of future reductions now jeopardizes vital defense programs."

Aerospace Power

Gen. Bennie L. Davis, Commander in Chief of Strategic Air Command, pointed out the importance of viewing the President's package in "its entirety to fully understand the contributions it makes in redressing the strategic imbalance that has evolved over the past few years." He underscored the importance of implementing the package as a totality because of the mutual support and synergism that the individual components provide each other.

Dr. DeLauer averred that the package, "contrary to popular belief," had been arrived at through a consultative process involving the Defense Department and the military services: "Much has been made [in the media and by members of Congress] about the point that OSD officials—the Secretary in particular—" did not consult the nation's military leaders about what they recommended to the President. Certain members of Congress, he acknowledged, "have been leaning all over that." Dr. DeLauer added that "almost everything that is in the package—command control and communications, strategic defense, Trident D-5, and the bomber—was recommended" by the services. The Air Force prevailed in most instances except for MX, he stressed.

The pervasive importance of the President's strategic force modernization plan stems from the fact that "the challenge is most serious and the need to strengthen our forces most evident in the area of strategic nuclear forces."

The tenor of the symposium's key presentations was that within the President's five-point program, the Air Force's first priority is the development of the B-1 bomber. As General Davis put it, "Of all our strategic weapon systems, the manned penetrating bomber stands alone as a reliable, combat-proven system; historically, bomber effectiveness has proven much higher than analytically predicted."

General Allen said that "unique among the elements of our triad of strategic weapons, the manned bomber can attack mobile or imprecisely located targets such as major troop formations out of garrison, mobile missiles, and aircraft. Then, bombers can recover, rearm, and reattack during protracted conflict."

Terming the B-1B the most cost-effective approach to modernizing the bomber leg of the triad, he said that design is "about eighty percent common with the original B-1, and will incorporate advances in design and avionics that will make it highly survivable against both existing and projected threats." Because the B-1B's radar cross section is reduced by an order of magnitude one-tenth below that of the original B-1 design—and by two orders of magnitude (one-one-hundredth) below that of the B-52—electronic countermeasures involving masking and deception are greatly facilitated.

As a result, "even though we expect the Soviets to make improvements in their air defense capabilities over the course of this decade, the B-1B, flying at low altitude with advanced electronic countermeasures and using good tactics and timely intelligence, will be able to penetrate Russian air defenses and strike targets throughout the Soviet Union well into the 1990s," according to General Allen.

In underscoring this point, General Davis added, "I would not be at all surprised if twenty-five years from now the Commander of SAC would be talking about the B-1 as I am talking about the [still highly useful] B-52 today." General Davis told the symposium that a recent CIA report to Congress alleging that the B-1 would not be able to penetrate Soviet defenses and would be no better than the B-52 involved two of the Agency's Russian specialists with limited knowledge of US weapon systems.

"In reviewing the proceedings it became apparent that both specialists were talking about the 1977 B-1" design and made no allowance for subsequent developments including new electronic countermeasures and reduced radar cross section. The latest CIA position, he said, was signed jointly by the Secretary of Defense and the Director of Central Intelligence, and predicts that the B-1B will be able to penetrate to the Soviet target complex until "well into the 1990s."

The Air Force clearly recognizes that cost and schedule are the two criteria that can make or break the B-1B program in Congress. "We are determined," General Allen asserted, "to bring the B-1B into service on time and within projected program costs."

Concerning reports by the Congressional Budget Office and the General Accounting Office that unleashed speculation on Capitol Hill and in the media about the final cost of the B-1B being almost twice the Air Force's cost estimate, General Allen explained that these two agencies confirmed the Air Force cost forecasts, but warned that "if we added features that we decided not to include the costs would go up." He countered this contention, saying that the B-1B as specified by the Air Force at this time is a "good, full-up" aircraft that won't require a major improvement package to ensure its ability to penetrate Soviet defenses in the 1990s.

General Marsh said, "We are starting this program with a complete understanding of the aircraft we plan to put on alert in 1986. And we arrived at this understanding through extensive consultation with the user on the most concrete and basic terms. After rigorous examination of a long list of possible enhancements, we selected only two for future incorporation; ALCM carriage—both internal and external—and additional command control and communications [capabilities]." The Air Force, he stressed, rejected design changes that were not "absolutely required by the mission, [and] we intend to continue this tight hold on requirement creep and all parties know it up and down the chain of command."

The Air Force plans to use a fixed price incentive contract for the B-1B program, he said, "but we know that is only a point of departure. The real secret to success is firm resolve on the part of both the government and the industry team to positively hold the line on cost. We intend to do our part—from the top down. We intend to be aggressive and penetrating in our analysis of cost performance data. And we expect industry managers to also be as alert as a major league infielder and as aggressive as an NFL linebacker in tracking cost performance."

With the improved radar and navigation system of the B-1B, General Davis said, "we will have an accurate navigation and weapon delivery capability with automatic terrain following at 200 feet [altitude] and at a speed of 0.85 Mach, or 645 miles per hour. The expanded . . . ECM package which will be included on the B-1B enables us to . . . counter the enemy's fighter and missile threat. The reduced radar signature greatly enhances our ECM effectiveness and reduces even further the enemy's detection capability."

As a result, there is assurance—on the order of a ninety percent probability—that the B-1B will be able to foil even advanced future Soviet look-down, shoot-down systems, he predicted. He and General Allen also underscored the importance of the B-1B in the context of nonnuclear force projection and of the Air Force's corollary mission, *i.e.*, maritime support.

The B-1B, General Allen told the AFA meeting, "will provide much needed long-range, heavy payload [and] conventional striking power for theater conflict. It will thus be an essential element of our ability to project US power over long distances on short notice—a capability that is critical to our deterrence of Soviet aggression in Southwest Asia and elsewhere."

Prudent Development of "Stealth" Technology

The President's decision to deploy the B-1B as soon as possible while the technology for an advanced technology or "Stealth" bomber (ATB) is being developed in a sequential manner clearly has the enthusiastic support of the Air Force's leadership. This tandem

". . . the manned penetrating bomber stands alone as a reliable, combat-proven system; historically, bomber effectiveness has proven much higher than analytically predicted."

approach, General Allen said, "makes good management sense. It allows the time needed to resolve the current technical uncertainties associated with the advanced technology bomber. Focusing on the development of an advanced technology bomber alone would be a risky course to follow. While the technologies involved are exciting and offer enormous potential, there would be a high degree of risk in concentrating solely on an advanced technology aircraft, because of the dramatic changes in aircraft design and manufacturing techniques involved."

Acknowledging the "Stealth" bomber's potential for revolutionizing air warfare, USAF's Chief of Staff pledged that "we will not shortchange this program. It is too important. It holds too much potential. But at this early stage it would be irresponsible for us to put all of our eggs in one basket and engage in a crash program to field such an aircraft. We must be confident that the design we select possesses the capabilities we require and is the kind of strategic bomber we would want to operate for decades to come." Dr. DeLauer suggested that by our fielding both the B-1B and ATB, the Soviets will be impelled to develop and maintain two generically different air defense systems which, in the aggregate, are going to cost them between $200 and $250 billion, yet "won't do them any good."

Introduction of two different types of strategic bombers into the inventory will not further strain the acute shortage in aerial refueling capacity, according to General Allen. That shortage will peak when the wholesale deployment of air-launched cruise missiles (ALCMs) on the B-52 fleet gets under way. Because the externally carried missiles increase drag significantly, "our tankage requirement will go up quite a bit. This will ease back as the reengining of the KC-135s picks up speed."

Meanwhile, General Davis pointed out, the tanker shortage is being exacerbated by the last revision of the Defense budget, which halted further procurement of KC-10 aircraft and slowed the reengining of the KC-135. Allowing for both strategic and general-purpose war requirements, he told the AFA meeting, there is a need "for about 1,200 tanker equivalents. The present capacity is about 570 tanker equivalents. Reengining the entire [KC-135] fleet would bring us up to about 800 tanker equivalents [and that combined with] a full buy of forty to sixty KC-10s would have made up the bulk of the deficit." At this time, it appears that the KC-10 program will be terminated, with only twelve or at best sixteen aircraft authorized, and the KC-135 reengining program slowed down to about 205 aircraft modifications over the next five years.

The Uncertain Status of MX

The President's strategic force modernization of October 2, 1981, rules out the multiple protective shelter (MPS, an arrangement involving a combination of concealment and limited mobility) basing for the MX ICBM system. Instead, the Administration chose a limited, initial deployment of some of the new missiles in fixed, superhard silos while continuing the quest for a survivable basing mode involving either continuous patrol aircraft, deep underground basing—meaning a missile that is deeply buried and uses exotic earth-moving equipment to dig itself out a day or so after an attack—or an ICBM defended by advanced ballistic missile defenses (BMD).

Although not a lasting solution to growing US ICBM vulnerability, "initially deploying MX in hardened silos will complicate and add uncertainty to Soviet attack calculations. More importantly, it is a needed early step toward countering Soviet ICBM capabilities. With greater accuracy and more than three times as many warheads as our newest Minuteman missiles, the MX will be able to destroy high-value Soviet targets such as hardened command posts, nuclear storage sites, and missile silos," according to General Allen.

General Davis added that to date no decision has been reached on deploying a number (probably between thirty and forty out of a total of about 100 missiles) of MX weapons in modified Titan and/or Minuteman silos. SAC, he said, will start phasing out Titan ICBMs next October, at a rate of one per month. Adding ruefully that Titan provides "a lot of capability" as the nation's only large ICBM, General Davis acknowledged that "taking it out of the inventory before we are ready to replace it causes a loss of capability, no question about it." SAC, he said, would prefer to deploy MX in Minuteman rather than Titan silos.

So far as survivable basing is concerned, the Air Force "will work hard at the remaining options," according to General Allen. Interpreting the intent of the Administration's MX decision, Dr. DeLauer said that MPS in the sense of a "reasonably soft multiple protective shelter system distributed over Utah and Nevada is dead. What is not dead is defense in combination with mobility or deceptive basing. That might be an enhancement to any investment we make in [BMD] interceptors. Also [allowing for present] BMD technology we might have to make the radars mobile or base them deceptively. That is not ruled out." General Allen concurred, stressing that there is increasing "enthusiasm" for a combination of MX and BMD that is enhanced through concealment or mobility.

In assessing the state of BMD technology, General Allen said that on an individual basis it is possible to hit the proverbial "fly in space. What is more difficult is to deal with a raid in an appropriate way" and will require further work. It also is easier to protect single, hardened targets "by means of low altitude interceptor detonations. To protect area targets—such as silo fields—requires layered [high as well as low altitude] defenses and that job is clearly harder." The consequence of a Soviet decision to deploy BMD systems to protect its ICBMs, in General Marsh's view, would be grim: "We have the [advanced strategic missile systems program, formerly known as the advanced ballistic reentry systems or ABRES] program, involving mostly technology work. It would take several years to field this technology" and deploy penetration aids to thwart Soviet ballistic missile defenses.

USAF's Space Defense Mission

Gen. James V. Hartinger, Commander in Chief of NORAD and ADCOM, announced at the AFA meeting that the US ASAT space interceptor system will gain IOC (initial operational capability) in about two or three years. The first squadron of F-15s modified and trained to launch this weapon will be set up at TAC's Langley AFB, Va., in January 1982, he said. (Originally, the US ASAT system was to have reached IOC in 1981 but that date first slipped to 1983 and, as a result of the Defense budget revision of September '81, was deferred another year.) The US ASAT, according to General Hartinger, involves a modified SRAM—carried aloft by an F-15—launching a thirty-three-pound weapon that is being guided by an infrared homing device to a "hit to kill." The US system, he said, compares favorably to the operational Soviet ASAT, but neither of them is able to reach up to geosynchronous altitude—22,300 miles up—where the early warning infrared satellites are deployed.

While conceding that "nothing is invulnerable," he stressed that in space "the further out you go [with satellite orbits], the lower the vulnerability." The Soviet ASAT, whose space testing is being watched by NORAD in minute detail, is clearly a "low-altitude weapon," General Hartinger said.

In a broader sense, General Allen stressed that there is no question that the Air Force "must fully step up to its responsibility as the executive agency for national security missions in space and do so soberly and responsively." That means avoiding premature commitments to incipient, tenuous concepts of space-based laser and particle-beam weapons which "clearly require far more research activity before one has any confidence whatsoever" in their future operational utility and feasibility.

The Chief of Staff also espoused a cautious attitude concerning the Space Shuttle, warning against making major commitments in the defense area, based on presumptions of technical capabilities "which are not yet there. . . . It is not mandatory that USAF take over operation of specific Shuttles in their entirety nor that we purchase our own Shuttles for defense missions. . . . There is no question that if the Shuttle becomes as routine [as modern air transports]—a concept that seems a tad away for the moment—then the Air Force will move into whatever role it needs to in order to fulfill its national security mission." General Marsh added that the Air Force is committed to launch the first Shuttle flight from its Vandenberg AFB facility in California by October 1985.

(The concluding report on the AFA symposium will appear in the February issue of AIR FORCE *Magazine.)* ■

Air Force Systems Command, a $19 billion enterprise, has the mission to advance aerospace technology and to acquire logistically supportable, cost-effective systems to meet validated operational requirements. That is a tall order, the execution of which is told in this interview.

DEVELOPING THE FUTURE

An Interview with Gen. Robert T. Marsh, USAF Commander, AFSC

GEN. Robert T. Marsh directs the research, development, test, and acquisition of aerospace systems for Air Force operational and support commands. In this interview, he discusses current programs of AFSC and looks over the horizon to discern trends in USAF development activities. The interview was conducted by F. Clifton Berry, Jr., Editor in Chief of AIR FORCE Magazine.

General Marsh, an Indiana native, entered the Army Air Forces in 1943, then completed aircraft mechanic and aerial gunnery training on B-17 and B-24 bombers before his appointment to West Point in 1945. Graduating in 1949, he began a series of increasingly responsible assignments in nuclear and electronic projects and units. Later duties covered space, reconnaissance, strike, and electronic warfare in Washington and in the field. Before assuming command of AFSC in February 1981, he commanded its Electronic Systems Division for nearly four years.

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AFM: How do you decide exactly what you need without making something too complex or so complex that it meets everybody's requirements but costs a lot and may not be supportable? It's the old question of quantity vs. quality, or simplicity vs. complexity.

General Marsh: I feel, as most of the leadership in the Air Force does today, that the very first and fundamental prerequisite is that everything has to focus on superiority. If you can't win, if you can't defeat the enemy with a given system, no matter how simple it is or how easy it is to operate or maintain, it's not worth building.

The "day fighter" argument says, "Wouldn't it be neat to go back to the F-86 days?" The simple fact is you can't do that against an enemy that has good long-range radar capability, fine high-quality air-to-air missiles, and good maneuvering ability. In that sense, the old dogfight days are gone. We simply must equip our airplanes with sufficient systems so they are superior to those of the enemy. That's a simple word—superior—but it may drive systems to complexity or sophistication. You don't refer to your pocket calculator as sophisticated or complex. You probably refer to it as a rather simple tool. But it gets the job done better than any way you've ever done it.

It seems to me that that's the sort of view one has to hold in my business. Given that we know the performance required, the name of the game is to do that job with the least sophistication possible, the least complexity. We must make it the most reliable within the constraints and the most maintainable, and at the least cost. But we can't sacrifice that first and fundamental requirement of superiority.

Look back in history. I like to consider the long bow. Obviously it required fletchers, longer arrows, and had more moving parts than a sword. But it certainly annihilated the French knights at the battle of Crécy. That's the real bottom line of all this . . . winning. Nearer our own time, look at radar. When introduced in England, radar was really a key to winning the Battle of Britain in 1940. Radar was far out in terms of people's understanding in those days. It was complex and it was sophisticated, but it tipped the balance of the fight. The introduction of precision guided munitions in Southeast Asia had a profound effect in that conflict. Initially they were sophisticated and complex, but they did the job. The point is that to outflank the enemy in performance, you require some degree of sophistication.

AFM: Hasn't it happened in cockpit displays and other displays where the actual information that a crew member has to deal with is simpler than it was before? The circuitry behind the panel might be considered wizardry, but the person is dealing with simpler displays than somebody twenty years ago.

General Marsh: Absolutely. I don't think any of the "simplicity vs. complexity" arguers have problems with the externals, such as the displays or the controls. But as soon as we encounter a reliability problem behind those, then they blame lack of readiness on complexity. We need to work these reliability problems in the very worst way, but we also had to do that back in the supposedly simpler days.

AFM: With the F-86, for example?

General Marsh: Sure we did. The problem's been with us forever, and will be with us forever. Given a certain degree of complexity, there will be reliability, maintainability, and supportability considerations. We sincerely believe, and we have the statistics to prove, that we are not less supportable, less ready, less able to generate our sorties than before. In fact, we are more capable in all of those areas.

Our problem is very simple. We needed to modernize the Air Force when we came out of Vietnam. We had insufficient resources to do it, so we made conscious decisions to constrain supportability dollars in order to lay those keels and get those new airplanes into production. We knew we were going to have supportability problems, and problems with logistics support and spares. I think the decisions were right, and we brought these new systems on line in the right sequence. If we had had to go to war with these new systems—the F-15, F-16, A-10, Wild Weasel, EF-111, AWACS—we might have held a different view of whether that was the right strategy. In my view, it was the right strategy. Now we really need to focus very hard on raising the level of readiness and supportability of those systems.

AFM: Do the people you deal with in industry and the

LEFT: F-15 cockpit instrument display. Far greater range of information is provided to the pilot without increasing panel size or number of instruments to monitor. Much of the information is projected on a HUD, so the pilot's attention can remain outside the cockpit. ABOVE: Air Force personnel removing buckled concrete from edge of small explosive crater. Craters from an airfield attack may range up to sixty feet in diameter. BELOW LEFT: Gen. Robert T. Marsh, AFSC Commander. BELOW: Ground crew member installing an electrical component in an F-15.

Congress and elsewhere in the government understand this, and are they receptive?

General Marsh: A few hold views to the contrary, but I don't think that's true of the majority. It's certainly not shared by the responsible leadership of the Air Force. Ask General Creech. He's charged with fighting the tactical air forces, and he clearly perceives the critical need for performance and capability. When we bring our spares support up to the wartime levels we have specified, we'll really be in good shape to fight with a sustainable, highly capable force.

AFM: What are some of the things going on within the AFSC system to improve sortie generation, or advances to get more sorties out of aircraft, for example?

General Marsh: One of the most important is in the air base survivability area. We took a major initiative last spring and formed an air base survivability management team at Eglin AFB, Fla. We're looking at the full range of things that affect our ability to keep the facilities operating and supporting sortie generation during and after attack. That includes rapid runway repair. We have had an aggressive effort under way in that area for some-time. It includes trying to understand how rough our runways can be so that, to the degree possible, we can assure realistic wartime requirements for aircraft operations are clear. In addition, this testing will help determine the degree of roughness that an existing aircraft can tolerate, as well as what changes we could make in landing gear to make them more capable of rough runway conditions.

AFM: Design limitations?

General Marsh: Yes, trying to realistically assess limitations of the airplane as it is now. We're looking at other survivability measures for our air bases. This includes active air defense. We're concerned about this, and we want to make darn sure that we have planned and supported security measures in case of attack. This ground attack threat, of course, also is of concern to the Army.

AFM: And you are working with the Army on that?

General Marsh: Yes, we are. And our air base defense against an attack will depend upon systems like Rapier. Now then, that's in the base survivability area . . . sortie generation is dependent upon the ability of the air base to support it. As to the aircraft itself, one thing we're trying to get is more flexible munitions, so that you won't have the tailoring requirement for every task. The low-level laser-guided bomb is a good example of this. It's a very versatile weapon. So are Antiarmor Cluster Munitions (ACM) and more versatile cluster munitions. We want to reduce the number of unique loads to worry about. More versatile weapons are certainly one of our major goals.

One very important area where we have a lot more work to do is the BIT . . . [the Built-in Test] capability. Built-in Test hasn't really fulfilled all of our hopes and expectations. It's generally true that the Built-in Test features of our avionics, our stores management sets, and our weapon release systems are more sophisticated generally than the item itself. The ability to automatically test and isolate faults is really a difficult engineering undertaking.

Getting an unambiguous indication of what's wrong with a radar is frequently a more difficult design problem than the radar itself. We are working very hard at that so BIT can quickly tell the flight-line mechanic which box to swap. We want BIT to be able to say that "this particular box is bad; replace it, and the aircraft will be back in commission." Today we remove a lot of boxes we think are bad, but they retest okay. Sometimes we get a BIT indication that says that one of several boxes may be faulty. We have to perfect BIT so that it becomes a lot less ambiguous, more reliable, and a lot more capable.

AFM: Does that mean that you have to train the people on the flight line and the immediate backup maintenance people to make up for the present shortcomings?

General Marsh: Yes. The flight-line mechanic's job today is tougher than it ought to be in that regard. We should be able to tell him with high confidence what Line Replaceable Unit needs to be replaced. It doesn't happen that way in too many cases.

AFM: Are the units and the people of the flight line, the young men and women who are dealing with it, involved with your engineers and designers on improvements?

General Marsh: We have a tremendous "lessons learned" program, and we work at getting the information directly from the field. All of our feedback does come from the field. If we don't get it ourselves, then our contractor tech reps do and it comes to us for review.

We've been working very hard on a BIT improvement program with the AWACS, for instance. We undertake BIT design at the outset of the development in the system, but it also has to have equal importance throughout the whole development test cycle.

AFM: Can you do that during the development process or do you have to build it in later?

General Marsh: Yes, and it must be done. Obviously, in complex software systems, to postulate every possible failure mode is an almost endless undertaking. To test against every failure mode and prove to yourself that you can isolate it in every case is tough. But with modern computer technology, you can run through a failure mode on LSI chips with complex test programs that will check every circuit in that system. So the answer is, yes, you can do it if you spend a lot of time on it at the outset. We have learned that testability of complex electronics circuitry is a major undertaking, but a vital one.

AFM: Does that lead into the need for engineers and designers, and the fact that the supply is less than the demand?

General Marsh: You're into one of my biggest problems. Getting the qualified, experienced engineers we need to carry out our responsibilities is vital. We had a big exodus of experienced engineers out of the command back in the '70s. Today about forty percent of all my officers are lieutenants. Now, they're fine, capable young people, but they naturally lack experience. Unless one's been through this BIT problem, or lived with one like it for awhile, he can't attack that problem in an aggressive way until he spends some time building the necessary framework.

AFM: Can you compress that experience in a very brief time, or do you just have to let them mature?

General Marsh: It's tough. We're taking many initiatives to try to accelerate the experience. We have all kinds of "lessons learned" information passing through the system. We have accelerated courses, and the Air Force Institute of Technology is helping us formulate courses that we can get out via our electronic blackboards and videotape courses to pass along lessons. We're working in every conceivable way that we know to make up for that lack of experience. You probably can't expect to make up for it completely; all you can do is minimize the problem. As I say, this is one of the toughest problems I have at the moment.

AFM: Are AFSC's civilian engineers a corporate memory and a corporate pool of experience for you?

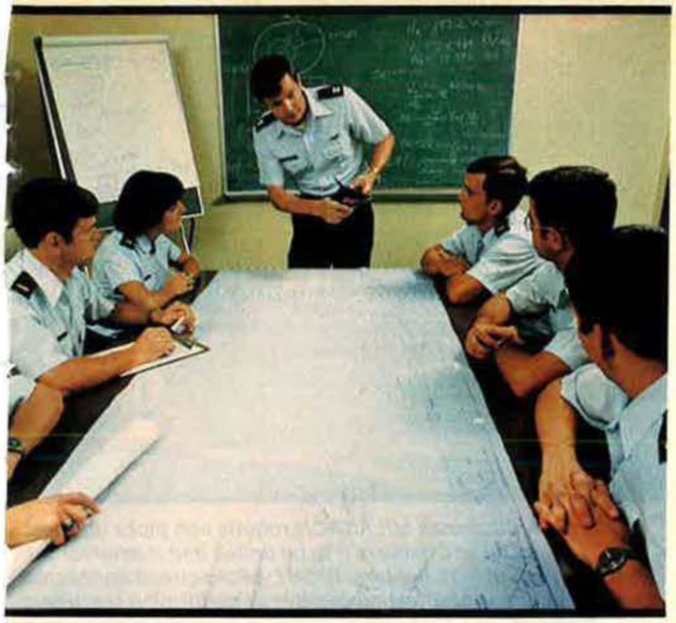
General Marsh: Yes. And they help to a great degree with that problem. Some of our organizations depend more on civilian engineers than others. For example, our Electronic Systems Division and the Space Division don't have the civilian engineers to the extent that we have them out at Aeronautical Systems Division. We also rely on federal contract research centers. But it's that blue-suit engineer we count on for understanding the real problem on the flight line. The officer brings a real understanding of the operator's problem, having operated the equipment. We need a guy who has maintained it, who's been in the maintenance squadron. He understands what it's really like. And that's what we're lacking today.

AFM: That's operational experience brought to bear on the design or the design issue?

General Marsh: That's just part of it. The other part is having people who have worked on several systems, been in the air, learned the lessons from other systems, and then being able to transfer them to a new one. To a great extent, we've lost that capability.

AFM: During a symposium at the AFA Convention the participants concluded there are no quick and easy answers. You can't suddenly create a generation of new engineers. Will you be faced with this for a generation, do you think?

General Marsh: It will be around for quite some time. It's a larger problem than just Systems Command, as you point out. It's a national problem. There are various projections that indicate the nation will be short some 16,000 engineers a year for some years to come. Unless something is done in a major way, that will tend to even



Engineers at the Wright Aeronautical Laboratory's Flight Dynamics Laboratory discussing flight control system design.

get worse because demographics are such that schools will likely be producing fewer engineers.

The problem has many dimensions. The faculty and plant capacity of the universities are particular problems. Universities are losing their faculty to the lures of industry. Their facilities are frequently out of date and will require great investment to update them. These kind of problems will face us for some years to come. That means that the Air Force may have to bear a disproportionate share of the shortage because we can't compete financially with industry. I think there are fairly tough times ahead. But we must try and retain those young engineers that we do get. And this will require some very special attention. The retention bonus for engineers that Congress recently passed will help. I just don't want to predict right now what we can do about retention, but that's one of our major objectives.

I think we can solve the accession problem with the many things I'm sure you've heard about—the ROTC scholarship program, the College Seniors program, and so on. We may be able to meet our recruiting objectives within the next three or four years, although I'm somewhat skeptical of that. Personnel thinks we can. If we succeed at that, then the question is how are we going to retain them. That'll be the major challenge.

AFM: Do you find that giving them bona fide engineering challenges tends to retain them?

General Marsh: Sure. We have a unique challenge in the command in that engineers coming out of school, just by the nature of their training, look forward to "hands-on" engineering efforts. That is what you're trained to do in school—go out and design something. Now we don't do much of that. We do some in our laboratories, but the major part of our engineers' duties is engineering management—to manage and oversee engineering, review engineering, and so on. The role of our engineer is to oversee the contractors' engineering. And that's important—very important—it's proven to be an absolute necessity. To some young people, that's not what they wanted to do. So, initially, they are somewhat frustrated, and that's a problem we have to cope with.

We have to persuade them that engineering management is challenging and rewarding. And the responsibility they soon are given is at a much higher level than that of their civilian contemporaries. We have to get them over the shock that engineering in the Air Force is not what they thought it was going to be. We've tried to do everything we can back in the ROTC, with films and all, to try to explain what an engineer does in the Air Force. We need to tell them that the engineer does engineering management, and that it's a very rewarding and important challenge.

AFM: You have formal programs working with, say, airframe manufacturers, to upgrade their equipment to improve their productivity. Do you have anything going with universities or schools of engineering to consciously provide engineers for Air Force needs?

General Marsh: Of course we have our AFIT program where, both in-house and with the universities, we send our people for both undergraduate and graduate training. We are expanding that, and production has been increasing. We have the Air Force Office of Scientific Research. We also have a grant and contract program for basic research with industry and the universities. That program, in itself, does support research. It beefs up specific programs, but it's not intended to bring those people into the Air Force. It does sponsor research that is of great value to the Air Force. Industry must likewise do more with the universities to help solve this problem.

AFM: The industries have been willing to work with you on productivity because you're sharing the expense of new machinery.

General Marsh: Yes. Now we've got to get industry to work with academia so that they can train people to be apprised of this new technology. Industry and academia interaction can help. They need to sponsor students and bring them in and let them interact with these new techniques.

AFM: It can't be just the Air Force that's trying to work with these young people.

General Marsh: No, it's got to be government, industry, and academia.

AFM: Well, that sort of leads into the engine topic and then multiyear procurement. We hear a lot about dependence on strategic metals, and that these metals are responsible for a high percentage of the components on the turbine engines. Are there efforts under way to reduce our dependence on metals by designing them out rather than looking for new sources of titanium, or cobalt, or whatever?

General Marsh: Yes. The answer is a straightforward yes. The Materials Lab and the Aero Propulsion Lab are investigating metallic technologies such as rapid solidification of metal powders and metal matrix composites and some nonmetallic technologies like ceramics and carbon-carbon as well as other composites. Specifically, by freezing metallics quickly to catch the solutions in uniform and very desirable phases, significant gains in material properties allow alloys to be used, containing less cobalt, for instance, that still maintain good high-temperature characteristics.

The Air Force, in cooperation with DARPA and NASA, is addressing rapid solidification technologies and eutectics, along with ceramics and composites work. We also have manufacturing technology programs to develop more material-efficient processes, and we are devising methods to recycle both used parts and manufacturing waste products that contain high percentages of these critical metals. We also have programs to reduce the volume of production scrap. Simply put, we're using technology and engineering "smarts" to try to overcome some of these critical materials problems.

AFM: Any other engine developments you'd like to mention?

General Marsh: Well, there's the ATEGG program [Advanced Turbine Engine Gas Generator]. And this is a technology program in which we address the core of the engine, the high-pressure compressor, the combustor, the high-pressure turbine. We have complementary component development programs. When we get the components brought sufficiently along in exploratory development programs, we put a core together in advanced development [ATEGG]. That's where the F100 engine came from. An ATEGG core technology was ready to go when we needed that 25,000-pound-thrust engine. And that's continuing now. In ATEGG and a companion program, APSI [Aircraft Propulsion Subsystems Integration], we've worked the problem of engine durability. Our approach calls for extensive testing early in the development cycle with heavy emphasis on durability and structural life of the engine. By doing more work in fewer engine stages, we've really reduced the overall engine parts count and thus reduced cost while increasing durability and reliability. What it means is this: We're developing technology to improve durability with adequate performance rather than just trying to increase performance alone. We're trying to strike a practical balance.

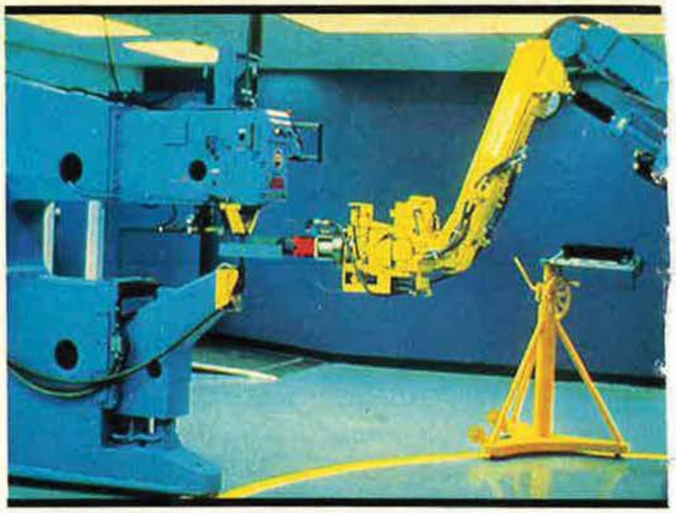
AFM: That really stimulates another one. Do you see more of industry offering, or Air Force requiring, warranties on systems and components? Do you see an accelerating trend that way?

General Marsh: There is definitely a trend toward increased use of warranties. We're still breaking ground in that area. In fact, we have a product assurance office at Wright-Patterson in conjunction with Logistics Command, and we're trying to assemble all of our experience on warranties in that office. We can then disseminate this information to all our program offices and thus be able to provide them the know-how and experience they may need when faced with decisions or questions concerning warranties.

We're trying to create a repository of all the best information on warranties. Here at this headquarters, to give this visibility, we have appointed an SES [Senior Executive Service] person who heads up my product assurance activities here on the staff. He reports directly to me in order to give emphasis to product assurance, reliability, maintainability, and supportability. He works all of our programs across the entire command, all to make sure that we're giving this maximum attention.

AFM: Is it fatuous to try to put a dollar figure on product assurance? It's not something you can assign numbers on right off the bat, can you?

General Marsh: No. It can be quantified. We have just broken through with the engine manufacturers on the warranties.



ABOVE: A Cincinnati MILACRON robotic arm picks up sheet metal and delivers it to be drilled and riveted for the construction of F-15 fighters. RIGHT: Micro-circuit connected with other circuits for testing capable of performing electronic measures at a high rate of speed compatible with modern operational integrated circuits.

AFM: The ones who have a good record think that that's fine for them. From a business point of view, the ones who are smart believe that.

General Marsh: The challenge of warranties is making that judgment. When you've bought a new car, you've probably had to decide whether or not to get a three-year warranty. I happened to pay $250 to $300 for an extended warranty for my car. It recently expired, and I don't think I ever used it. Now in retrospect they made a lot of money on that warranty.

AFM: But you had 20/20 hindsight on that.

General Marsh: That's the challenge. Given your understanding of the durability of the hardware, how do you calculate the value of that warranty? Spending the taxpayers' money on warranties—we need to make a very careful and informed judgment. We have to decide how much it's worth to us to procure that warranty.

AFM: You're doing that in engines?

General Marsh: That's not easy.

AFM: It must be an art, more than a science. Doesn't that apply where you are bringing in robotics—the computer-aided manufacturing—aren't you working with industry on that?

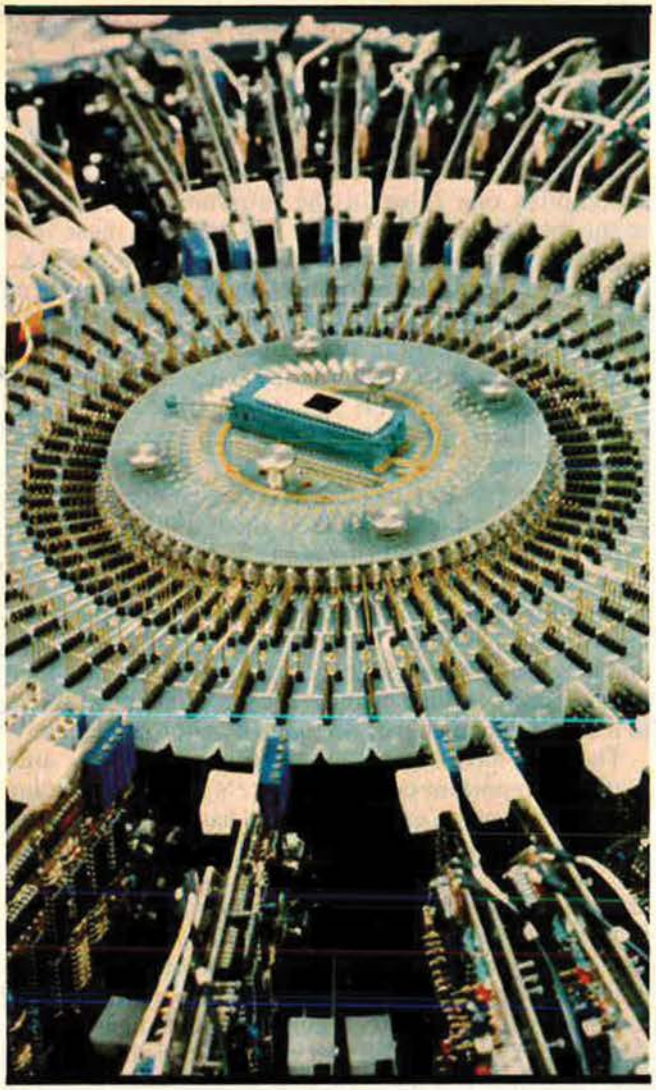
General Marsh: You're absolutely right.

AFM: Isn't it a cooperative thing where you're putting down some money and they're putting down some money?

General Marsh: It's a little bit different there. In the case of the F-16, we put up $25 million and General Dynamics put up $100 million to invest in tooling. We struck an agreement right then. In return for that investment, we lowered our projected budget for the procurement of the aircraft by something like $400 million. We had a firm agreement that we would lower the price of those airplanes under certain specified conditions.

AFM: I went through that plant a couple of months ago, and the people working there thought it was good for both sides.

General Marsh: And it should be. You ought to strike an agreement that promises a return to the contractor on



his investment and provides a corresponding return to the government for their share of the investment. That's what you're looking for.

AFM: It certainly benefits the people working on the machines, working on the plant floor. They are part of it.

General Marsh: Yes, they are more satisfied.

AFM: Less frustration.

General Marsh: You'll be seeing a lot of that in every program we construct from here on. We are doing whatever we can afford to do and everything that is sensible by way of promoting capital investment for improved productivity. It's a subject that's very much on our minds.

AFM: Will you write this into your contracts?

General Marsh: Yes. We're asking our people to consider this. We call it MANTECH [manufacturing technology investment program], and the ones that show the greatest promise of return are our candidates for the program.

AFM: I haven't touched on or asked you about the Air Force role in space or command control and communications—two subjects that are really important. Space gets a lot of attention, but C^3 doesn't, even after the President announced his decision. Do you want to expound on those in sequence?

General Marsh: Well, on space, I probably don't have a lot to say that you haven't already heard from others. I think we have grown to the point where we are a lot more dependent on space. If one thinks about it, we are greatly dependent on space for warning, for navigation, for real-time weather data, and, of course, surveillance purposes. So, if you add all of that up, it represents a very substantial portion of US military capability.

We are very much in space already. When one talks about the future of space, we can honestly say that the future is now. We're already there. When one asks, "What's the future of space?" I say the analogy is much like when Columbus went west and found the new land. Since 1492 we've been in the exploitation business. We are at that stage in space. The exploration is over. Yes, we're there, and now one does in space whatever is practical and cost-effective to do. It's not a matter of a great unknown anymore. It's there—we understand it very well, and so we perform those military missions that can best be performed in space. I'd say we're just in a steady role of expanding the application of space through our missions and as our technology advances.

AFM: But you say we have to step back and see it to realize in how many ways we use space.

General Marsh: Sure. Consider improved bomber warning for the nation. We're trading off space-based vs. ground-based radar. That's the way I'm viewing the problem now. It's a series of very straightforward tradeoffs.

AFM: In communications command and control, we have so many ways to communicate that the issues raised by, say, instant access to somebody say a thousand miles away don't get discussed because the President can reach that F-111 pilot in his cockpit. Do people take communications for granted now and not realize the traps and also the opportunities?

General Marsh: Are you really asking, are we afraid that if we enhance our communications it might provide a more centralized control? I don't think so. Let me try, if I can, to tell you what I think the deficiencies are. Incidentally, C^3 is such a broad area, sensors, for example, and warning and type of radar receiver, and so on, that you've got to be somewhat specific and articulate.

C^3's major deficiencies, I believe, are those of survivability and interoperability—getting from one system, if you will, into another.

What do I mean by survivability? I mean jam resistance. I mean redundant in the event of an all-out attack. Our C^3 goes through some very critical nodes these days. By nodes, I mean towers and mountaintops, and switching centers. Alternate paths don't exist and the ability to switch to alternate paths doesn't exist. So the vulnerability of those nodes are important deficiencies, and they need to be fixed.

You can't restrict yourself to UHF or HF or a few others, because some may be vulnerable to the vagaries of ionospheric or nuclear effects. You need to have multiple schemes for enduring communications capabilities. So I think in the survivability area we need to talk about satellites, and that opens up other challenges. You have to be able both to protect your satellites, by some means—proliferation or spares in orbit, or active defense of them if you encounter any threat. So when I say survivability, I mean it in the broadest sense.

Tactical Air Control Center (TACC), a transportable system about the size of two van-trucks and joined together by an inflatable building. In this area are data-processing equipment, radar displays, and equipment for ground-to-air communications.

Much more needs to be done to ensure enduring C^3 in all manner of wartime conditions. It's a fragile system today, very fragile.

As to interoperability, we don't have total interoperability between the Army and the Navy and our own service; we don't have interoperability with our allies or interoperability between strategic systems and tactical systems. We've grown up in the C^3 world just putting another system into the field, in many cases without assuring the ability of that system to cross over and interconnect with another system. Once you have an architecture that doesn't have a lot of interoperability, it is very difficult to fix. So that will require some significant investment to get this capability.

AFM: Will there be developments in the C^3 like those in avionics—standardized languages, for instance?

General Marsh: Sure. We will have standard waveforms and more. A lot of that is going on in JTIDS and other programs. The Air Force is getting one architecture, TDMA, and the Navy is going with another, distributed TDMA. We selected the waveforms so that those two can be interoperable. That is very, very important. We've done that with HAVE QUICK antijam. You can have that with both UHF and VHF radios. We're making sure different UHF radios can all be adapted to the same antijam scan.

I think a lot is going on, and we've learned our lesson. We now know that when a new system is laid on, we must address interoperability from the outset.

We haven't discussed command centers yet. Much improvement is going on in command centers, and I'm talking about airborne command centers as well as fixed ones. We need to make sure that they are survivable, and we must know what's needed in order to ensure that they are physically survivable. When one is talking about survivable command centers, he also must talk about surviving data bases, so that the war effort can be continued and data can be handed off from one to another. Command centers deserve an awful lot of attention.

AFM: In everything you talk about, you sound enthusiastic. Are there any frustrations?

General Marsh: I've thought about what I'd like to accomplish in this job. Let's break it down. If I could accomplish one thing in the programs area, in our acquisition methods, it is this: We must get these new programs laid down properly. I mean the B-1, the MX, the new warheads, the C^3 initiatives. We must get them off on a good footing because we absolutely cannot afford to be sowing the seeds that will, in four or five years, result in gross cost growths and mismanagement. Everything depends on structuring those programs properly at the outset. In the program area, that is the real challenge.

In the people area, if I can accomplish one thing, it's to solve the problem we talked about a little bit ago of experience. I want to bring along and hand over to my successor an experienced, high-quality R&D and acquisition team. In other words, to overcome the problem that we have now with the shortage of experience and to regrow that experience and get this team back up where it can continue meeting the job. Right now, we're in less than good shape. So that's a major challenge.

Then we haven't said anything about another area that's an important concern. There's been a disturbing trend downward in exploratory and basic research funding over a number of years. That must be reversed. We're on the verge of losing our technological leadership in the world, and the Air Force must play its part in this role and reinforce its commitment to basic and exploratory research and advanced development. We must keep the technology moving forward so we have the options available to continue to build superior new Air Force systems. You can neglect that area only so long, and then you will have cast the die permanently in terms of technological superiority. So we must reverse that.

One last area, if I could do one other thing. We've talked about acquisition management and all, but of fundamental importance to this command is our developmental planning activity. We are the source of the new ideas, of the forward thinking in the Air Force. That's the great heritage of the Air Force—our ability to look out to the future and postulate systems like ICBMs, space vehicles, lasers, precision-guided munitions. That's our heritage . . . forward thinking. Our development planning capability in the Systems Command is less than what I would like it to be, and I am going to set as a goal the reinvigoration of that, and recreate within Systems Command the climate that fosters new ideas and doesn't fear occasional failure. I want to put up a WELCOME sign to creative industry. I want to have the wherewithal to pick up good ideas, and to develop their potential. We don't currently have that, and we're going to create it.

I think that over recent years we've gotten into a mode where other agencies than the Air Force have become the ones who foster and support new aerospace ideas. We want to regain that leadership in Systems Command. I want to leave here with a healthy developmental planning activity ongoing.

AFM: Thank you very much, General Marsh. ■

AIRMAN'S BOOKSHELF

The US Experience in Southeast Asia

Following are reviews of three books concerned with US involvement in the war in Southeast Asia. Two—each first in a series on the history of the conflict—explore the US's early commitment. The other consists of vignettes of individual Americans' experiences in SEA.

The United States Air Force in Southeast Asia: The Advisory Years to 1965, by Robert F. Futrell with Martin Blumenson, Office of Air Force History, 1981. 398 pages with index, bibliography, glossary, appendices, and maps. Superintendent of Documents, Government Printing Office, Washington, D. C. 20402. $14.

As evidenced by the appearance of Vietnam veterans on the cover of *Time* Magazine this summer, enough time seems to have elapsed for Americans to be able to consider the country's obligations to the veterans of the war in Southeast Asia without confusing them with reactions to the war itself.

Perhaps we are ready to engage in an examination of the war, too, without the disabling fever that infected our nation during the war and its immediate aftermath.

If so, access to the details of our military involvement in Southeast Asia is essential to distilling the lessons that remain to be drawn from our experience there. Such access is valuably afforded by the Office of Air Force History's recent publication of *The United States Air Force in Southeast Asia: The Advisory Years to 1965,* the first volume in a series that will examine the Air Force's role in the war.

The book begins shortly before the Japanese surrender in 1945, noting Ho Chi Minh's operations against the Japanese and OSS support of him in what was then called Indochina. The ensuing twenty years are organized in the book by Presidential administrations, with about sixty pages of text devoted to the fifteen years of the Truman and Eisenhower Administrations and 210 pages to the last five years of the period covered, during which the Kennedy and Johnson Administrations were in power.

The book ends appropriately in 1965, as Lyndon Johnson starts his only full term in office. The North Vietnamese have attacked the destroyer *Maddox* in the Gulf of Tonkin; Congress has resolved that the US could respond with "all necessary steps, including the use of armed force"; and the President has authorized Operation Barrel Roll (air interdiction in Laos) and Rolling Thunder (air attacks in North Vietnam). Clearly, the war to follow would no longer see the US in a predominantly advisory role.

The Advisory Years is not a book for the casual reader, perhaps properly so because it was not prepared for casual purposes. Nevertheless, I found unsatisfactory the straight chronological presentation of events grouped into chapters that sometimes strain to be homogeneous. An introductory overview or even a concluding summation may well have remedied this reviewer's sense that the book lacks a cohesive theme. But for those interested in factual detail, the book will serve them well. It is extensively indexed and footnoted and should be considered a valuable primer of excellent scholarship, indispensable for one who would undertake a serious look at the origins of the war.

This reviewer discerned a dominant thread running through the book: extreme Air Force frustration over several factors that prevented the effective use of airpower during the advisory years. The authors do not state this explicitly although as historians it would have been appropriate.

One major frustration was the paramount role played by the US Army, insisted upon by Defense Secretary Robert S. McNamara. Thus, the Army developed its own air force, disrupted unity of air command, and left the Air Force convinced that airpower did not get its day in court.

Also, the Air Force, and particularly the air commandos, chafed mightily under the requirement that their efforts be advisory only. (In one instance, when eight Americans and one Vietnamese were killed in an air crash, the flight was portrayed as an effort to train the lone Vietnamese.)

Additionally, political/diplomatic constraints blunted air operations. When Prince Sihanouk threatened to invite the Chinese into Cambodia if his territory were violated, Secretary of State Dean Rusk said that avoiding such risks was more important than attacks on VC strongholds. The Geneva accords, generally respected by the US during those years, barred introduction of jet aircraft and new air bases into South Vietnam.

Finally, the nature of the war itself leaves open the question whether airpower could have been effective even without the aforementioned restrictions. Insurgency tactics of concealment, dispersal, and surprise; prevailing weather and terrain; intermingling of friend and foe; and the absence of significant industrial targets in North Vietnam's agrarian economy all illustrate the problems of Air Force targeting.

Whether these difficulties are finally remedied or whether they represented determinative handicaps in the use of airpower must wait review of succeeding volumes.

Other matters explored in the book include the details of air operations in general; formation of unified and component organizations; discussion of key engagements such as Dien Bien Phu; mounting of specific projects like Ranch Hand (of special interest to Vietnam veterans in light of the current controversy surrounding use of the herbicide Agent Orange); a fascinating description of the developments leading to President Diem's assassination in the same month President Kennedy was shot; and liberal references to the positions taken by key decision-makers in addition to the Presidents (McNamara, Rusk, Taylor, Wheeler, LeMay, Westmoreland, etc.).

But, in the end, to one who was

there, the book leaves an aftertaste of both resigned sadness in witnessing again the spectacle of a great nation being inexorably drawn into a morass, and renewed determination to learn how that fate may be avoided in the future.

—*Reviewed by Joseph C. Zengerle, former Assistant Secretary of the Air Force (Manpower, Reserve Affairs and Installations) during the Carter Administration, and a Vietnam veteran. He now practices law in Washington, D. C.*

The Chilling Reality

Everything We Had: An Oral History of the Vietnam War by Thirty-three American Soldiers Who Fought It, compiled by Al Santoli. Random House, Inc., New York, N. Y., 1981. 265 pages with photos, glossary, and biographies. $12.95.

This book traces the United States's involvement in Vietnam from 1962 until the fall of Saigon in 1975 through the first-person accounts of thirty-three American veterans of the conflict.

Their candid insights reveal the chilling reality of the Vietnam War, a human truth only beginning to be put into perspective by historians and by the American people themselves.

The author, Santoli, himself a Vietnam veteran, has sensitively compiled these stories replete with contradictions mirroring the paradox that was Vietnam: A land of paradisal beauty whose people were caught in a web of unending carnage and despair.

Rifleman Jonathan Polansky's recollection of the picturesque village of Lang Co underscores the tragedy of Vietnam. Initiating a program to teach the village children English, Polansky became involved with his students' families and with a young Vietnamese widow. "Happier than . . . [he] had ever been in the States, . . ." he planned a future with the woman and managed to forget the war. But when he and his unit returned from a three-month mission to another region, Polansky discovered the village razed, its inhabitants massacred by the Viet Cong as American sympathizers.

Anguish and cynicism pervade these accounts. Some, like Navy SEAL Mike Beamon's surrealistic tale of special forces operations entitled "Frogmen" and rifleman Thomas Bird's account of ambush and atrocities in "Ia Drang," make the reader recoil in horror and disbelief. Others

AIRMAN'S BOOKSHELF

will restore one's faith in the bravery and resilience of the human spirit.

For example, Lynda Van Devanter, now an activist for veterans rights, found her hope in the future reaffirmed when she delivered a Vietnamese baby at a field hospital. Karl Phaler, former advisor to the Vietnamese Navy, collected more than $15,000 in donations from concerned people throughout the world to found an orphanage.

During his six years in solitary confinement, Adm. William Lawrence, now Superintendent of the US Naval Academy, developed a communications network of coughs, taps, and broom-sweeping that kept fellow POWs informed, their mental activity alive, and their morale up. In order to keep mentally alert, Lawrence composed iambic pentameter poetry (one poem later became the state poem of Tennessee) and did higher mathematics in his head. The Vietnam experience has instilled in him "a great feeling of inner calm and serenity."

Others returned with ambivalent sensations—loud sounds or passing helicopters trigger flashbacks of combat and dead comrades wrapped in ponchos or body bags. As Stephen Klinkhammer, a Navy corpsman during the evacuation of Saigon, learned, "There is no understanding. . . . People want me to bury it. I can't bury it. I did learn something and I'm not sure what. But I know it's affected me a whole lot . . . because I don't want to see it happen again and I really care about people. . . ."

It is the honesty and intimacy of these accounts that make *Everything We Had* unforgettable. They give us, the noncombatants, the chance to experience vicariously Vietnam and to bear witness to the ordeals our soldiers endured and continue to endure.

—*Reviewed by Ann Leopard, Editorial Assistant.*

Into the Quagmire

The Vietnam Experience: Setting the Stage, by Edward Doyle, Samuel Lipsman, and Stephen Weiss. The Boston Publishing Co., Boston, Mass., 1981. 191 pages with index. $11.95.

The most common, and essentially accurate, analogy that comes to mind when considering America's experience in Vietnam is that of the United States landing with both feet in a quagmire. The creation of that swamp and the tenacity of its muck is nowhere better described within the short compass of 191 pages than in the Boston Publishing Co.'s introductory volume to its new series, "The Vietnam Experience."

Titled *Setting the Stage,* this book takes the first step in placing the fall of South Vietnam in 1975 into the context of Vietnamese history, bringing the story forward to the end of World War II. The forces that later were to frustrate America's venture into the area were already in place in 1945, awaiting only the final act in which the United States would accomplish little more than postpone the denouement that was centuries in the making.

Little in history, of course, is that inevitable. Yet the authors, by frequently projecting major steps of the drama forward in time toward what lay ahead, impart a sense of inevitability which, while debatable on some specifics, provides unity to the volume.

The more things seemed to change in Vietnam throughout its history the more they remained the same. One persistent and recurring ingredient of the quagmire, which sucked in and enervated constant attempts to change it, was internal resistance to any move that sought to bring centralized order to a decentralized, feudal society. Whether launched from without by the Chinese, Japanese, French, or Americans, or from within by the Scholars, Buddhists, or Catholics, these frequent attempts to forge a modern nation foundered on the shoals of feudalism.

The legacy of this centuries-old struggle was the Vietnamese society characterized by traits only too familiar to contemporary Americans. Guerrilla warfare, with all its trappings, became a way of life early for the Vietnamese, whether in opposing the Chinese in the first century, the Mongols in the thirteenth, or the Japanese, French, or Americans in the twentieth. The drama was played out over these centuries through repeated attempts by one group or another to "win the hearts and minds of the peasants." From this developed two other staples of Vietnamese life: rebellion as a common tool of social change and dependence by those seeking change on outside assistance. As a result, Vietnam's history has been one of constant fighting with her neighbors.

Although this first volume barely reaches the period of America's first tentative relations with Vietnam, the outcome of the future American plunge into this milieu already seems predetermined. The question that leaps to mind is why we did not see this at the time, thereby avoiding subsequent nastiness? The answer lies outside the scope of this review and likely resides, in part, in American hesitancy to incorporate in any serious way historical perspective in its decision-making process. It will be interesting to see if and how this question is treated in later volumes. In the meantime, this first tome does set the stage well by making it clear that the quagmire is primarily economic and social rather than military or even political.

While this volume breaks no new ground, its value lies in encapsulating earlier scholarship into useful form. The absence of footnotes makes it impossible to verify and follow up on specifics, but the bibliography is dependable. One distracting note for the serious reader is the periodic disruption of the text by colorful but obtrusive pictorial essays containing information that in a more scholarly volume would appear in explanatory footnotes. Also, it is to be hoped that the selection of photographs of Americans who in this volume are depicted only as pugnacious or drug-sodden does not presage an editorial policy that will guide the rest of the series.

—Reviewed by Col. John Schlight, Office of Air Force History.

New Books in Brief

Afghanistan: Key to a Continent, by John C. Griffiths. Prior to the Soviet invasion of Afghanistan, many people would have been hard pressed even to locate Afghanistan on a map. Yet for hundreds of years this fiercely independent nation has been a "fulcrum of empires," situated strategically between China, India, the riches of the Persian Gulf, and the southward-glancing Soviet Union. Author Griffiths, who has traveled extensively in Afghanistan and who knows personally the country's leading political figures and tribal leaders, provides rich (though sometimes impressionistic) insights into the history, society, politics, and culture of this unusual nation caught between the Middle Ages and the twentieth century. With illustrations, references, and index. Westview Press, 5500 Central Ave., Boulder, Colo. 80301, 1981. 225 pages. $20.

The High Road, by Ben Bova. Author Bova, a science fiction writer and editorial director of *Omni* magazine, makes an impassioned plea in *The High Road* for mankind to refocus its energies on the exploration and exploitation of space "for one brutally simple reason: survival." His main thesis is that the pressures generated by a burgeoning world population will eventually force either an expansion into space or an apocalyptic collapse of civilization. While Bova's views tend to gloss over substantial practical problems and to overlook man's propensity to carry his many imperfections with him, his enthusiastic arguments for a renewed space program are sure to win applause from those already convinced and give pause to the present-day "Luddites" he admonishes. With a preface by former astronaut Sen. Harrison Schmitt (R-N. M.) and index. Houghton Mifflin Co., Boston, Mass., 1981. 289 pages. $11.95.

Jane's Fighting Ships 1981–82, edited by Capt. John Moore, RN. This eighty-fourth edition of *Jane's Fighting Ships* should by now need no introduction; however, for the uninitiated, it is simply the world's foremost authority on military naval vessels. In his Foreword, Captain Moore warns that financial difficulties and a lack of innovation in naval programs threaten to destroy the West's ability to provide a credible deterrent to an expanding Soviet navy. Arguing that available resources for naval spending are diminished by "delays in decision-making, inefficient procurement procedures, and a failure to capitalize on modern thinking," Captain Moore calls for more flexible and responsive procurement practices and a "willingness . . . to accept new concepts." Jane's Publishing Inc., New York, N. Y., 1981. 794 pages. $140.

The Strategy of Electromagnetic Combat, edited by Lt. Col. Richard E. Fitts, USAF. Written by Air Force Academy faculty members, this unabridged publication grew out of a desire to relate classroom academics to the real-world electromagnetic environment. The book provides first a broad overview of the tactics and strategy of electromagnetic combat and then proceeds to more technical and operational details. Though the book is specialized, readers can expect to gain a basic understanding of this increasingly important field. With tables, illustrations, appendices, glossary, and index. Peninsula Publishing, P.O. Box 867, Los Altos, Calif. 94022, 1980. 283 pages. $17.95.

—Reviewed by Hugh Winkler, Ass't Managing Editor.

THE BULLETIN BOARD

By James A. McDonnell, Jr., MILITARY RELATIONS EDITOR

"Former Spouse" Benefits Aired

The recent Supreme Court "McCarty" decision has sparked several proposed bills aimed at clarifying issues flowing from the decree. The decision, stating that military retired pay could not be divided as part of a divorce-settlement distribution of community property, has evoked strong feelings on the concept of an ex-spouse sharing both active-duty and retired benefits.

Proponents of both sides of the argument have filled congressional hearing rooms with what one observer told AIR FORCE Magazine is the most "impassioned debate I've heard on any issue in a long time." Ex-spouses, singly and in organized groups, have packed hearings whenever these proposed bills have been discussed.

Sen. Roger W. Jepsen (R-Iowa) has introduced a bill that would treat retired pay either as the sole property of the member or as the property of both member and spouse, depending on the law in the divorce-granting state. His bill also would afford certain health-care and survivor benefits to the former spouse.

Companion legislation was introduced in the House by Rep. G. William Whitehurst (R-Va.), who said, "I have long been an advocate of official recognition of the contributions of the long-term military spouse." Noting that frequently the military spouse interrupted education and career progression because of military moves, Representative Whitehurst said, "Certificates of appreciation, grocery bag logos, and laurels on a husband's efficiency report are no longer satisfactory compensation in today's society."

Both bills would honor state court-ordered deductions from retired pay for child support, alimony, or property settlements. Also allowed would be designation of former spouses as Survivor Benefit Plan (SBP) beneficiaries, and would give unremarried spouses, formerly married for a minimum of twenty years, continued health care at military facilities or through CHAMPUS for a pre-divorce condition. Representative Whitehurst notes that this proposed legislation was prepared after consultation with DoD.

Other proposals cover wider ranges. For example, Rep. Pat Schroeder (D-Colo.) would give an automatic pro-rata share of both retirement pay and survivors benefits to ex-spouses who had been married at least ten years. Sen. Dennis DeConcini (D-Ariz.) would allow the military spouse to claim whatever the state court felt fair, including part of the retired pay. Rep. Kent Hance (D-Tex.) would like to see the government guarantee payment of state court-directed awards, including pension shares, by having DoD remit funds directly to the ex-spouse.

Testifying for DoD, Army Lt. Gen. R. Dean Tice, Deputy Assistant Secretary of Defense for Military Personnel and Force Management, observed that "the issue is very personal and one that lends itself to emotional involvement." He testified that DoD holds ". . . that the federal government should not be directly implicated in the decisions of state courts in domestic relations matters."

He stressed that the McCarty decision, while nixing consideration of military retired pay as community property, did not interfere with a state court's right to consider retired pay as income in determining amounts awarded for alimony and/or child support. He said he also felt that state courts did consider spousal hardships, such as those generated by military service, when fixing compensation. In summation, he deferred enunciation of any DoD position, pending issuance of a fully coordinated Administration position.

In any event, there is no question but that this issue will continue to receive priority attention and vocal advocacy from those on both sides, far into the foreseeable future.

Rawlings Award Presented

A plaque designated the Gen. Edwin W. Rawlings award for energy conservation was presented by the Air Force Association to the Air Force in a Pentagon ceremony, marking the beginning of the third annual Air Force Energy Awareness Week. This new award, sponsored by retired Air Force General Rawlings, was established by AFA and its affiliate, the Aerospace Education Foundation. The first two recipients of the award, Capt. James McEvoy and SMSgt.

Gen. Edwin W. Rawlings, USAF (Ret.), center, and AFA and AEF Executive Director Russ Dougherty, right, present the Rawlings Energy Conservation plaque to Lt. Gen. Billy Minter, DCS/Logistics and Engineering. General Minter accepted the award on behalf of the Air Force at a recent Pentagon ceremony. See item. (USAF photo)

Wayne Moore, were honored at AFA's Convention last September.

Lt. Gen. Billy Minter, DCS/Logistics and Engineering, accepted the plaque on behalf of the Air Force from General Rawlings and Russ Dougherty, AFA and AEF Executive Director *(see photo)*. The plaque will be permanently installed at the Pentagon and inscribed with the names of individual recipients.

General Rawlings has long been concerned with energy conservation efforts. His desire to promote Air Force-wide interest resulted in the establishment of this award.

Air Controller Support Continues

The number of military air controllers serving at civilian FAA facilities had risen to 810, at 100 locations, at press time. A requirement for 435 additional people, at ten more locations, was pending. Dr. Alton G. Keel, Jr., Assistant Secretary of the Air Force for Research, Development and Logistics, said, "We are currently assessing the impact of supporting the additional requirement."

Of the 810 augmentees, the Air Force, designated coordinator for the overall effort, has the largest share—490, or sixty percent. There are 206 Army, for twenty-six percent, and 114 Navy and Marine Corps, for fourteen percent. Within the Air Force, meanwhile, steps were being taken to bring a higher degree of administrative order to the controllers' status. Air Force Secretary Verne Orr directed that the Air Force controllers be allowed the option of converting an extended TDY status to PCS, if it were anticipated that TDY tours would run six months or more.

Instructions to the field cautioned, however, that each controller be thoroughly counseled to ensure understanding of the advantages and disadvantages of each option. PCS, for example, would entail loss of per diem, but would, of course, allow movement of household effects. On the other hand, it was impressed upon members that, upon termination of the assignment, which could be of short duration, they might very well be assigned back to their previous base. Members were asked to choose one of the two options, and commanders were directed to expedite paperwork either to effect the PCS or to request necessary waivers for extended TDY.

In related action, the Air Force announced an exception to normal accrued leave policy that would allow augmented controllers to accrue up to ninety days (rather than the normal sixty) through Fiscal Year 1982. This exception will help prevent loss of accrued leave for controllers unable to take leave either because of work conditions at their augmented location or—for those remaining at military facilities—because of reduced manning levels at the home station.

Program Taps Vietnam Vets

President Reagan has established, as part of ACTION, the national volunteer agency, a new program, the Vietnam Veterans Leadership Program, designed to highlight the leadership resources of Vietnam veterans.

"It is time to tap the enormous resource of able and successful Vietnam veterans, who stand ready to come forward to help solve the problems still faced by their fellow veterans," said Thomas W. Pauken, director of ACTION and himself a veteran of Vietnam. John P. Wheeler III, also a Vietnam veteran, serves as the VVLP national program director.

During 1982, the VVLP will be established in fifty communities across the United States. Programs are already under way in Philadelphia, Baltimore, San Antonio, Wilmington, Phoenix, and Nashville. Each of the fifty communities will have a volunteer chairman and a salaried project director, each to be both Vietnam veterans and community leaders.

They will recruit volunteer Vietnam veterans to work at the senior levels of the communities' business and government structure to help build and maintain a coordinated community-wide effort to assist the thousands of men and women who still have significant problems associated with their Vietnam experience, such as underemployment or unemployment.

The program, designed to serve as a catalyst rather than as a specific service delivery mechanism, will not attempt to duplicate or overlap the services already provided by the Veterans Administration and its outreach centers, or by local community-based organizations or veterans service organizations.

At a cost of $2 million per year, it is intended to be a short-term, cost-effective volunteer effort. The federal role will be phased out by September 1984, when the program will be turned over to the local communities.

STEP Program Made Permanent

Air Force Chief of Staff Gen. Lew Allen, Jr., has okayed continuation of the Stripes for Exceptional Performers (STEP) program on a permanent basis.

Essentially, the program siphons off a limited number of enlisted promotion slots for use by major commanders and commanders of large separate operating agencies outside of the normal centralized promotion system to promote airmen with exceptional potential. While some critics of the program claimed that it tended to destandardize promotion criteria, it is generally believed to be a program that has gained overwhelming acceptance from the working level troops, and is a powerful motivator. One commander told AIR FORCE Magazine, "This is a good program. It works. If we know we have somebody who is doing an exceptional job, we can promote. It's increased competition in my units tremendously."

Some changes accompany the permanent status. While the test STEP allowed promotions to the grades of Senior Airman through Master Sergeant, the already-operating Senior Airman Below the Zone program now will give deserving Airmen First Class comparable opportunity. Also, to include airmen who are assigned to units not eligible for STEP because of a small enlisted population, commanders or other senior officers in such organizations may now nominate airmen for STEP consideration to Hq. AFMPC, where a board will select the best. For the foreseeable future, the annual STEP promotion quota will be about 445. The test STEP saw some 200 airmen change stripes.

Sergeant Wins Slogan Contest

Air Force SMSgt. James M. Rankin of the 2187th Communications Group in Aviano, Italy, has been named winner of the 1982 Federal Voting Assistance Program's Voting Slogan Contest *(see "Bulletin Board" item, Aug. '81).* His slogan, "Be Part of America's Future, Vote!", won out over more than 7,000 entries from around the world.

THE BULLETIN BOARD

His slogan will key the media campaign to motivate the more than 5,000,000 US service members, their families, and US citizens residing abroad to participate in the upcoming 1982 state and federal elections. The panel of judges that selected the winning entry included Sen. Charles Mathias, Jr., (R-Md.) and Rep. Augustus F. Hawkins (D-Calif.).

"Your Mother Wears Combat Boots"

Perhaps. In any event, the Air Force Uniform Board has now okayed the wearing of combat boots by women with all pantsuit combinations. Also, it set October 1 of this year as the phaseout date for the women's blue utility uniform with slacks and wraparound skirt. After that date, women required to wear the utility uniform will wear the green fatigue shirt and trousers.

Other changes approved by the Board:

- Let major commands decide when authorized members can wear camouflage fatigues.
- Allow aircraft operations people assigned to the 89th Military Airlift Group—guardians of *Air Force One* and other high-priority passenger transports—to wear a light blue utility uniform.
- Authorize tactical air control personnel to wear the black beret and bloused trousers with all uniform combinations, and give these members assigned to work with US Army units on Army posts authority to wear the unit designation patch on the shoulder of the utility uniform.

Shoulder-board grade insignia for the top three enlisted grades have also been blessed in principle, but would-be wearers must await availability of the boards at military clothing stores, possibly by spring of this year. Members are specifically cautioned not to wear commercially purchased boards before they are available in clothing sales.

Also, a new blue pullover sweater for inside and outdoor wear has been approved, but only for those assigned to Washington, D. C., in joint departmental assignments. Sharp-eyed observers might have noted some Pentagon assignees testing this recently, and it looks good. General availability of the sweater is unknown at this time.

Short Bursts

Sen. Daniel K. Inouye (D-Hawaii) has introduced legislation that would continue **CHAMPUS eligibility** for beneficiaries past age sixty-five. Under current law, eligibility for Medicare blocks CHAMPUS coverage. AFA has long championed a lifting of this restriction, not only because of the broader coverage CHAMPUS affords, but also because it believes continued identification with the military is a significant "peace-of-mind" benefit for retirees. Hearings are not yet scheduled on the measure.

Rumblings about **cutting back on commissary subsidies,** thus raising user costs, were surfacing at press time. Every Administration in recent memory has, sooner or later, made overtures to gut this benefit. Commissary supporters are gearing up for a possible battle again in 1982.

Congress wants greater **sharing of VA and DoD medical facilities.** Noting that the two agencies already exchange resources on an informal basis, lawmakers want to assure that VA, and not the private sector, will serve as the principal backup to DoD for medical care during war or national emergency.

VA will now accept **copies of discharge certificates** "certified as a true and exact copy by a public custodian of records" for claims processing. It notes that this step is taken in response to lengthening delays in obtaining verification of veteran's service from military departments.

Two new groups have been added to the growing list of those designated as **"having served on active duty,"** a move that opens up veterans benefits to those so named. The new designees, named by the Secretary of Defense, are **Reconstruction Aides and Dietitians** in World War I and the group known as **Male Civilian Ferry Pilots.**

Dr. Richard H. Kohn, right, was recently named Chief of the Air Force Office of History. Dr. Kohn was an associate professor of history at Rutgers University before assuming the top history job in the Air Force. He is shown during a recent visit with Air Force Communications Command historian Dr. Thomas S. Snyder, left, and Dr. Snyder's assistant, Dr. Joseph P. Harahan, at Scott AFB, Ill. (USAF photo by TSgt. Edward Nightingale)

The Case for the All-Volunteer Force

By Ed Gates, CONTRIBUTING EDITOR

Editor's note: Mr. Gates's opinions on conscription and national service are his own, and not necessarily USAF or AFA positions. Because the topic is—and will remain—important and controversial, AIR FORCE *Magazine welcomes the expression of differing viewpoints and arguments on it.*

The President recently reiterated his support for the All-Volunteer Force and his opposition to a peacetime draft, noting in the process that recruiting and personnel retention have improved significantly. Whether or not that will silence critics of the Chief Executive's military manpower policies remains to be seen, although shortly before his report a Harris Poll found that sixty percent of the public favored replacing the AVF with a draft of young males.

That's somewhat surprising, since it suggests that the public has largely forgotten the negative aspects of conscripted service as it operated in years past and would probably operate again if renewed. It suggests also that many citizens are unaware of the improved recruiting and retention programs under the AVF.

The cornerstone of any draft system is a huge training establishment that swallows up tens of thousands of inductees periodically, puts them through basic and technical training, scatters them about, gives them some on-the-job training, and may even send them overseas. Then, just as they're on the verge of producing, of carrying their weight and contributing to the mission, their time is up. They go home (few draftees sign for more service). The government receives little mileage from its considerable investment.

So, the induction-training-release pattern continues, and the draft-oriented service finds itself bogged down with staggering unit turnover, instability and ineffectiveness, and mounting disciplinary problems.

Shorter draft periods, as have been suggested and which are commonplace in Europe and elsewhere, would compound the utility problem.

Meantime, scattered support continues for "universal service" under which all nondisabled draft-age male youths would serve a hitch in the active force, Reserve Forces, or in government poverty and social programs. Universal service has a pleasant ring to it; it smacks of treating all people equally and sharing the burdens of democracy. Certainly it rates a spot high on the government's list of "nice to have" programs. But the idea is impractical, the potential expense enormous. The Administration has promised to reduce the federal bureaucracy, not expand it by pushing millions of youths into make-work projects.

Critics of the AVF are rightly concerned about the quality and quantity of personnel available for military service, and the difficulties have been heavily publicized. But a rosier picture is emerging. Mr. Reagan and the Defense Department disclosed that FY '81 was the services' best recruiting year since the start of the AVF in 1973. Some officials say the best since World War II. All goals were met or exceeded. The number of high school graduates increased, and the percentage of recruits in the lowest acceptable mental category plunged.

The favorable results of the Navy's FY '81 recruiting year are worthy of special note; USN exceeded its recruiting goal for the second consecutive year and new sailors raised their test scores significantly. Furthermore, the Navy, which earlier reported serious retention problems among experienced petty officers, also revealed that more than 4,000 active-duty and Reserve sailors and retirees have applied for the 1,560 billet openings on the battleship *New Jersey*, whose rehabilitation at Long Beach, Calif., is "proceeding apace" and is scheduled to be completed early in 1983.

The Air Force, of course, chalked up another satisfactory recruiting year, long a routine performance. And the Air Force, like the other services, is enjoying improved retention of skilled members.

Better manning didn't just happen. Recruiters went out and produced. In-service members, Reservists, and friends and relatives of military people lined up prospects. Military leaders worked hard to raise the "quality of life" in uniform.

Most importantly, the government came through on its promises of better pay, allowances, and benefits. Military service now is not only well rewarded, it is the envy of growing numbers of outsiders. More service people realize this and are staying in. This good news, of course, must be tempered by the high rate of unemployment, which in some cases makes military service more attractive.

Other important support for retaining the AVF and rejecting draft reinstatement has emerged from a recent seminar that included the services' and Defense Department personnel chiefs, congressional and think-tank manpower experts, sociologists, educators, and the like. Their conclusion: The All-Volunteer Force has been unfairly blamed too often for the services' people problems. Keep it.

Another reason—perhaps the most compelling—for continuing the AVF and forgetting about a draft is tied to today's attitudes among draft-age youths. Late last year, the government reported, 800,000 of them had thumbed their noses at Uncle Sam by refusing to register under the present Selective Service law. They, and doubtless many of their counterparts who did register, albeit reluctantly, are reminiscent of the draft dodgers and country-skippers of the Vietnam era. Who needs them? Who wants them? Certainly not the military establishment. ■

Adding emphasis to funding requests for VA activity, the agency notes that **more than half of those who served** in the military during *all* of this nation's wars are still alive. Of more than 38,000,000 war period participants—going back to the Revolution—more than 25,000,000 are still living today. In addition, there are more than 4,000,000 living veterans of peacetime eras.

New **rules for separated military members** seeking unemployment benefits after leaving service require completion of at least one year of military service. Additionally, the ex-service person must not have resigned or voluntarily left the service nor been discharged for cause.

Georgia now allows a **state tax exemption** of $2,000 for all retirees over age sixty-two, including retired military. Boosters in the state legislature are pushing for total exemption of military and federal employee retired pay, a move that would parallel exemptions now available to state employees and teachers.

Senior Staff Changes

PROMOTIONS: To **Major General:** Leon W. **Babcock,** Jr.; Robert D. **Beckel;** John A. **Brashear;** Duane H. **Cassidy;** William M. **Charles,** Jr.; Joseph H. **Connolly;** Charles J. **Cunningham,** Jr.; Thomas G. **Darling;** William A. **Gorton;** Monroe W. **Hatch,** Jr.; Paul H. **Hodges;** William L. **Kirk.**

Donald L. **Lamberson;** Gerald D. **Larson;** William J. **Mall,** Jr.; Charles **McCausland;** Robert E. **Messerli;** Joseph D. **Moore;** Richard D. **Murray;** David L. **Nichols;** Peter W. **Odgers;**

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George B. **Powers,** Jr.; Richard W. **Pryor;** Bernard P. **Randolph.**

Robert H. **Reed;** Thomas C. **Richards;** Robert A. **Rosenberg;** Robert D. **Springer;** Thomas S. **Swalm;** William E. **Thurman;** Edward L. **Tixier;** Harold W. **Todd;** Brien D. **Ward;** Clifton D. **Wright,** Jr.; Kermit Q. **Vandenbos.**

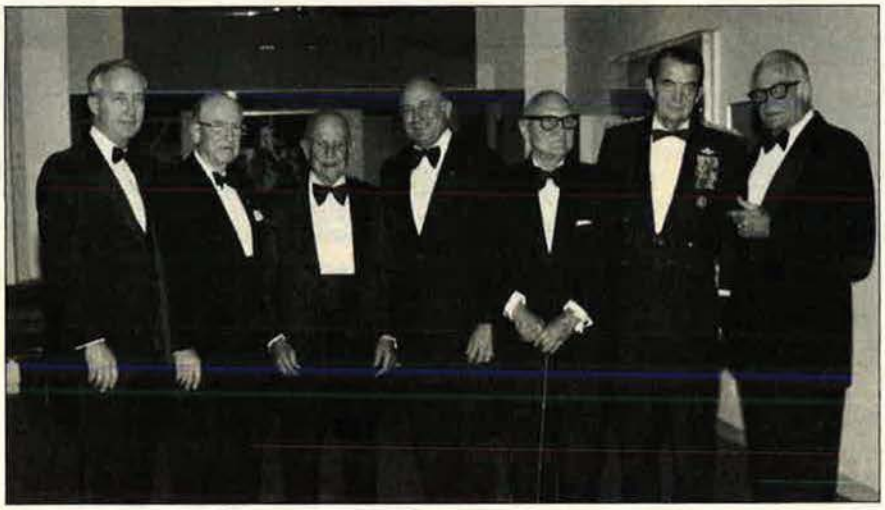
RETIREMENTS: M/G Richard C. **Bowman;** B/G Richard T. **Drury.**

CHANGES: B/G Michael H. Alexander, from Cmdr., AEDC, AFSC, Arnold AFS, Tenn., to Dep. for Communications & Information Systems, ESD, AFSC, Hanscom AFB, Mass. . . . **B/G Elmer T. Brooks,** from Cmdr., 381st SMW, SAC, McConnell AFB, Kan., to Dep. Dir., Int'l Negotiations, J-5, OJCS, Washington, D. C. . . . **M/G Melvin F. Chubb, Jr.,** from Strategic System Prgm. Dir., ASD, AFSC, Wright-Patterson AFB, Ohio, to DCS/Systems, Hq. AFSC, Andrews AFB, Md., replacing M/G James A. Abrahamson.

M/G Donald L. Evans, from DCS/Data Systems, Hq. SAC, Offutt AFB, Neb., to Joint Prgm. Manager, WWMCCS, Information Systems, The Pentagon, Washington, D. C. . . . **B/G Donald W. Goodman,** from Ass't Vice Dir. for Attaches and Trng., DIA, Washington, D. C., to C/S, DIA, Washington, D. C. . . . **B/G Edward J. Heinz,** from DCS/Intelligence, NORAD/ADCOM/ADC, Peterson AFB, Colo., to Dir., J-2, Hq. USEUCOM, Vaihingen, Germany, replacing retired B/G Billy B. Forsman . . . **B/G (M/G selectee) William E. Thurman,** from Cmdt., Defense Systems Management College, Fort Belvoir, Va., to Dep. for B-1B, ASD, AFSC, Wright-Patterson AFB, Ohio.

SENIOR ENLISTED ADVISOR CHANGES: CMSgt. Raymond F. Enright, to SEA, Hq. AFTEC, Kirtland AFB, N. M., replacing CMSgt. Zach J. Allison . . . **CMSgt. Larry L. Vance,** from Supply Chief, 4450th Tactical Gp., Nellis AFB, Nev., to SEA, Hq. USAFA, Colo., replacing retired CMSgt. Marvin G. Penfield . . . **CMSgt. Robert J. Zahorchak,** to SEA, Hq. AFESC, Tyndall AFB, Fla., replacing CMSgt. Wade H. Grimm. ■

INTERCOM



The National Air and Space Museum provided an appropriate site for the Aerospace Education Foundation's second annual Salute to Jimmy Doolittle. In attendance from left: Rockwell International executive James McDivitt; National Geographic Society's Dr. Thomas McKnew; Gen. Jimmy Doolittle; AFA National President John G. Brosky; Gen. Ira Eaker; Chairman of the Joint Chiefs of Staff Gen. David C. Jones; and Sen. Barry M. Goldwater, Chairman of AEF's Board of Trustees.

AEF's Salute to Jimmy Doolittle and Ira Eaker: An Evening to Remember

It was an evening to remember as top corporate executives and military and congressional leaders gathered at the National Air and Space Museum for the Aerospace Education Foundation's second annual black-tie "Salute to Jimmy Doolittle." This year's Salute was truly a special affair, for in addition to honoring General Doolittle, the Salute recognized airpower pioneer Gen. Ira Eaker.

General Doolittle and General Eaker have lent their names and prestige to the Foundation's two fund-raising programs, which support the Foundation's work in making available Air Force courses to civilian schools and in financing historical projects. The Salute also honored those corporations that have made contributions to the Foundation as corporate Fellows.

The elegant Salute dinner was attended by many distinguished guests, including US Supreme Court Chief Justice Warren Burger; Rep. Melvin Price (D-Ill.), Chairman of the House Armed Services Committee; Senate Armed Services Committee member Sen. Howard Cannon (D-Nev.); Secretary of the Air Force Verne Orr; Chairman of the Joint Chiefs of Staff Gen. David C. Jones; and Air Force Chief of Staff Gen. Lew Allen, Jr.

As the educational affiliate of the Air Force Association, the Aerospace Education Foundation pioneered a program making educational courses developed by the Air Force available for use by civilian schools. This project is funded largely through the "Jimmy Doolittle Fellow" program, in which individuals or groups and corporations may affiliate as Fellows for a $1,000 or $15,000 contribution, respectively. The funds raised are applied to adapting Air Force courses for civilian use. Thirteen corporations have been strong supporters of the Foundation, and two corporate Doolittle Fellows have contributed twice. Corporate contributions to the program total $225,000. In addition, there are 241 individual Doolittle Fellows.

The General Ira C. Eaker Historical Fellowship Program, announced at the Foundation's Silver Jubilee luncheon held during last year's AFA National Convention, raises funds for the Foundation's historical projects. Thus far, one corporation—Rockwell International—has already become a corporate Eaker Fellow, and twenty-one individuals have also subscribed.

In the Midst of History

The gala affair, held among the Air and Space Museum's displays of America's aerospace heritage, united

Two great airpower pioneers—Jimmy Doolittle (left) and Ira Eaker—greet one another at the AEF's Doolittle Salute held on October 27, 1981.

JCS Chairman Gen. David C. Jones, himself a Doolittle Fellow and an Eaker Fellow, paid special tribute to General Eaker at the Salute.

A symbolic mace for the Community College of the Air Force was presented by (left) Aerospace Education Foundation President Dr. Don Garrison, and CMSgt. Lewis Spence, (right), President of the Air Force Sergeants Association, to ATC Commander Gen. Thomas M. Ryan.

The center of attention is Ira Eaker, honored jointly with Jimmy Doolittle at AEF's black-tie evening. With General Eaker, from left: Senator Goldwater, AFA President John G. Brosky, Air Force Secretary Verne Orr, Supreme Court Chief Justice Warren E. Burger, and Jimmy Doolittle.

the two airpower pioneers with the machines they flew in making history. In his welcome, AFA and Foundation Executive Director Gen. Russell E. Dougherty, USAF (Ret.), pointed out the Jimmy Doolittle display documenting General Doolittle's exploits, and the model of the Loening Amphibian with this inscription on the fuselage: "Capt. Ira C. Eaker, Pilot."

After the two legendary heroes received an enthusiastic welcoming ovation, General Dougherty explained that General Doolittle's wife, Joe, was the first Doolittle Fellow, but that Jimmy Doolittle himself was not named a Fellow until this year. "We've learned something in these past seven years," General Dougherty said, "and this time the first two Ira Eaker Fellows have been awarded to General Eaker and his lovely wife, Ruth."

General Dougherty then introduced the evening's master of ceremonies, Sen. Barry M. Goldwater (R-Ariz.), Chairman of the Foundation's Board of Trustees.

Senator Goldwater noted that man first flew just before his birth. "That's in my lifetime!" he exclaimed. "I've been privileged to watch the growth of aviation . . . a thrilling experience."

Senator Goldwater said that he thought it was appropriate to honor the personal contributions of these "two magnificent men in the shadows of these historic flying machines." Noting that "I and all of us in this room are not the only ones honoring you tonight," he then read to the audience portions of a letter from President Reagan *(see p. 106)*.

Senator Goldwater recognized several distinguished guests, and then explained how funds generated by the Doolittle Fellow program are used to supply Air Force-developed courses for use by civilian institutions. The courses are provided on a nonprofit basis, covering only cost of reproduction and distribution. Funds from the Eaker Fellowships will be used to support historical research to ensure national appreciation for America's aerospace heritage.

"Currently we have 241 individual and thirteen corporate Doolittle Fellows, and we have one corporate and twenty-one individual Eaker Fellows," Senator Goldwater noted.

Backbone Support

The Foundation Board Chairman went on to pay tribute to the corporate Fellows "who furnish the backbone support for our operations." Senator Goldwater was optimistic "that many more corporations will join us by this time next year."

Representatives of corporate Fellows were recognized individually by

United States Supreme Court Chief Justice Warren E. Burger, right, discusses the evening's program with AFA National President and Pennsylvania Superior Court Judge John G. Brosky.

Senator Goldwater *(see box below)*. When he came to the General Dynamics Corp., GD Vice President for International Affairs Otto Glasser offered an additional $1,000 personal contribution to the Foundation for an Eaker Fellowship.

Senator Goldwater also recognized the Foundation's top individual contributors: W. Clement Stone, President and Chief Executive Officer of the Combined Insurance Companies (who was unable to attend); AFA National Director and Foundation Trustee Bill Spruance; and AFA's Iron Gate Chapter, represented by Chapter Secretary and National Salute Coordinator Dorothy Welker.

Senator Goldwater then introduced Maj. Gen. Leigh Wade, USAF (Ret.), who was recently honored by the Society of Experimental Pilots as the "Honorary Fellow of the Year." The Senator also paid tribute to the "organization that gave birth to our Foundation and has sustained it over the years—the Air Force Association." He then presented AFA Chairman of the Board Victor R. Kregel and AFA National President Judge John G. Brosky.

A Special Presentation

Part of the evening festivities was devoted to presentation of an academic mace to the Community College of the Air Force. The idea for the mace, which has symbolized protection and prestige since medieval times, was advanced by one of the College's advisors, Dr. Jerome Lysaught, Professor of Education and Preventive Medicine at the University of Rochester. A "macemaker" was found and a joint venture struck between AFA and the Air Force Sergeants Association.

Senator Goldwater requested Gen. Thomas M. Ryan, Commander of Air Training Command (which has jurisdiction over the College); CMSgt. Lewis Spence, President of the Air Force Sergeants Association; and Foundation President and Tri-County Community College President Dr. Don Garrison to come to the podium. The two presented the mace to General Ryan, who responded with appreciation for the support the Community College has received from AFA, the Aerospace Education Foundation, and the Air Force Sergeants Association.

Living Legends

Chairman of the Joint Chiefs of Staff Gen. David C. Jones then paid tribute to the men of the hour. Noting that it was a stroke of genius to bring together the names of Doolittle and Eaker for an evening, he said, "These two great men—born in the same year . . . 1896—how fortunate our country is, and the Air Force, that these two great men went into aviation and accomplished so much in peacetime."

Jimmy Doolittle, who was AFA's first National President and a driving force behind its formation, achieved fame as a flyer through races, endurance records, technical achievements, and aerobatics. He earned many aviation "firsts," including the first to accomplish an outside loop; the first blind takeoff, set course flight, and landing; and the first speed records for seaplanes over a straight course, in a pontoon-equipped Curtiss R3C-2. He also won many air races and endurance contests and set innumerable speed and distance records.

His most famous exploit, however, was as leader of the "Tokyo Raiders," who made the daring bombing raid on Tokyo on April 18, 1942. For this effort he received the nation's highest tribute, the Medal of Honor.

General Eaker—who earned his wings in 1918, fifteen years after the Wright brothers' first powered flight at Kitty Hawk—is still a respected airpower authority and advisor to top military and civilian leaders here and abroad. As a flyer, planner, commander, and writer, Ira Eaker is recognized as one of a select few who helped shape the world's aerospace forces.

General Eaker set an endurance record of 150 hours in the *Question Mark*, a Fokker trimotor, in 1929, thereby helping to establish the feasibility of aerial refueling. He made the first transcontinental flight solely on instruments in 1936, led the first B-17 attack on Europe in 1942, and in 1944 led the first shuttle bombing mission from Italy to Russia and back. His career spanned from service in the Signal Corps Aviation Section to the Army Air Forces. He retired in 1947, three months before establishment of the Air Force as a separate service.

In 1979, General Eaker was awarded a Congressional Medal for his achievements in airpower—from the early records he set through his postwar promotion of airpower in his syndicated col-

Aerospace Education Foundation Corporate Fellows

Corporate Jimmy Doolittle Fellows:

Company	Representatives at the Salute
Boeing Company, The	Gene M. Bradley, Washington Director of Congressional Affairs
Fairchild Industries	Hal Howes, Director of Government Relations
Garrett Corporation	W. Bruce Arnold, Executive Advisor for Congressional and International Affairs—Washington Office
General Dynamics Corporation	Otto J. Glasser, Vice President, International Affairs—Washington Office
General Electric Company	Harry Levine, Program General Manager, Congressional and Executive Office Relations—Washington Office
Hughes Aircraft Company	John Widdicus, Assistant Manager, Program Development
Martin Marietta Aerospace	Laurence J. Adams, President
Mutual of Omaha Insurance Company	V. J. Skutt, Chairman
McDonnell Douglas Corporation	Robert H. Hinder, Vice President of Government Marketing—Washington Office
Northrop Corporation	Donald Hicks, Senior Vice President, Marketing and Technology
Rockwell International	James McDivitt, Vice President, Strategic Management
United Technologies Corporation	Eugene Tallia, Vice President, Pratt & Whitney Aircraft Group—Washington Office
Vought Corporation	Michael Collins, Vice President, Field Operations

Corporate Ira Eaker Fellows:

Rockwell International	James McDivitt, Vice President, Strategic Management

umns, numerous books, and frequent lectures.

General Jones told the dinner audience that he remembered the exploits of Jimmy Doolittle in air races and Ira Eaker's flight in the *Question Mark*, and their brilliant service in World War II. He added, "In the business world, they've demonstrated that their leadership could be transferred." General Jones said that he was proud to be a Jimmy Doolittle Fellow and an Ira Eaker Fellow.

"I have a real special feeling for Ira Eaker," General Jones continued. "I love that man. When I was Air Force Chief of Staff—I'd known Ira before—we became very close. He would come by and [we would] talk about the problems. And he would write brilliantly about them. He was a friend. He was an advisor—and still is to this day."

Senator Goldwater returned to the podium to present two beautiful AFA clocks to the Doolittles and the Eakers "with our deep love, affection, and respect." Returning to his seat after the presentations, the Senator was surprised as AFA Executive Director Russ Dougherty called him back to the podium to receive an AFA clock for himself and Mrs. Goldwater.

General Dougherty then called on Paul Garber, Historian Emeritus of the National Air and Space Museum, to close the evening with a recital of a poem Garber had written especially for the occasion, "To Fly."

THE WHITE HOUSE

WASHINGTON

October 27, 1981

Dear General Eaker:

I am delighted to send you my warmest congratulations on this special occasion. I am proud to join the Aerospace Education Foundation in honoring you and General Doolittle for your outstanding contributions to American life.

This event provides me with a welcome opportunity to express my high regard for your accomplishments as an author, aviation pioneer, record-breaking pilot, and military officer. Your life epitomizes the drive and achievement that have been instrumental in making our country a leader among nations.

Of all your achievements, the leadership you demonstrated during a critical period in World War II stands as a monument to your character and determination. In 1942, you took over command of the United States bombers in the European Theatre. In the following months, the American Bomber Command dealt blow after blow to the enemy's war effort, saving literally thousands of American and Allied lives.

Throughout our history, in times of crisis, Americans of vision and leadership have risen to the challenge. You are an American who not only rose to meet a threat to our nation but inspired those you led, and brought fear to the tyranny we struggled to overcome.

For this and much more, our country owes you a great debt. May tonight's tribute serve to partially repay that debt and remind all Americans of the valor of those who served in the American Bomber Command.

Ronald Reagan

General Ira Eaker
Aerospace Education Foundation
Washington, D. C. 20006

Technical Courses for Civilian Schools

The Aerospace Education Foundation began reproducing and distributing Air Force technical courses nine years ago when an independent evaluation team found that both students and teachers preferred the Air Force course over similar civilian courses.

The evaluation team found that students taking the Air Force courses learned faster and retained the technical information longer than students in similar civilian courses. The highly visual course content coupled with the self-paced structure of many of the Air Force courses kept interest high, even among slow learners.

Foundation officials reasoned that since taxpayers had already invested heavily in developing Air Force instruction, civilian schools could benefit from Air Force-developed teaching techniques, particularly since these techniques proved to be more effective. In this way, the taxpayer's dollar could do double duty.

The Foundation now offers sixty-one course packages (ranging from Electronic Principles and Automotive Mechanics to Computer Science and the Metal and Construction trades), eighteen home study courses, and eleven special publications. The courses are used by more than 850 schools and training centers in all fifty states, the District of Columbia, and various foreign countries.

Distinguished Guests

Many distinguished civilian and military guests attended the Salute to Generals Doolittle and Eaker, including Dr. Alton G. Keel, Assistant Secretary of the Air Force for Research, Development and Logistics; the Hon. Tidal W. McCoy, Assistant Secretary of the Air Force for Manpower, Reserve Affairs and Installations; Rhett Dawson, Staff Director of the Senate Armed Services Committee; Mrs. Carl Spaatz, widow of the first USAF Chief of Staff; Earl Eisenhower, Press Secretary for Senator Goldwater and nephew of the late President; Gen. Robert C. Mathis, USAF Vice Chief of Staff; Gen. Bennie L. Davis, SAC Commander in Chief; Gen. Robert T. Marsh, Commander of Air Force Systems Command; and Gen. Thomas M. Ryan, Jr., Commander of Air Training Command.

Also, Lt. Gen. Hans H. Driessnack, USAF Ass't Vice Chief of Staff; Lt. Gen. Kelly Burke, Air Force Deputy Chief of Staff for Research, Development and Acquisition; Lt. Gen. Billy Minter, Deputy Chief of Staff for Logistics and Engineering; Lt. Gen. Jerome O'Malley, Deputy Chief of Staff for Plans and Operations; Lt. Gen. Charles C. Blanton, Deputy Chief of Staff for Programs and

INTERCOM

Balloons participating in the Fifth World Hot Air Balloon Championship meet conducted at Battle Creek ANG Base, Mich. See item.

Evaluation; Lt. Gen. John S. Pustay, President of the National Defense University; Maj. Gen. Guy L. Hecker, Jr., USAF Director of Legislative Liaison; Maj. Gen. Herbert L. Emanuel, Assistant Deputy Chief of Staff for Manpower and Personnel; Brig. Gen. Richard F. Abel, Director of Public Affairs; Col. Arnald Gabriel, USAF Band Commander; Maj. Gen. Leigh Wade, USAF (Ret.), pilot of the *Boston* on the first flight around the world in 1924; CMSgt. Lewis Spence, President, Air Force Sergeants Association; Dr. Noel W. Hinners, NASM Director; Regent Emlyn I. Griffith, Aerospace Education Foundation Secretary; George D. Hardy, Foundation Treasurer; Earl D. Clark, Jr., AFA Secretary; and George H. Chabbott, AFA Treasurer. —By Robin L. Whittle

Dick Bong's Medals Restored to Museum

A tip from an informant has led to the recovery of decorations and other memorabilia stolen August 27 from the Richard I. Bong Memorial in Poplar, Wis. *(See November issue, p. 17.)*

An airman stationed at nearby Duluth IAP, Minn., surrendered to police in connection with the case, reports Edward Orman, President of AFA's Head of the Lakes Chapter in Duluth. Motivation for the burglary is anybody's guess, although the suspect is reputed to be a collector of military medals and other paraphernalia.

The AFA Chapter in Duluth was instrumental in publicizing the theft from the World War II ace of ace's memorial and was in the forefront in raising a substantial reward for the return of Major Bong's medals.

Since there is reason to believe that no one will claim the reward, the money will be either returned to the donors or applied to financing a security system for the memorial, said Mr. Orman.

In an interesting historical aside to the matter, here are excerpts from a letter received from Sheriff Fred J. Johnson of Wisconsin's Douglas County. Sheriff Johnson was directly involved in the investigation of the theft and in the ultimate outcome:

"On December 27, 1942, I was a member of the 32d Infantry Division and was engaged with my fellow infantrymen in combat against the Japanese on what is known as the Old Airstrip at Buna, New Guinea. It was at this time that twenty-five Japanese bombers and fighter plane escorts bombed Urbana and Warren fronts, which was the airstrip area of Buna. P-38 fighter planes intercepted and fought the Japanese aircraft in a dogfight over Buna. These P-38s were from the 49th Fighter Group, Fifth Air Force, stationed at the Laloki Airdrome, Port Moresby, New Guinea.

"Maj. Richard I. Bong, who was then a lieutenant, fought in that air battle and got the first two victories of his career that day, with thirty-eight more victories yet to come. Major Bong shot down a Val bomber and a Zeke fighter in that action. Fifteen Japanese aircraft in all were destroyed. The air battle was clearly visible to those of us on the airstrip and we observed several Japanese aircraft on fire and crashing in the ocean.

"It wasn't until after the war that I learned that Major Bong was involved in that air battle, his first."

Battle Creek ANG Base Hosts World Balloon Championship Meet

Some 150 balloons representing twenty-five nations participated recently in the Fifth World Hot Air Balloon Championship conducted at Battle Creek ANG Base, home of Michigan Air Guard's 110th Tactical Air Support Group.

The week-long event drew an estimated 425,000 spectators in just the first two days, more than twice the number anticipated. Besides the balloon events, the Air Force Thunderbirds Demonstration Team and the Army's Golden Knights were also on hand. Various military aircraft and a flying replica of the *Spirit of St. Louis* provided a static display.

On a personal note, cochairman of the event was Col. Howard C. Strand, at the time Commander of the 110th. The week marked Colonel Strand's last period of service before retirement in a career that spanned thirty-eight years. Colonel Strand, who has logged more than 9,300 flying hours, will continue to serve as Vice President of AFA's Great Lakes Region.

UNIT REUNIONS

20th Pursuit Group
The 20th Pursuit Group through the 20th Tactical Fighter Wing reunion will be held on May 7–8, 1982, in Austin, Tex. **Contact:** Brig. Gen. Dick Baughn, USAF (Ret.), 1366 Lost Creek Blvd., Austin, Tex. 78746.

28th Bomb Group, 11th AF
Members of the 11th Air Force are planning to hold their reunion in conjunction with the Confederate Air Force Air Show on October 8–10, 1982. **Contact:** Isaac J. Brill, 5251 E. Thomas Ave., Fresno, Calif. 93727.

73d Bomb Wing Association
Superfort Combat Groups 497, 498, 499, and 500; Service Groups 65, 91, 303, and 330; plus attached and assigned units on Saipan during WW II will hold their reunion on May 20–23, 1982, at the Marriott Hotel in Denver, Colo. **Contact:** 73d Bomb Wing Association, 105 Circle Dr., Universal City, Tex. 78148.

82d Fighter Group
The 82d Fighter Group will celebrate its fortieth anniversary on March 4–7, 1982, in Orlando, Fla. **Contact:** George L. Simp-

THIS IS AFA

The Air Force Association is an independent, nonprofit, aerospace organization serving no personal, political, or commercial interests; established January 26, 1946; incorporated February 4, 1946.

OBJECTIVES

The Association provides an organization through which free men may unite to fulfill the responsibilities imposed by the impact of aerospace technology on modern society; to support armed strength adequate to maintain the security and peace of the United States and the free world; to educate themselves and the public at large in the development of adequate aerospace power for the betterment of all mankind; and to help develop friendly relations among free nations, based on respect for the principle of freedom and equal rights for all mankind.

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(ex officio)
National Commander
Arnold Air Society
Columbus, Ohio

son, 5421 Winfree Dr., Orlando, Fla. 32806. Phone: (1-305) 277-6198.

316th Troop Carrier Group
Members of the 316th TC Group, including the 16th, 36th, 37th, 44th, 45th, 75th, and 77th Squadrons, will hold their fortieth anniversary reunion on May 27–30, 1982, at the Stouffer's Inn, Dayton, Ohio. **Contact:** Jack Smith, 8307 Roland Ave., Cincinnati, Ohio 45216.

461st and 484th Bomb Groups
A reunion of the 461st and 484th Bomb Groups will be held on May 28–30, 1982, at the Sheraton-Dayton Hotel, Dayton, Ohio. **Contact:** Bud Markel, 1122 Ysabel St., Redondo Beach, Calif. 90277. Phone: (213) 316-3330. Frank O'Bannon, 137 Via La Soledad, Redondo Beach, Calif. 90277. Phone: (213) 375-1747. Reservations: Sheraton-Dayton Hotel. Phone: (800) 325-3535.

584th Bomb Squadron
The 584th Bomb Squadron will hold its reunion on May 1–7, 1982, in Nokomis, Fla. **Contact:** William J. Miller, P. O. Box 761, Nokomis, Fla. 33555. Phone: (813) 488-3632.

Offuttaires
The Offuttaires is an Officers' Wives Club singing group from Offutt AFB, Neb., in existence for twenty years. This spring we are planning a reunion for all members and former members. Those interested should contact me at the address below.

Susan Srulowitz
3211 Golden Blvd.
Omaha, Neb. 68123

7th Bomb Wing
We are attempting to contact ex-members of the 7th Bomb Wing and supporting units of Carswell AFB, Tex., assigned during the B-36 era (1948–1958), for a reunion in 1982. Please contact:

7th Bomb Wing
B-36 Era Reunion Committee
P. O. Box 16337
Fort Worth, Tex. 76133

Class 42-I
We would like to hear from members of the Kelly Field Class of 1942, in regard to holding a reunion, probably in San Antonio in late 1982. Interested members should contact:

Howard D. Barrett
1810 Raydon Dr.
Arlington, Tex. 76013
or
John P. Byrne
9318 Country Club Dr.
Sun City, Ariz. 85373

Class 44-F
I am trying to locate students and instructors of Luke Field Class of 1944-F, for a future reunion. Also attempting to locate Jack Purcell (instructor Luke Field), and Raymond Jones (instructor Santa Maria). Please contact me at the address below.

Robert D. "Don" Newman
308 Winnebago Dr.
Lake Winnebago, Mo. 64034
Phone: (800) 821-3508 (toll free)
(816) 537-7888

75th Troop Carrier Sqdn.
The 75th TC Squadron of the 435th TC Group has been holding reunions every two years since 1971. We would like to establish contact with those who served in the 76th, 77th, 78th, and Headquarters Squadrons in the ETO during WW II. Need names and current addresses. Please contact me at the address below.

Robert C. Richards
139 Kiser Dr.
Tipp City, Ohio 45371

373d Fighter Group
I would like to hear from everyone who was connected with the 373d Fighter Group in Europe during WW II in regard to a group reunion. Please send your name, address, and WW II duty to me at the address below.

Richard Gibian, Sr.
American Candy
Manufacturing Co.
Rte. 5, Box 34-A
Selma, Ala. 36701
Phone: (205) 875-1450

Coming Events

March 13, **Iron Gate Chapter 19th National Air Force Salute,** Sheraton Center, New York City . . . April 26–27, **AFA Symposium, "Electronics and the Air Force,"** Colonial Hilton, Wakefield, Mass. . . . May 7–8, **South Carolina State Convention,** Myrtle Beach . . . May 14–15, **Tennessee State Convention,** Chattanooga . . . May 28, **AFA Nominating Committee and Board of Directors Meeting,** The Broadmoor, Colorado Springs, Colo. . . . May 29, **Twenty-third Annual Outstanding Squadron Dinner,** The Broadmoor's International Center, Colorado Springs, Colo. . . . June 18–19, **Ohio State Convention,** Columbus . . . June 24–25, **AFA Symposium, "Airlift—The Key to Modern Military Mobility,"** St. Louis Marriott Hotel at Lambert International Airport, St. Louis, Mo. . . . June 25–27, **New Jersey State Convention,** Cape May . . . July 9–11, **Texas State Convention,** Kerrville . . . July 16–18, **Pennsylvania State Convention,** Coraopolis . . . September 12–16, **AFA National Convention,** Washington, D. C.

Add a couple o
you may not need th

Needless to say, the purchase of different aircraft to meet different mission requirements is, to some extent, inevitable.

A jet fighter will never double as a cargo plane.

But the number of aircraft types you need to buy in order to perform such missions as priority personnel transport, cargo transport, air ambulance service, flight inspection/calibration, pilot and systems training, remote surveillance, search and rescue and reconnaissance and mapping can, in fact, be reduced dramatically.

To one.

For example, a Canadair Challenger outfitted for cargo transport can quickly be converted into a 28-passenger people-hauler. Or a 14-passenger people-hauler with a large cargo area.

A Canadair Challenger outfitted for priority transport of V.I.P. personnel can, with the addition of two partitioned operators' consoles, easily double as a surveillance or flight inspection/calibration aircraft.

A Challenger outfitted for remote sensing and surveillance can quickly be refitted for reconnaissance and mapping.

A Challenger outfitted as an air ambulance or MED/EVAC aircraft can, with relative ease, switch to a flight inspection/calibration interior. Or an advanced pilot and systems trainer interior. Or a maritime surveillance/search and rescue interior.

All told, the variations of equipment you can move into and out of a Challenger are far too numerous to mention.

What's just as important, the Challenger gives you more AC power to run it on than any other aircraft in its class.

In fact, it's the only all-AC electrical system you'll find on any jet short of the latest commercial airliner. Unlike DC systems, AC gives you the benefits of extreme light weight in relation to power produced and far less chance of electrical failure due to low current, constant frequency and the obvious fact that there's no need for cumbersome inverters.

As for those of you who just want to get from point A to point B, you'll find the Challenger will fly you more economically and in greater comfort than any comparable jet in the world.

Overall, the Canadair Challenger averages a 22% lower rate of fuel consumption per mile than a Gulfstream III, virtually the same rate of fuel consumption per mile as the far smaller Falcon 50 and, hard as it may be to believe, a 24% lower rate of fuel consumption per mile than the small, short-range T-39.

Yet the Challenger is actually ger than all of them in the one dir sion crucial to passenger comfort and a realistic working environme width.

Measured at the floor line, th Canadair Challenger is roughly 3C wider than the Gulfstream III, anc 48% wider than the Falcon 50.

And speaking of range.

With the Challenger's big fuel tanks and extremely low rate of fu burn, you can cross the Pacific wit one stop, fly from New York to the Middle East with one stop or fly fr Washington to London non-stop.

Or, getting back to multiple m sions, fly a thousand miles out for remote surveillance and still rema on station for four to five hours before flying back.

To find out more about the ai craft that can perform the roles of two or three or four aircraft, just c Mr. James B. Taylor, President of Canadair Inc., at 203-226-1581. write Canadair Inc., 274 Riverside Avenue, Westport, CT 06880.

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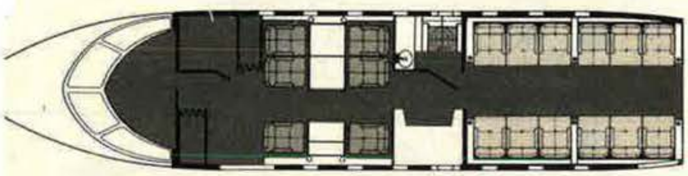
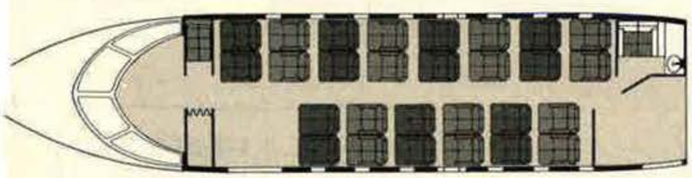
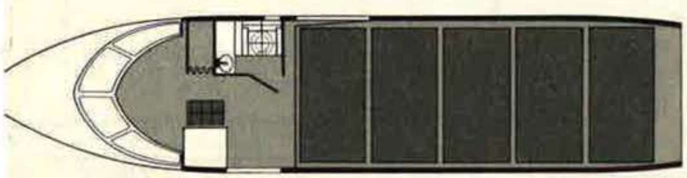


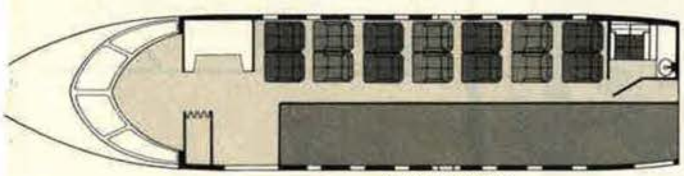
VIP Interior



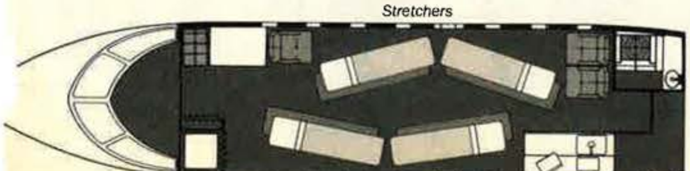
28-Passenger Interior



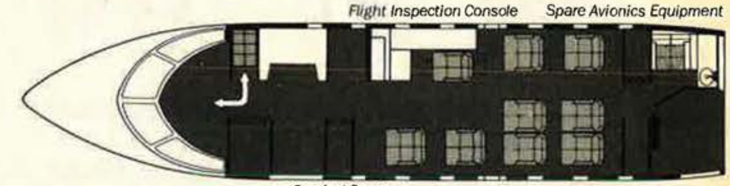
Cargo Configuration



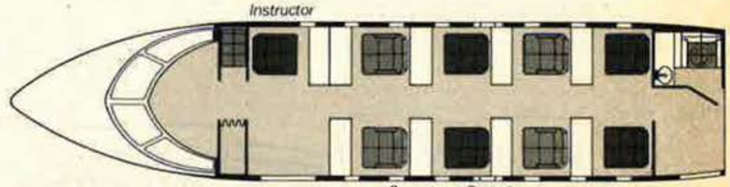
Passenger/Freight Configuration



Air Ambulance



Flight Inspection/Calibration



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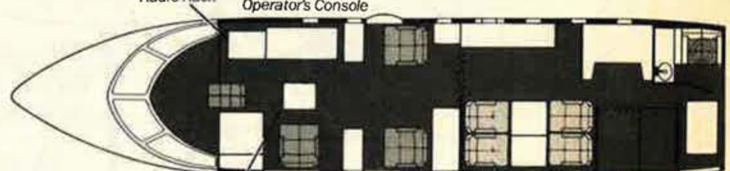
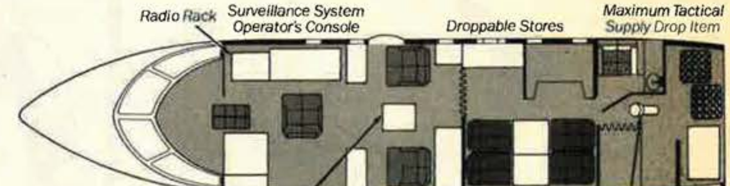
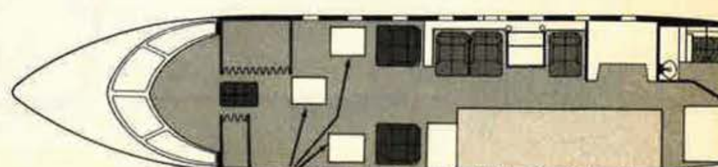


Remote Sensing and Surveillance



Maritime Surveillance/Search and Rescue



Reconnaissance and Mapping

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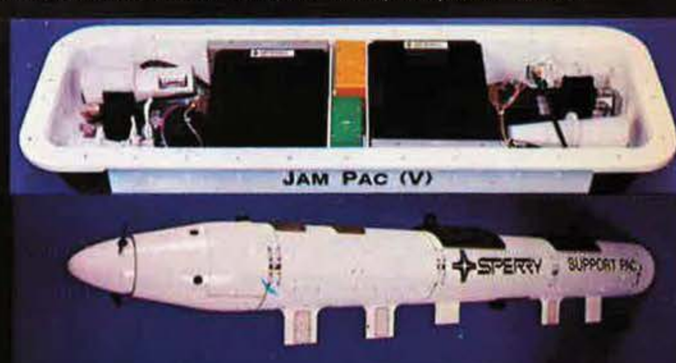

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