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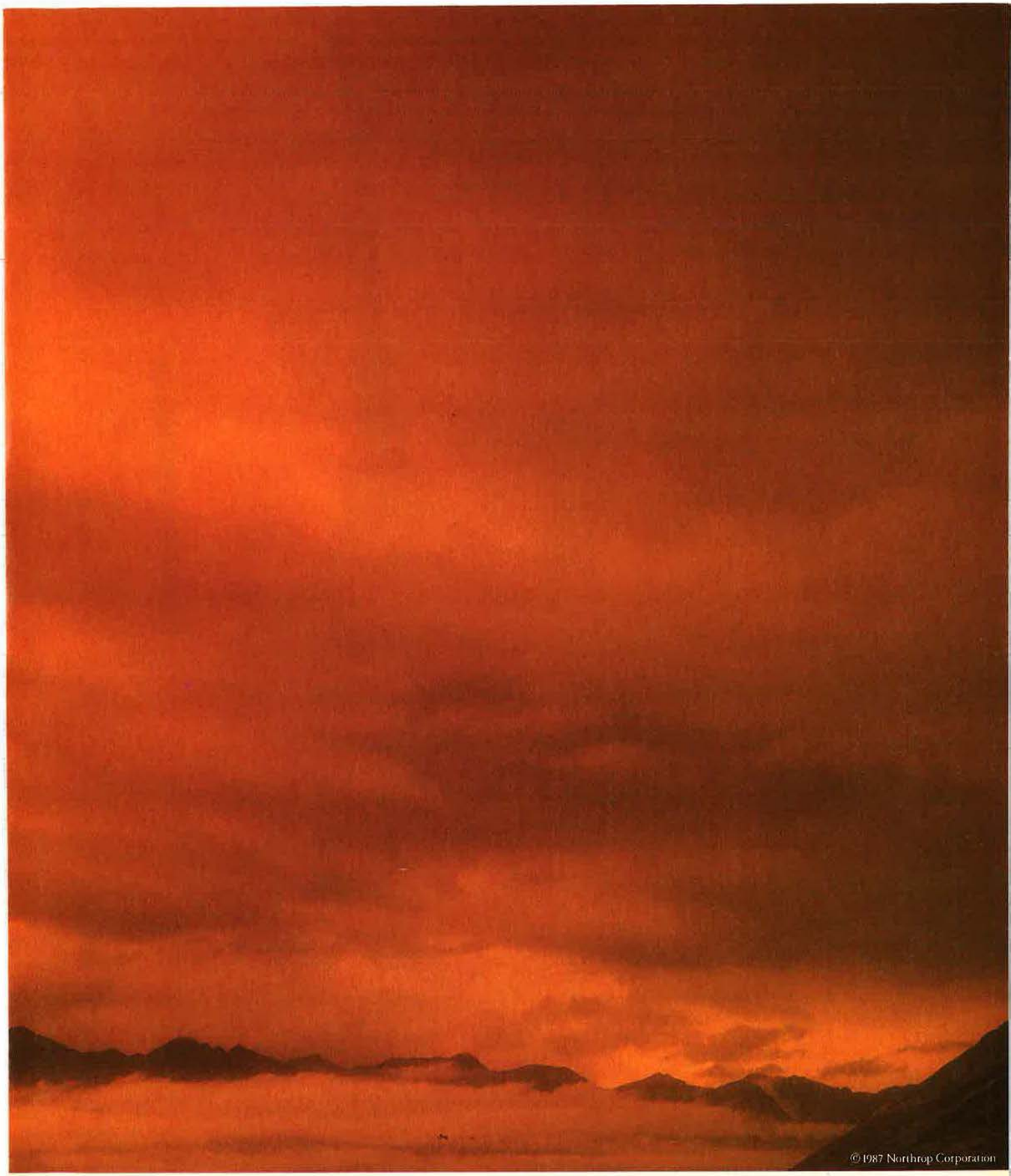

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JUNE 1987
VOLUME 70, NUMBER 6

AIR FORCE MAGAZINE
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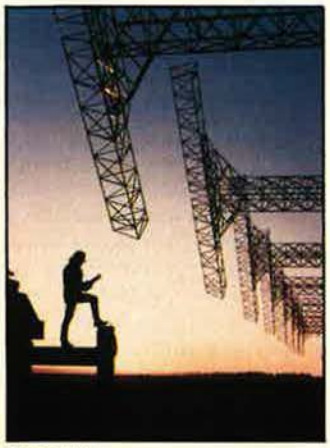

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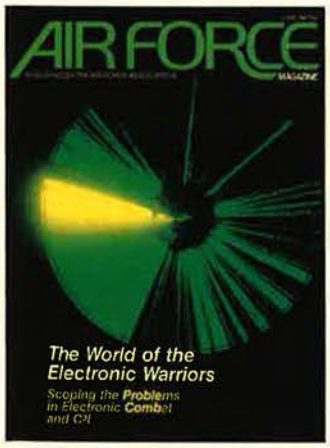

About the cover: A color-enhanced photo of a ground-radar screen shows how an EF-111's jamming transmissions make it impossible to decipher radar returns. A special section on "Electronics" begins on p. 44.

Special Section: Electronics

Features

Departments

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AN EDITORIAL

The Russians and Their Reforms

By David L. Gray, PUBLISHER

THE Soviet Union may—or may not—be in the midst of fundamental change. In either case, General Secretary Mikhail Gorbachev has won the enthusiastic acclaim of the international community for his well-advertised program of internal reforms. Even before Gorbachev decided it was all right for the babushkas to read *Doctor Zhivago,* though, many Westerners were already in the habit of straining to find positive interpretations for the behavior of the Soviet Union. Now, each time Gorbachev frees another dissident or promises to pull his invasion troops out of Afghanistan, the perception grows that the Soviet threat is melting away.

The Soviet Union is well into its third decade of the most relentless and massive buildup of military power the world has ever known. This continues unabated, although obscured considerably by the new talk of peace and cooperation flowing steadily out of Moscow. So strong is the desire to believe a Russian Renaissance is under way that those who urge caution are likely to be regarded as obstructionists.

Gorbachev is no doubt sincere about economic, political, and social reform insofar as it suits his purposes. The Soviet economy is a scandal. The work force is unmotivated and lethargic. Both industry and the military are largely dependent on stolen technology. Soviet per capita GNP trails not only the major Western nations but also East Germany and Czechoslovakia in the Eastern bloc. It is roughly on a par with that of Hungary. Any superpower with such shabby credentials would have reason to welcome change.

But does this mean that the Russians, after seventy years of struggling for world domination, are ready to renounce the October Revolution, chuck out Marxism-Leninism, and hammer their MiGs into plowshares? Don't bet on it.

A recent editorial in *The Economist* observed that free nations have long been repelled by three aspects of the Soviet regime: "It has been an undemocratic police state of the worst kind; its economy for the past twenty-five years has done shamefully badly; and it has been a geopolitical menace." We would do well to watch developments in all three of these areas as we assess the Gorbachev Revolution. Although *The Economist* did not rank its three factors by severity, the one that threatens the West most directly is Soviet ambition for global power.

Despite Gorbachev's talk of change, growth of the Soviet military machine has actually accelerated during his tenure. *(See "The Guns of Glasnost," p. 84 of this issue.)* The GNP of the Soviet Union is only about fifty-five percent of that of the United States, yet some fifteen to seventeen percent of it is allocated for military use. (The US allocates just over six percent of its GNP to defense.) A major motivation for Gorbachev's reforms, in fact, may be concern about the ability of the Soviet Union to sustain its military power objectives.

Improved productivity is a big element in Gorbachev's plan. He says he intends to get two-thirds of his increase from industrial modernization and the other third from "human factors." More money has already been channeled to industrial reconstruction and tooling. The aspiration is to bring quality up to "world standards," which is revealing in itself.

The inability to match Western technology worries and sometimes obsesses the Russians. Stealing secrets is one way to narrow this gap. East-West trade cooperation—which Gorbachev has been applauded for promoting—is another. A pervasive envy and awe of American technical ingenuity, especially fear of what it might achieve in defense against ballistic missiles, have stimulated Soviet interest in arms control.

Gorbachev says he intends to increase quantity and quality at the same time, which is difficult under the best of circumstances, and that is hardly the prevailing condition in the USSR today. So far, what the workers have gotten out of this, mainly, is more work. Consumer demands go unmet. There are indications of dissatisfaction as a result of the crackdowns on factory inefficiency and shakeups of a system that has been comfortable for bureaucrats and petty officials.

To make his reform program really work, Gorbachev would probably have to take the Soviet Union much farther in the direction of a market economy, with supply geared to demand, greater freedom of choice, and more encouragement of innovation. That would almost certainly lead to a revision of budget priorities—more butter, fewer guns—a loosening of control by the power elite, and a drift toward democratic capitalism.

The Soviet Union qualifies as a superpower in one respect only: its huge military establishment, which it has used effectively to intimidate other nations and to keep its vassal states from breaking free. Unless the Russians maintain their military posture, their status in the world will be diminished. Even if industrial reform works to an improbable degree, the Soviet Union will still not be a leader in the economic arena. And if Gorbachev manages to direct the yields of increased productivity toward military purposes, then reform has only made the Soviet Union a more formidable adversary.

We should give Gorbachev his due and listen to what he has to say. He is an energetic reformer, and some good may come of what he is doing. But we should also inspect his offerings carefully. They may not be as they seem on the surface. For example, the Soviets made a great show of withdrawing some forces from Afghanistan—but quietly had brought in two infantry units from Central Asia for the express purpose of being able to withdraw them. We should also remember that we have seen apparent reform in the Soviet Union before.

Nikita Khrushchev looked like the antidote to Stalin's despotism, and American college students nearly made a cult figure of him in 1959. Yet it was he who made the aggressive bid for Soviet domination by introducing missiles into Cuba. Partly for his failure in that and partly for his reform notions, the Old Guard toppled him eventually and launched a wave of counterreform. And then there was détente in the 1970s, when the optimists thought the Russians might tear down the Iron Curtain. It proved to be only a screen for business as usual.

The Soviet Union remains a totalitarian state—which is one reason why its economy is in a mess—and its military power continues to grow and threaten the rest of the world. Are we to believe that the Russians will suddenly stop being Russians? It would be foolish to expect too much and relax our guard. When something seems too good to be true, it probably is. ■

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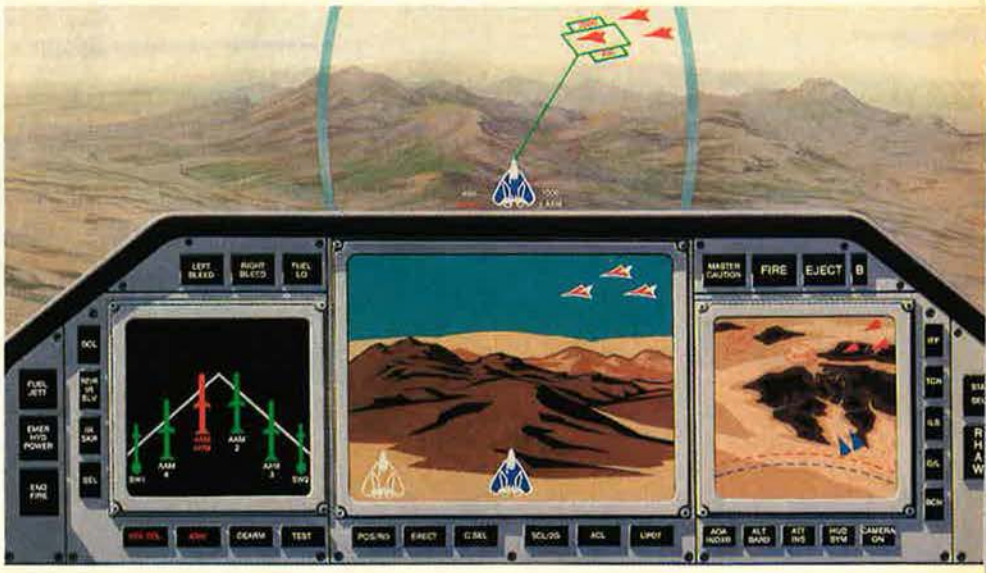

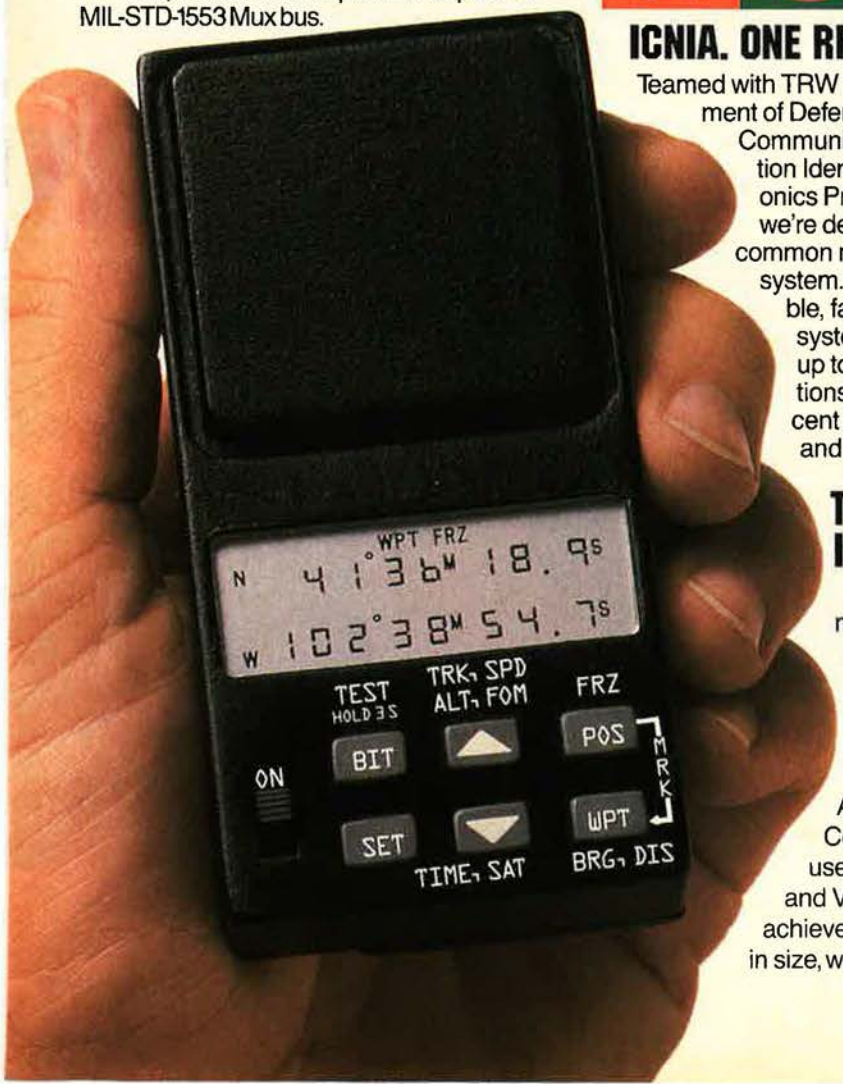

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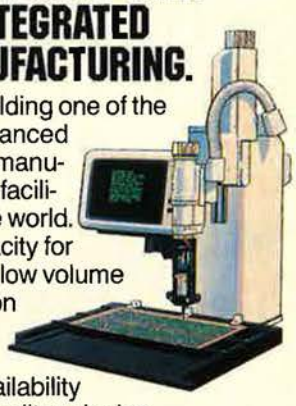

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AIRMAIL

The Top Ten

I have just finished reading your very interesting article "The Top Ten" *(April '87 issue, p. 84)* and enjoyed it thoroughly, but I am astonished.

I found that I agreed more with Chuck Yeager and Robin Olds than with the others. The astonishing part is that not one of your "judges" named the F/A-18 Hornet, probably the very best fighter that the world has ever known. I know that it is usual for people to name aircraft that they flew or are familiar with, but someone has not done their homework. Not even to be mentioned is inexcusable.

Perhaps McDonnell Douglas has not done their advertising, or perhaps the F/A-18 pilots just don't do enough bragging, but that aircraft is eye-watering.

I hope that I find some support for my convictions, at least from the Navy, Marines, or Canadian forces. Thank you for a very fine magazine.

Maj. Gen. Bobby E. Walls,
OklaANG
Drumright, Okla.

I certainly cannot argue with the qualifications of the panel of experts that selected the top ten airplanes of all time, but I was disappointed at the omission of a most versatile and durable aircraft used all around the world—the C-130.

Since the prototype flew in 1954, this aircraft has been used for attack, bombing, transport, drone launch, electronic warfare, rescue, Arctic resupply, tanker, reconnaissance, weather, special operations, as well as other missions I've probably forgotten.

I just wanted to put in a vote for *my* favorite plane.

SMSgt. William Peters,
USAF (Ret.)
Sandwich, Mass.

In selecting the top ten airplanes of all time in your April '87 issue, your panel of distinguished members of the aviation community seems to have overlooked one of the most efficient airplanes of the European conflict, the Martin B-26 Marauder.

This aircraft was one of the most maligned planes of its time. However, more than 5,000 of these planes were built. It sustained the lowest loss rate per sortie of any combat plane in the ETO and achieved the highest bombing accuracy in the ETO.

I believe this was one of the most significant airplanes of its time. I am certain that many readers will concur.

Col. H. V. McDonald,
USAF (Ret.)
Mesa, Ariz.

Scott Crossfield had the best balanced list of the top ten airplanes of all time in "The Top Ten" in the April '87 issue. Some of the panel members were very narrow in their selections—listing nearly ten airplanes from one country, manufacturer, or even type!

OK—here's my prejudiced list: Wright Flyer, DC-3, Piper Cub, B-17, 707, Spitfire, P-51, Focke-Wulf 190, *Shturmovik*, and Concorde.

Your magazine is great.

Jerome C. Baer
Bellevue, Wash.

Re: Your article "The Top Ten" in the April '87 issue.

Here's to Generals LeMay and Hansell, who picked as their Number 1 the *true* Number 1 of all time—the B-17.

Col. Campbell Palfrey, Jr.,
USAF (Ret.)
Honolulu, Hawaii

I've enjoyed reading AIR FORCE Magazine for many years—keep up the good work. But the article entitled "The Top Ten" by Jeffrey P. Rhodes in the April 1987 issue really caught my attention.

While all of the aircraft listed were certainly outstanding and history-making, not one of your "experts" even mentioned the *Voyager* designed by Burt Rutan and flown by his brother, Dick, and Jeana Yeager around the world nonstop and unrefueled. Not only did this performance exceed the previous record by about 100 percent, but the entire project was conceived and carried out by individuals without any government or significant corporate funding.

In my opinion, the *Voyager* should be ranked along with the 1903 Wright Flyer and the *Spirit of St. Louis* in the top ten.

James H. Gates
Hermosa Beach, Calif.

Your article "The Top Ten" in the April '87 issue incorrectly identified the North Korean defector who delivered a MiG-15 to US forces in 1953 as Kim Suk Ho.

I was the other test pilot on the MiG-15 project and was the first to fly the airplane. Much misinformation has been published about our tests on Okinawa, and AIR FORCE Magazine can make a contribution to accuracy by publishing the Korean pilot's correct name, which is Noh Kum Suk.

Thanks for a great magazine.

Maj. Gen. H. E. "Tom" Collins,
USAF (Ret.)
San Antonio, Tex.

Re: The article "The Top Ten" in the April '87 issue.

Maj. Gen. Haywood Hansell did *not* lead the first large-scale Superfortress mission against Japan. That honor went to Lt. Gen. Emmett O'Donnell, Commander of the Saipan-based 73d Bomb Wing.

General Hansell was ordered by General Arnold not to participate in any missions against the Japanese homeland because of his extensive knowledge of Pacific campaign plans.

Col. Rollin C. Reineck,
USAF (Ret.)
Kailua, Hawaii

Do you have a comment about a current issue? Write to "Airmail," AIR FORCE Magazine, 1501 Lee Highway, Arlington, Va. 22209-1198. Letters should be concise, timely, and legible (preferably typed). We reserve the right to condense letters as necessary. Unsigned letters are not acceptable, and photographs cannot be used or returned.

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AIRMAIL

I enjoyed Jeffrey P. Rhodes's article "The Top Ten" in the April '87 issue. However, he incorrectly identified the Curtiss-Wright AT-9 as one of the Beechcraft SNB *(sic)* variants when listing David McCampbell's choices.

The JRB variant could have been listed as well, but not the AT-9. The Curtiss-Wright airplane, incidentally, had flight characteristics that were entirely different from those of the Beechcraft Model 18 series machines.

Herb Cook
Fort Worth, Tex.

Jeffrey P. Rhodes's article "The Top Ten" in the April '87 issue contains two typographical errors in the segment on David McCampbell. To keep the record straight, David McCampbell was in VF-15, not VF-51, and the name on the side of his aircraft was *Minzi III*, not *Minsi III.*

Although I am ex-naval aviation, I am a member of the Air Force Association. I have found the magazine to be most interesting and informative.

J. R. "Bill" Bailey
Slidell, La.

• *Though no panelist listed the* Voyager *among their top ten, Scott Crossfield did mention the globe-girdling aircraft during conversations with author Jeffrey P. Rhodes. This was reported in the article on p. 90.*

General Collins notes correctly that the article misidentified the North Korean defector. The correct name is Noh Kum Suk. We were evidently one more victim of misinformation and are grateful to General Collins for this opportunity to set the record straight.

Colonel Reineck asserts correctly that General Hansell did not lead the first large-scale B-29 mission against Japan. We should have reported that General Hansell made the decision to launch the first significant Superfortress mission against the Japanese home islands.

The correct designation for David McCampbell's fourth choice is Beechcraft SNB. The Air Corps knew it as the AT-7.

Lastly, David McCampbell should have been listed as a member of VF-15, not VF-51. However, Captain McCampbell confirms that his F6F Hellcat was named Minsi III.—THE EDITORS

Emphasizing the Ilities

After two "sorties" into the teeth of the AIR FORCE Magazine editorial staff concerning R&M 2000, I finally began to sleep easy after reading John T. Correll's "The Rise of the Ilities" in the April '87 issue. What struck me was the subtle sense of urgency you conveyed to the industrial base. The R&M 2000 program is here. It is not going away. It is a basic drumbeat that is increasing in intensity. My congratulations on a super statement to the world on where AFA stands on this issue.

Your citing of the major commands as the key to reversing the "timidity" trend is right on. Please keep in mind that your reference to new systems applies equally to modifications and preferred-spares acquisitions. You should know that a growing number of key leaders in the air logistics centers, system program management offices, and item management offices are beginning to demand that early planning for resource allocations for system improvements clearly display R&M impacts on emerging programs. You should also know that we too understand that innovative business strategies that exploit the combined performance and R&M capabilities of such technologies as VHSIC are out there for the taking.

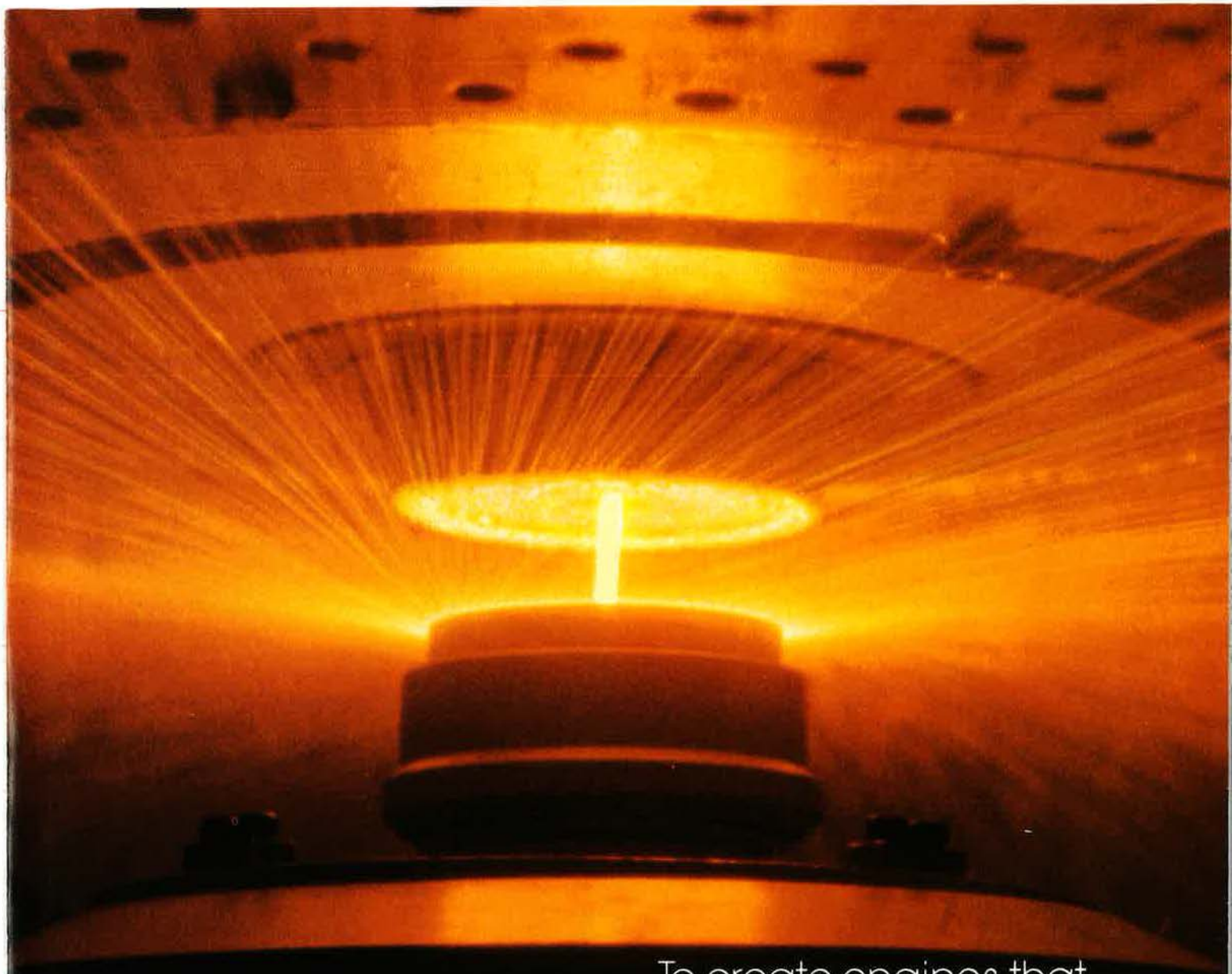
Folks who have lived with the "half-life-of-a-flashbulb" performance in ECM systems are bowing their necks now and saying, "No more! Demand it, spec it, and reward it!" Low bid awards are quickly becoming history in light of innovative competition, split awards, and well-thought-out reliability and maintainability specifications and source-selection ground rules. The day is near at hand when contractors will pick up AFLC requests for proposals, go direct to the "centerfold," and see technical deliverables that will encourage the quality contractor to bid and discourage the traditional "low bidder" from bothering to respond.

It will be a shame if contractors do not heed the warning that the total Air Force is committed to R&M. No one will have any sympathy for those who see their business bases wither away. They were forewarned.

Hats off to AFA! The R&M 2000 heat is on. Keep stoking the fire!

Col. John C. Reynolds, USAF
Wright-Patterson AFB, Ohio

Your excellent editorial "The Rise of the Ilities" in the April '87 issue covered weapon systems and their components very well. There is another category of equipment, however, where R&M gets short shrift. I



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refer to commodities, those lowly items like air compressors, welding machines, pickup trucks, etc., that are bought competitively from the commercial marketplace.

The lowly commodities, by the way, consume about a quarter of DoD government dollars and at least as much of its maintenance time and money.

In an article published in the Winter 1987 issue of *The Air Force Journal of Logistics,* a simple approach to improving R&M for commodities is offered. The approach involves the use of comparative life-cycle costs to discriminate among competing commercial equipment.

Improvement of the ilities is clearly a worthwhile effort. The improvement should involve the whole force.

Thomas W. Sherman, Jr.
Michigan City, Ind.

Edwards AFB

I just finished reading Gen. T. R. Milton's outstanding article in the April '87 issue, "Airing It Out at Edwards." He has done an admirable job painting a picture of the Air Force Flight Test Center and the NASA Dryden Flight Test Center, but failed to mention one of the Air Force's most significant R&D assets, the Air Force Rocket Propulsion Laboratory (AFRPL). Since AFRPL is usually ignored by authors writing about Edwards AFB, I'd like to take this opportunity to acquaint readers with this leading-edge laboratory and the exciting work being done there.

The mission of AFRPL is to investigate and develop new rocket propulsion and space technology and to aid in its application to Air Force missions. A representative sampling of current work at the laboratory includes guidance and propulsion technology development for the Strategic Defense Initiative's kinetic energy weapons, development of storable liquid rocket engines for next-generation orbital transfer vehicles, and multiple-pulse solid rocket motors for such tactical missiles as AMRAAM. In addition, there is significant basic research going on in such areas as rocket combustion stability, optimal missile guidance methodology, and nondestructive testing and inspection of solid rocket motors.

The laboratory employs more than 400 scientists, engineers, and technicians. Roughly one-third of these are military. The laboratory's in-house budget for FY '86 was about $39 million; this was significantly augmented by more than $90 million in SDI funding. This is a small investment for the payoff the Air Force has received.

AFRPL was heavily involved with the development of the Peacekeeper ICBM, the Small ICBM, SRAM II, and several tactical air-to-air and air-to-ground missiles. In a slightly different vein, initial testing of the Saturn V F-1 engines occurred at AFRPL in the early and mid-1960s.

General Milton refers to "an air of permanence" at Edwards. AFRPL contributes to that air. There are several unique testing facilities at AFRPL that aren't available elsewhere in the nation. For example, the F-1 test stands mentioned above are being refurbished to support Air Force development of hydrocarbon engines for the new heavy launch vehicle under development by Space Division. A unique solar rocket test stand is nearing completion of construction and checkout. Electric rocket test facilities have been in operation for more than two years.

As an AFRPL alumnus (I left in 1986), I feel that your readers deserve to know about this laboratory and the work going on there now. Too often, technology development work in the Air Force gets ignored in the glare of testing, acquisition, or operations. Yet AFRPL and sister laboratories are where the advances will occur that will keep the Air Force flying and fighting well into the next century!

Maj. Timothy K. Roberts, USAF
Wright-Patterson AFB, Ohio

AIRMAIL

A photo in the article "Airing It Out at Edwards" in the April '87 issue shows an A-17A flying over a tent city at Muroc.

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Fort Walton Beach, Fla.

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Oregon City, Ore.

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Please contact the address below.

Giancarlo Garello
Viale Alessandro Magno, 217
00124 Rome
Italy

AIRMAIL

refer to commodities, those lowly items like air compressors, welding machines, pickup trucks, etc., that are bought competitively from the commercial marketplace.

The lowly commodities, by the way, consume about a quarter of DoD government dollars and at least as much of its maintenance time and money.

In an article published in the Winter 1987 issue of *The Air Force Journal of Logistics,* a simple approach to improving R&M for commodities is offered. The approach involves the use of comparative life-cycle costs to discriminate among competing commercial equipment.

Improvement of the ilities is clearly a worthwhile effort. The improvement should involve the whole force.

Thomas W. Sherman, Jr.
Michigan City, Ind.

Edwards AFB

I just finished reading Gen. T. R. Milton's outstanding article in the April '87 issue, "Airing It Out at Edwards." He has done an admirable job painting a picture of the Air Force Flight Test Center and the NASA Dryden Flight Test Center, but failed to mention one of the Air Force's most significant R&D assets, the Air Force Rocket Propulsion Laboratory (AFRPL). Since AFRPL is usually ignored by authors writing about Edwards AFB, I'd like to take this opportunity to acquaint readers with this leading-edge laboratory and the exciting work being done there.

The mission of AFRPL is to investigate and develop new rocket propulsion and space technology and to aid in its application to Air Force missions. A representative sampling of current work at the laboratory includes guidance and propulsion technology development for the Strategic Defense Initiative's kinetic energy weapons, development of storable liquid rocket engines for next-generation orbital transfer vehicles, and multiple-pulse solid rocket motors for such tactical missiles as AMRAAM. In addition, there is significant basic research going on in such areas as rocket combustion stability, optimal missile guidance methodology, and nondestructive testing and inspection of solid rocket motors.

The laboratory employs more than 400 scientists, engineers, and technicians. Roughly one-third of these are military. The laboratory's in-house budget for FY '86 was about $39 million; this was significantly augmented by more than $90 million in SDI funding. This is a small investment for the payoff the Air Force has received.

AFRPL was heavily involved with the development of the Peacekeeper ICBM, the Small ICBM, SRAM II, and several tactical air-to-air and air-to-ground missiles. In a slightly different vein, initial testing of the Saturn V F-1 engines occurred at AFRPL in the early and mid-1960s.

General Milton refers to "an air of permanence" at Edwards. AFRPL contributes to that air. There are several unique testing facilities at AFRPL that aren't available elsewhere in the nation. For example, the F-1 test stands mentioned above are being refurbished to support Air Force development of hydrocarbon engines for the new heavy launch vehicle under development by Space Division. A unique solar rocket test stand is nearing completion of construction and checkout. Electric rocket test facilities have been in operation for more than two years.

As an AFRPL alumnus (I left in 1986), I feel that your readers deserve to know about this laboratory and the work going on there now. Too often, technology development work in the Air Force gets ignored in the glare of testing, acquisition, or operations. Yet AFRPL and sister laboratories are where the advances will occur that will keep the Air Force flying and fighting well into the next century!

Maj. Timothy K. Roberts, USAF
Wright-Patterson AFB, Ohio

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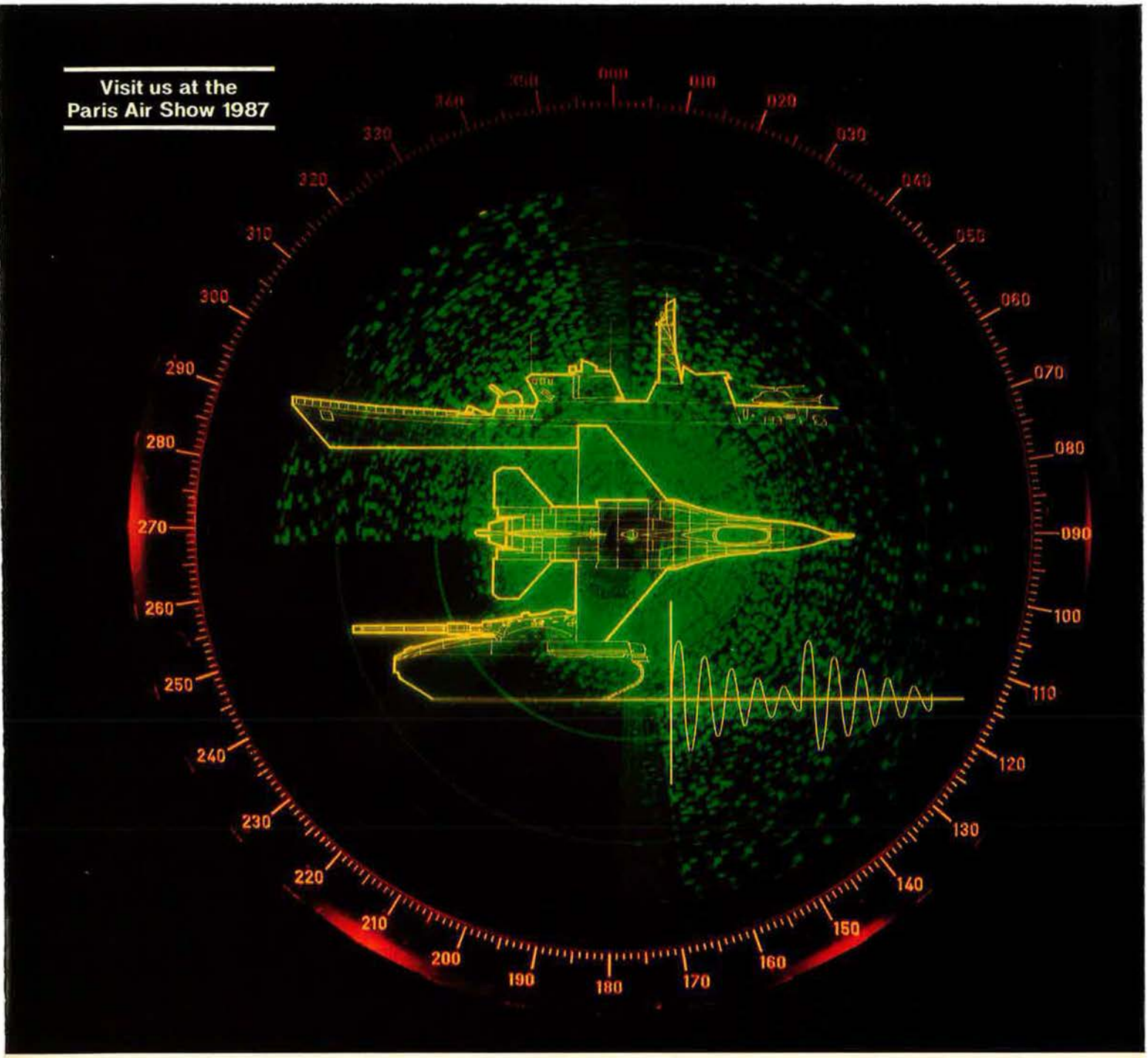

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AIRMAIL

43d Bomb Wing

The 43d Bombardment Wing is attempting to document its past, and we would like to contact any readers who may be able to help us.

We are attempting to find illustrations and artifacts of Air Force operations in the Marianas from 1898 through 1967. We are particularly interested in the World War I, World War II, and Korean War periods, since we have sufficient photographic coverage from 1967 to the present.

Readers are asked to send us any items that they would like to donate. If you have negatives or photos that you would like returned, please enclose return instructions, and we will copy them and return them.

Lt. Col. Donald J. Cann, USAF
43d CSG/OT
APO San Francisco
96334-5000

Lowry Chapel

Here at Lowry AFB, Colo., we are in our fiftieth year of service to our country. One of our important projects is the refurbishing of our Chapel I (the Eisenhower Chapel), which is on the National Registry of Historic Buildings.

We are trying to collect memorabilia (pictures, etc.) about this chapel and especially about President Eisenhower's attendance at the chapel. Any help from readers would be appreciated.

Col. John J. Flattery, USAF
Center Chaplain
3415th ABG/HC
Lowry AFB, Colo. 80230-5000

Collectors' Corner

I served during the Korean conflict with the 307th Bombardment Wing (B-29) and want very much to obtain a breast or shoulder patch for this wing and/or a breast or shoulder patch for the wing's 370th Bomb Squadron.

I will pay a premium price for any patches if they are in good to mint condition. Please contact me at the address below.

John P. Stockton III
A-4 Carver Place
Lawrenceville, N. J. 08648

I am looking for a leather flight jacket (A-2 style?) of the type worn by the American Volunteer Group in China, circa 1940–41, including all of the patches and the "Blood Chit" worn on the back.

Any information about where I might find such a jacket as well as AVG photos, patches, etc., would be greatly appreciated.

Matthew Swain
725 Monroe St.
Rockville, Md. 20850

The mission of Detachment 24, 40th Aerospace Rescue and Recovery Squadron, is to provide helicopter support for the USAF Survival School at Fairchild AFB, Wash. The detachment has recently begun a patch collection representing all Air Force units whose personnel have been trained by the Survival School.

We would be grateful to any unit or individual willing to donate unit patches to our collection.

1st Lt. Tracy W. Colburn, USAF
Det. 24, 40th ARRS
Fairchild AFB, Wash.
99011-5000

I am currently with the Michigan Air National Guard and in the process of collecting various patches for our "brag board."

I collect patches from all branches of the military service, including the Coast Guard. I would greatly appreciate any patches that readers could send me.

David Munyon
2488 Glenbrook S. W.
Wyoming, Mich. 49509

I am a serious collector of ANG/AFRES unit and aircraft patches. I have a good trade list and would appreciate hearing from other Air Guard and Reserve members who are interested in trading.

Lee Kampstad
412 Sandy Lane
Elkhorn, Wis. 53121

I am a French Air Force exchange officer with the US Air Force. I am looking for patches from USAF squadrons to put in a display case at French Air Force headquarters. I would like to make this a large and impressive display.

Cmdt. Philippe Courty
P. O. Box 724
Randolph AFB, Tex. 78148

I am an Air Force patch collector and am seeking other collectors with whom to trade patches. I have various patches from Tyndall AFB, Fla., and other bases to offer in trade.

Steve Szulczynski
P. O. Box 10492
Panama City, Fla. 32404

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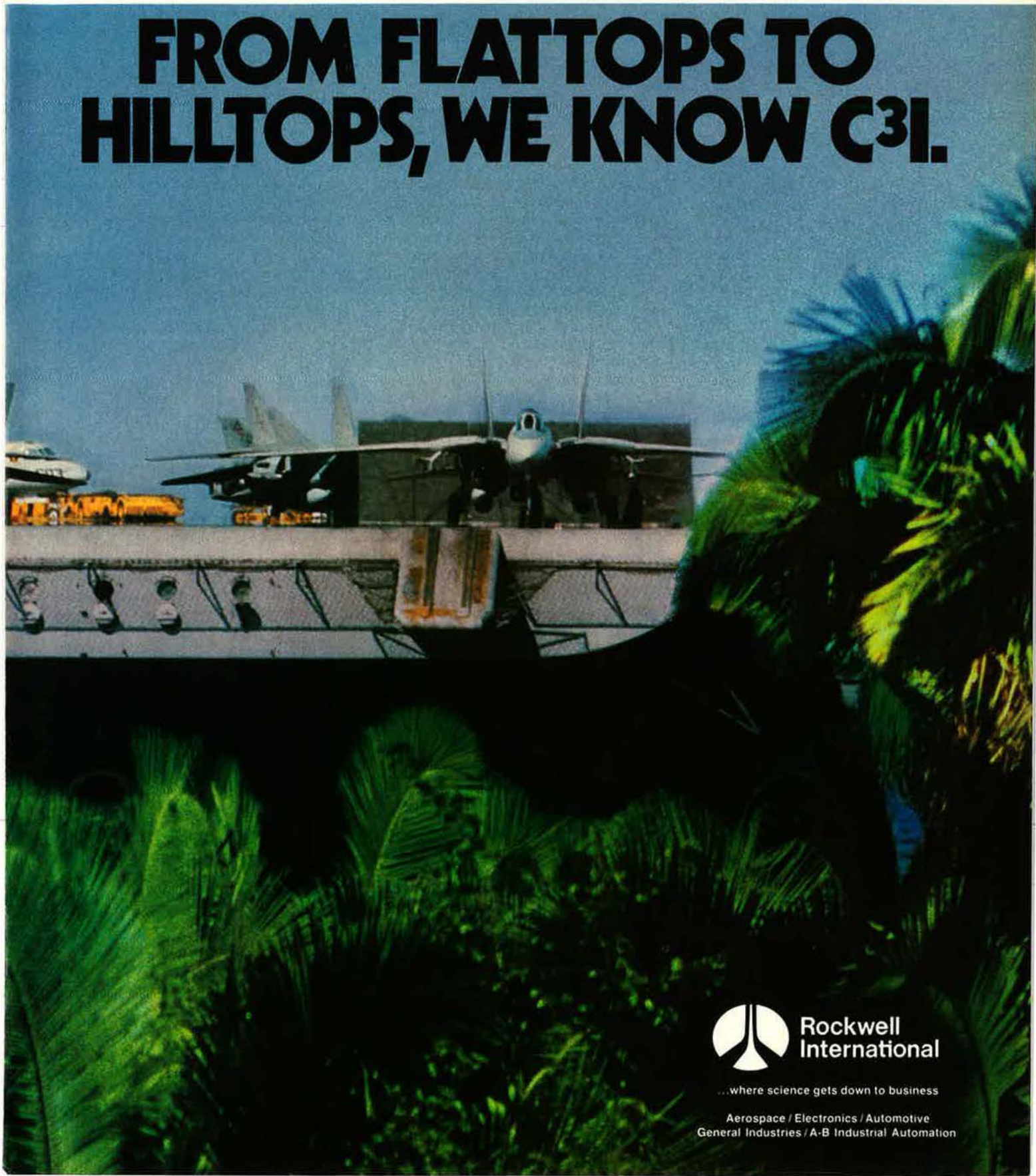

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IN FOCUS...

The Nuclear-Conventional Link

By Edgar Ulsamer, SENIOR EDITOR (POLICY & TECHNOLOGY)

Senator Nunn says that US arms-control objectives are foggy and warns against agreements that fail to ensure some balance in conventional theater forces.

Washington, D. C., April 30 The Chairman of the Senate Armed Services Committee (SASC), Sen. Sam Nunn (D-Ga.), believes that the "growing pains" of the B-1B strategic bomber "are regrettable but largely curable with bucks" but that the aircraft's ability to penetrate to Soviet targets is "extremely questionable." During a meeting with a group of defense writers, he predicted that USAF's new strategic bomber "essentially is going to be used conventionally and as a cruise-missile carrier. If we ever can get the Navy and the Air Force working together, it is [also] going to be used against ships. It will be useful, but we will have paid an awful lot of money for it." He faulted the Reagan Administration for going ahead with the B-1B program because he claims that the aircraft's ability to penetrate was in question and that "Stealth," the Advanced Technology Bomber (which is about to enter limited production), offers a "better alternative."

The influential Senate Armed Services Committee Chairman was also critical of the Administration's approach to arms control, charging that the White House has failed to enunciate long-term US goals concerning the nuclear strategic field, on the one hand, while neglecting the intrinsic link between conventional force levels and nuclear theater forces, on the other. Senator Nunn, whose committee is key to ratification of any arms accord, stressed that he had not yet developed a firm stance on the incipient INF (intermediate-range nuclear forces) accord that he thought might be concluded within the next few months. He did make clear that such an accord must be tied to measures that over time ensure some balance in conventional forces and capabilities between NATO and the Warsaw Pact.

As a minimum, he suggested that the accord should include a "supreme national interest clause" that unambiguously allows this country to abrogate the accord before "we complete the withdrawal of all INF systems" if by that time the conventional forces balance is still skewed in favor of the Warsaw Pact. In the context of Europe, he complained, "all we ever seem to talk about is nuclear [forces, even though their role there is that of a prop] for balancing out conventional capabilities." Hence the importance of such a supreme national interest clause that serves notice to both the Soviets and the American and West European "public" that after a given period following the signing of the accord, "we will look at the conventional forces balance and if it doesn't exist, invoke" the special clause that opens the door to abrogation of the accord.

The conventional balance, Senator Nunn explained, should be achieved through negotiations as well as modernization. The reduction in conventional forces ought to be "asymmetrical," meaning a far greater number of Soviet than US forces must be withdrawn to compensate for the East's current vast advantage. For a starter, he suggested that thirteen Soviet and "about" two US divisions should be withdrawn along with the implementation of measures that ease NATO's "short-warning" problem engendered by the large Soviet advantage in forward-deployed armor and artillery tubes.

A rather sticky aspect associated with the withdrawal of conventional forces is the issue of potential "reintroduction of forces." If the Soviets, for instance, take some of the troops and armor now deployed near the West German borders and move them to the USSR's western military districts while the US has to move its units back to the CONUS, that "would be a nonstarter," in Senator Nunn's view. An equitable conventional forces balance along NATO's Central Front, he argued, is attainable only through asymmetric force reductions and measures that ensure "equal time reintroduction" capabilities of the forces the two sides agree to withdraw.

Arms reduction, by itself, is not likely to correct the existing imbalance in conventional forces, in the SASC Chairman's view. There is a burning need for an "education campaign" in the US and European NATO countries. Such a campaign is needed to generate public support for improved conventional warfare capabilities that can markedly raise the nuclear threshold and make NATO's "flexible response" doctrine a viable concept rather than merely a trigger for theater nuclear and strategic nuclear retaliation.

Secondly, Senator Nunn argued, "leap-frog technologies" capable of such revolutionary advances as "making the Soviet force structure, [especially] tanks, obsolete" need to be brought to bear on the conventional warfare challenge. While many of the concepts associated with the "leap-frog technologies" involve "dark programs" that can't be discussed, he suggested that they were sufficiently mature to be taken seriously.

Lastly, Senator Nunn contended that closer cooperation in terms of the development, production, and acquisition of weapons among the NATO powers would go a long way toward balancing the alliance's conventional warfare capabilities against those of the Warsaw Pact. Over the past twenty-five years, with the possible exception of one year and not counting the Pact's low manpower costs, the Western alliance outspent the Soviet bloc on defense. Greater cooperation on arms matters within the alliance could increase significantly the West's return on investment in conventional warfare defense, he contended.

While acknowledging that an INF accord could be potentially bene-

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A TV-guided glide bomb can be controlled after launch by a sophisticated weapon control system. The AXQ-14 data link system is used with the GBU-15 glide bomb. Imagery from a camera in the bomb's nose is transmitted from a weapon data link on the rear of the bomb to the launch aircraft or to another aircraft equipped with the system. The data link provides two-way communications that allow the weapon to be launched and guided accurately to its target from safe standoff distances. The GBU-15 can be "steered" all the way to the target by a weapons system operator, or it can be launched on a programmed course and the operator can make mid-course corrections. Hughes Aircraft Company has delivered more than 1,000 weapon data links to the U.S. Air Force.

The Hughes Consolidated Repair Facility will save the U.S. Army Missile Command $1 million per year. The new 26,000 sq. ft. building in Las Cruces, New Mexico will be the central repair and logistic support center for sophisticated Roland radar and electro-optical units made by Hughes. The Roland system is a short-range, all-weather system that uses supersonic missiles to defend against low-altitude threats. It is currently deployed with full-time troops of the New Mexico Army National Guard at McGregor Range, New Mexico.

Improved access to a new generation of giant Intelsat satellites is planned. Intelsat VI, designed and built by Hughes, is a series of five of the world's largest, most powerful commercial communications satellites. Each will have the capacity to carry 120,000 telephone calls and at least three television channels simultaneously. Making this possible is the use of very advanced digital modulation techniques. Design changes, the result of a system modification contract from the International Telecommunications Satellite Organization (INTELSAT), also will more than double the downward signal capacity of the satellite's spot beams, permitting greater coverage of North America and more connections with Europe. Called the satellite of the 21st century, each satellite in the Intelsat VI series stands 39 feet high and will use terminals as small as two feet in diameter. The first Intelsat, built by Hughes more than 20 years ago, was 4½ feet high and required Earth terminals nearly 100 feet in diameter.

A helicopter night vision system incorporates a sophisticated flight computer to aid in navigation and reduce pilot workload. The Hughes Night Vision System (HNVS) is a low-cost, forward-looking infrared (FLIR) system that provides excellent imagery and object detection in any visibility condition, day or night. The flight computer is highly accurate and easy to operate. It superimposes flight symbology and navigational data over the FLIR imagery to give the pilot a single display. All flight computer functions can be modified by software to meet different requirements.

A two-way television system enables Minnesota students to be taught by teachers miles away. A consortium of seven school districts in east-central Minnesota operates this system in conjunction with local cable television operators as part of an elementary and high-school program to promote telecommunications technology in education. It allows each district to produce and transmit live video and audio signals to other schools. Thus, specialized classes such as foreign languages and advanced mathematics and science are shared among the seven districts. The system also allows administrators to attend regional meetings without traveling. It consists of a microwave path from Cambridge to six outlying school districts 6 to 26 miles away. The microwave transmitters and receivers were manufactured and provided by Hughes.

For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

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ficial, Senator Nunn was concerned about the associated "downsides." He cited specifically the psychological danger of the West being lulled into disregarding conventional warfare requirements and of agreeing to a limited number of short-range INFs without actually developing and deploying these weapons. (At present, the US has no weapons of this type, while the Soviets do.) In case the accord permits short-range theater missiles of this type, he suggested that the US convert a number of the then outlawed Pershing IIs to "IAs" by removing one of the stages and thus reclassify them as short-range INFs.

U-Turns on Arms Control

The current round of arms-control talks is clearly picking up momentum. Equally obviously, the negotiations are veering away from the Administration's top priority, START (strategic arms-reduction talks), because of the USSR's singular concentration on INFs (intermediate-range nuclear forces).

In a recent meeting with Pentagon correspondents, the Director of the US Arms Control and Disarmament Agency (ACDA), Kenneth Adelman, acknowledged that the Soviets had "rejected out of hand" the US proposal to "zero," *i.e.*, eliminate, all strategic ballistic missiles. He suggested that there was little likelihood of this proposal being resurrected. The thumbs-down signal by the Soviets is probably being welcomed tacitly by many US defense analysts in Congress and elsewhere who saw this particular "zero option" as a potentially calamitous booby trap. There is widespread apprehension that building up deterrent capabilities by means other than ballistic missiles would prove difficult and costly. More importantly, the very premise of the proposal seems to stand or fall with the ability of the US to maintain a leak-proof ballistic missile defense consistently and permanently—in order to neutralize Soviet breakouts or cheating—in the view of some experts.

The near-term US arms-control goals, according to the ACDA head, revolve primarily around reducing by fifty percent the strategic nuclear capabilities of the two countries, "delinking" START from discussions about SDI, setting sublimits on larger land-based ballistic missiles, and engaging the Soviets in "cooperative arrangements" on defense in space. In terms of theater nuclear force reduction issues, US interest is riveted on short-range INFs: "We want to freeze at current Soviet levels [of short-range weapons of this type] and [be free ourselves] to build up to that level," according to Mr. Adelman. He pointed out that because of the upgrading of the 108 Pershing Is (short-range INFs) to Pershing IIs (LRINFs, or longer-range INFs), the US no longer has any short-range INFs in its inventory anywhere.

IN FOCUS...

The Soviets, on the other hand, maintain a burgeoning inventory of missiles of this type, consisting of 900-kilometer-range Scaleboards, 500-kilometer-range SS-23s, and 300-kilometer-range SS-1c/Scud-Bs. The SS-23, which is now coming into the operational inventory, is thought to be a replacement for the Scud-B. More than sixty Scaleboard launchers are "forward-deployed" in Eastern Europe. These front-level weapons that normally accompany Soviet combined arms formations are now in position to strike deep into Western Europe. Another forty Scaleboards are situated along the Soviet border with China. One battalion of Scaleboards is located near Southwest Asia and Turkey, while another one is thought to be kept in strategic reserve. More than 500 SS-1cs are located opposite European NATO.

Below the shorter-range INFs are SNFs (short-range nuclear forces), consisting, on the Soviet side, of some 500 Frogs and SS-21s deployed against European NATO as well as more than 10,000 artillery tubes and howitzers designed to fire nuclear rounds. Recent US intelligence reports stress that the USSR enjoys a "substantial numerical superiority" in these types of weapons and continues to upgrade them. In addition, the Soviets also dominate in terms of INF aircraft and are reducing the qualitative advantages NATO held in this category of dual-capable aircraft. The capabilities residing in the US SNFs, consisting of Lance tactical missiles and nuclear artillery, are substantially below those of the Soviets.

For the time being, neither the US nor the Soviet Union has sought to include SNFs in INF reduction talks. Also, there have been no moves by either side to put a lid on sea-based forces that could play the same role as INFs. On the Soviet side, there are thirteen Golf II-class ballistic missile submarines (not counted as strategic weapons), each of which carries three SS-N-5 SLBMs. Six of these submarines are assigned to the Baltic, where they pose a threat to European NATO. In addition, the Soviet Navy includes at least 288 surface ships, 340 submarines, and about thirty other combatants that carry nuclear-capable cruise missiles. On the US side, there are at present more than thirty surface ships and submarines (out of a potential of more than 190) certified to carry the nuclear Tomahawk land-attack cruise missile (TLAM/N), which has a range of in excess of 1,350 nautical miles. Within the next five years, a total of about 500 TLAM/N missiles will be deployed aboard US naval vessels.

The high degree of Soviet interest in concluding an INF accord is manifested by the fact that Moscow variously suggested three solutions to the crucial short-range INF problem, according to the ACDA Director. One involves a freeze at current Soviet levels, which would presuppose that the US build up an equivalent capability. The second proposal, which gained prominence in the recent Moscow negotiations, centers on moving the short-range Soviet INFs back from Czechoslovakia and the GDR (East Germany). Lastly, there have been hints by Soviet arms-control negotiators that suggest Moscow's willingness to "zero out" the SS-12s and SS-23s.

The original stumbling block to an INF accord—the 441 three-warhead, 5,000-km-range SS-20s and the 112 2,000-km-range SS-4s on the Soviet side and the 108 1,800-km-range Pershing IIs and the 208 deployed 2,500-km-range ground-launched cruise missiles (GLCMs) on the US side—are no longer considered at issue, according to Mr. Adelman. If the other facets of an INF accord can be resolved, each side would reduce its inventory of LRINFs to 100 warheads. The Soviets would pledge to station their remaining LRINFs in Asia, while the US would keep its allowed inventory in the CONUS.

In this context, the USSR announced opposition to US plans to use retired Pershing IIs as ASAT (space interceptor) launchers. The US, on the other side, is seeking a clear definition of the line of demarcation between the European and Asian parts of the USSR. The permitted number of LRINFs would have to be moved to the Asian portion of the USSR under the proposed accord.

A central and clearly fundamental concern, the ACDA head pointed out, is arising in the US and especially in NATO Europe as a result of Moscow's INF push: How real is the potential for

Soviet circumvention, meaning the substitution of short-range nuclear weapons for the SS-20s and SS-4s? There is concern in Congress also about the Soviet ability to transport surreptitiously and relatively quickly some or all of the remaining SS-20s from Soviet Asia to eastern Europe aboard the C-5-like Condor airlifter.

Soviet leader Mikhail Gorbachev's current all-out drive toward sealing an INF accord, meanwhile, is being viewed with increasing apprehension by senior NATO officials. As the Defense Department's Assistant Secretary for International Security Policy Richard Perle pointed out at an international conference in Munich, Germany, recently, "Our European allies have begun, in private at least, to express once-unspoken misgivings about the abandonment of the Pershing and cruise missiles that were so recently the object of hostile demonstrations throughout Europe."

Gen. Bernard W. Rogers, SACEUR, at the same time warned the US Congress that "NATO should not seek such strong conventional forces that we delude ourselves and the Soviet Union into concluding that war [between the two blocs] without the potential use of nuclear weapons is feasible." He added that NATO's first-use option of nuclear weapons is the pivot of the alliance's ability to deter, because "if attacked conventionally today, NATO would face fairly quickly the decision to escalate to a nuclear response in order to halt the aggressor's advance." In the final analysis, General Rogers pointed out, "the Soviets must be faced continually with the prospect that any aggression against NATO will run the incalculable risk of escalating to the strategic nuclear exchange," the thing they fear most.

IN FOCUS...

Turning to the hotly debated issue of broad vs. narrow interpretation of the ABM Treaty that is threatening the US with a constitutional crisis, the ACDA head pointed out that the Soviets' reading of this accord is at odds with either approach. Moscow, he explained, wants to determine solely on the basis of "intent" what is permissible under the accord and what is not. Test activities involving ABM-related technologies are permitted, if their only purpose is research; they are outlawed if there are plans to incorporate the test results in operational systems.

The internal US dispute, which basically pits the Republican Administration against the Democratically controlled Congress, revolves around Talmudic cogitations over the intent associated with the accord's text. At the core of the argument is whether or not SDI-related tests involving space-based or mobile components constitute violations of the ABM Treaty. Depending on the interpretation, the initial phase of the US SDI (Strategic Defense Initiative) program either could proceed or would have to be delayed.

Poll Finds Public Chary of Arms Control

A national public opinion poll commissioned by the bipartisan "Committee on the Present Danger" unearthed strong distrust of Soviet motives in arms control and firm opposition to any agreements that would leave the Soviets with advantages in either nuclear or conventional forces. The poll, which involved the random sampling of 1,004 US households early in April and centered on current bilateral negotiations aimed at mutu-

ally limiting INFs based in Europe, showed that seventy-one percent of the respondents don't "trust the statements of Soviet leader Gorbachev on arms control." Most of those sampled also expressed doubts about Soviet willingness to comply with arms-control accords.

By a wide margin—a total of sixty-six percent of the respondents—Americans seemingly believe that the Soviets violate existing arms-control accords. Nevertheless, forty-two percent of those queried recommend that the US seek to negotiate new agreements, while fifty-one percent believe that this country should concentrate instead on getting the Soviets to abide by existing agreements.

While the respondents overwhelmingly endorsed the concept of placing equitable limits on medium-range theater missiles in Europe, they expressed opposition by an even wider margin to any agreement that does not provide for equality on both sides as well as adequate verification procedures. When asked if they would favor an agreement to limit INFs if the accord left the Soviets with an advantage in other types of nuclear weapons in Europe, eighty-three percent of the sample expressed themselves in opposition. If an accord resulted in a Soviet advantage in conventional forces, seventy-seven percent of those polled would reject such an agreement.

Dispute Over NASA's Space Station

The US Space Station, slated to become operational in 1996, is now envisioned as a 110-meter-long boom to which three pressurized laboratories and a pressurized "habitat" are attached in the middle, NASA's Deputy Administrator Dale D. Myers recently told a congressional space panel. Cost of the system, following a revision of the baseline configuration, he explained, can be expected to be about $10.9 billion, expressed in 1984 dollars. This total does not include some $1.3 billion that NASA expects to spend on associated engineering and technical support activities over the next eight years.

The revised baseline configuration, the NASA official explained, is meant to establish a permanently manned presence in space as well as to develop a full-blown "research center" in space, including a polar orbit platform. The design is to be relatively elastic to allow for evolutionary growth. Further, the US Space Station program is predicated on "significant international participation, including elements of the Canadian Mobile Servicing System [as well as] pressurized modules from both Europe and Japan."

Defense Secretary Caspar W. Weinberger, meanwhile, spelled out US national security concerns associated with the Space Station program in a public letter to Secretary of State George Shultz. While the Pentagon recognizes that the Space Station is a civilian program managed and funded by NASA, he emphasized that "we regard the future US Space Station as an important national asset [that] must be available for any national security purpose consistent with our national obligations."

Explaining to the State Department that the Pentagon was examining "possible DoD uses" of the Space Station and would formulate specific plans on how to use the facility as the program matures, Secretary Weinberger expressed the belief that "we may be in danger of paying too high a price for international cooperation in this undertaking." The US should not "fail explicitly to reserve the right to conduct national security activities on the US elements of the Space Station, without the approval or review of other nations." ■

CAPITOL HILL

By Brian Green, AFA DIRECTOR OF LEGISLATIVE RESEARCH

Washington, D. C., April 30

House Passes Budget

The House of Representatives has approved defense budget ceilings that seriously endanger the nation's defenses, according to Secretary of Defense Caspar Weinberger.

The House approved a budget resolution for FY '88 that includes $282 billion in defense outlays (the amount actually spent in the fiscal year) and $289 billion in defense budget authority (the amount that DoD and other defense agencies can obligate to spend in the current and future fiscal years). The House budget reduces outlays by $15 billion and budget authority by $23 billion compared to the Administration request of $297 billion and $312 billion respectively. That's an inflation-adjusted decrease of five percent compared to FY '87.

In addition to rapping the magnitude of reductions, Secretary Weinberger expressed concern over the effects of reducing outlays disproportionately compared to budget authority. (Only a fraction of the money for procurement and R&D accounts is spent in the year in which it is authorized. The remainder is spent over the next several years. Thus, large BA cuts in these accounts are needed to achieve modest outlay savings. Money allocated for manpower and operations and maintenance [O&M], on the other hand, is spent very quickly. To achieve reductions such as those imposed by the House budget requires large cuts in accounts with a high spend-out rate, *i.e.,* manpower and readiness.)

Secretary Weinberger estimated that if military personnel accounts were not exempted from cutbacks, a $15 billion outlay reduction would require a $29 billion cut in budget authority. The cuts, according to the Secretary, would entail termination of the Small ICBM program; reduction of the active forces by 206,000, or almost ten percent; elimination of military pay raises; a $7.1 billion reduction in O&M funding that "will result in . . . a rapid deterioration in the readiness of both active and reserve forces"; and a $10.3 billion cut in procurement funding, including $3.5 billion in Air Force programs.

Even deeper cuts in O&M and personnel accounts would be needed to fit the $15 billion outlay cuts in the framework of a $23 billion budget authority reduction. If O&M and personnel accounts were protected, however, Secretary Weinberger estimated that procurement funding might be slashed by more than fifty percent and overall defense budget authority by up to $66 billion to achieve the necessary outlay reductions.

HASC Markup

The House Armed Services Committee (HASC) subcommittees are remarking the defense authorization bill to match the House budget resolution constraints. The HASC earlier approved an authorization bill with $306 billion in budget authority and $294 billion in outlays.

Key program actions include:

- Approval of twelve of the twenty-one MX Peacekeeper ICBMs requested. Funding for R&D on rail-garrison basing for the MX was cut from $591 million requested to $250 million.
- Approval of $2.1 billion (of $2.2 billion requested) for the Small ICBM.
- Approval of $3.6 billion of $5.7 billion requested for the Strategic Defense Initiative (SDI). In a 25–24 vote, the committee decided to impose the so-called narrow interpretation of the ABM (Antiballistic Missile) Treaty on the Administration *(see "Capitol Hill," May '87 issue).*
- A zeroing of procurement funding for the Advanced Cruise Missile, the Ground-Launched Cruise Missile, and the Bigeye chemical bomb.
- A reduction from $416 million requested for the B-1 program to $376 million. The committee forbade the Air Force from "undertaking any fixes, enhancements, or modifications to the B-1 without specific prior approval by Congress."
- A reduction in funding for the F-15-launched antisatellite (ASAT) weapon from $356 million to $50 million. The committee did not ban ASAT tests against objects in space, though this same issue will in all probability be raised again on the House floor.
- A reduction in the AMRAAM (Advanced Medium-Range Air-to-Air Missile) program from 630 to 500 missiles.
- Authorization for the first two C-17 airlifters.

Four Senate Budgets

The Senate Budget Committee, unable to agree on the proposal submitted by Committee Chairman Sen. Lawton Chiles (D-Fla.), decided to submit four budget proposals to the full Senate. The Chiles proposal calls for a $14 billion reduction in defense outlays from the $297 billion Administration request and $7 billion less than FY '87. In addition to Senator Chiles's budget, the committee agreed to submit the President's budget, a budget proposal by Sen. Ernest Hollings (D-S. C.) that calls for a one percent increase in defense outlays and $34 billion in new taxes, and a budget reflecting the huge defense reductions imposed by the Gramm-Rudman-Hollings balanced budget law formula that would ordinarily be invoked only if Congress failed to approve a budget.

Other alternatives are expected to be introduced on the Senate floor. Floor action was delayed because none of the alternatives appeared to have enough support to win approval.

ATB Competition

HASC Chairman Les Aspin (D-Wis.) and Rep. Sam Stratton (D-N. Y.) proposed that the Advanced Technology Bomber be procured on a competitive basis. The two will introduce an amendment to the defense authorization bill to provide $100 million to implement the competition. They offered several competitive options, including a complete second production source, an annual competition for final assembly and checkout, and a competitively established production-management study of the program.

Some sources question whether the more comprehensive proposals for competition are practical for the 132-bomber program. ■

DEFENSE DIALOG

GIMADS. The Generic Integrated Maintenance Diagnostic System—GIMADS—is a program under development by Rockwell International and prime contractor General Dynamics to assist the Air Force in institutionalizing the diagnostic process. Autonetics Strategic Systems Division (ASSD) will help develop a process for integrating maintenance diagnostics into the design, development, and deployment phases of a weapons system procurement to improve and sustain weapon system readiness. GIMADS is a hierarchial maintenance approach for tomorrow's Air Force.

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VHSIC APPLICATION. The first operational application of a Very High Speed Integrated Circuit (VHSIC)-populated board has been successfully tested on an Air Force F-111. Developed by ASSD, this pin-for-pin compatible replacement for the F-111 Digital Signal Transfer Unit (DSTU) Interface Board transfers data from digital storage to the pilot's CRT for display of navigation, armament status, and target disposition. This and similar VHSIC insertion programs are expected to play a significant role in USAF upgrades of the F-111 avionics.

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AEROSPACE WORLD

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By Jeffrey P. Rhodes, AERONAUTICS EDITOR

Washington, D. C., April 28

★ The planned February 18, 1988, date for the launch of the first Space Shuttle flight since the *Challenger* disaster has been postponed, the National Aeronautics and Space Administration announced on April 22.

NASA Associate Administrator for Space Flight Rear Adm. Richard H. Truly said that two major tests—a "wet" countdown and a flight readiness test—will be conducted before the actual launch. A "wet" countdown is one in which the external tank is filled with liquid hydrogen and liquid oxygen. During a flight readiness test, the main engines are fired for twenty seconds while the Shuttle stack is secured to the launchpad.

These tests will add several weeks to the processing time for the Orbiter *Discovery,* which will be flown on the next mission. No new date was announced for the first flight, but the delay extends the gap between manned US spaceflights to at least twenty-six months.

In other dreary space news, the US spacelaunch rate in 1986 fell to its lowest point in history, the US Space Command recently announced.

The US had only six launches, or one fewer than in 1958, the first year the nation started putting satellites into space. Those six launches did boost eleven satellites into orbit, though, or four more payloads than were launched in 1958.

Conversely, the Soviet Union had ninety-one spacelaunches in 1986 that carried 114 payloads into orbit.

The US Space Command catalogs man-made objects in space, determines their orbits, and predicts where those objects will reenter the earth's atmosphere. At the end of 1986, a total of 17,287 space objects had been cataloged, and 6,215 of those were still in orbit.

On a happier note, the *Voyager 2* spacecraft successfully executed a midcourse correction in mid-March that will now put the galactic traveler near the planet Neptune twelve hours earlier than expected. This correction will optimize the data return to earth when the spacecraft passes within 5,000 miles of Neptune's north pole at 4:00 a.m. the morning of August 25, *1989.*

Voyager 2, launched August 20, 1977, is now so far away in the solar system that it took three hours and six minutes for the signal from earth to reach the spacecraft and a like time for word to be received that the correction was made. In case you're wondering, Neptune is more than 2,700,000,000 miles from earth.

The *Voyager 2* spacecraft, like its sister ship *Voyager 1,* is managed by NASA's Jet Propulsion Laboratory in Pasadena, Calif.

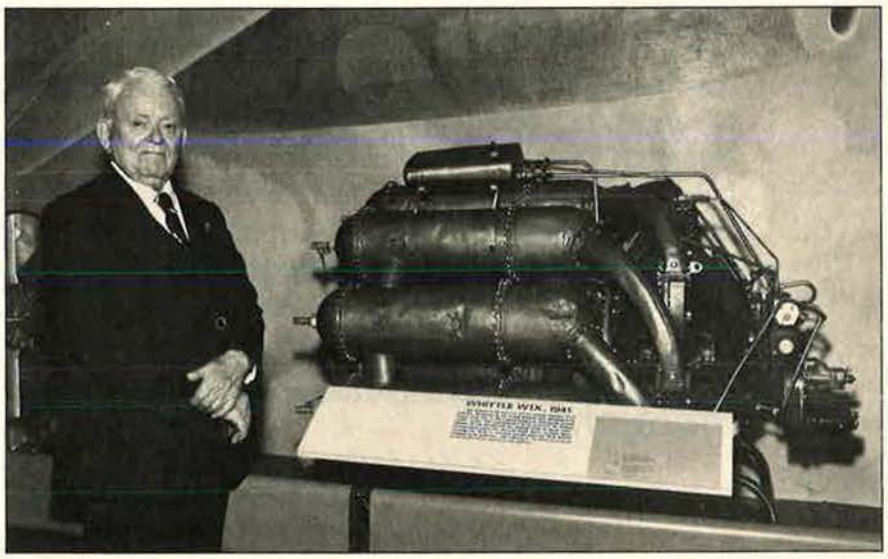
★ What began as a proposal to power a transatlantic mail plane that could carry 500 pounds of mail at 500 mph at 69,000 feet and eventually led to one of the biggest advances in aviation recently turned fifty years old. On April 12, 1937, Frank Whittle, who would later be knighted, bench-tested the first practical jet engine, the WU, in the laboratories of Cambridge University in England.

Sir Frank first proposed his idea for the use of a gas turbine engine or rockets to propel future aircraft in a thesis during his final term as a flight cadet at the Royal Air Force College in Cranwell in 1928. The thesis was later published in the *RAF Journal* and garnered a prize for its author.

On the first test of the WU, the engine began to accelerate out of control. Even after Sir Frank shut off the control valve, the runaway engine spooled up to 8,000 rpm before slowly dropping. The engine ran under control on the fifth try.

After Sir Frank did his earlier work almost as a sideline to his military assignments, the British Air Ministry became interested in his engine development work and gave his company, Power Jets Ltd., a contract in 1939 for an engine that could be used in flight trials. Full-scale development of the engine began a year later. Gloster Aircraft Co. was given a contract for an airframe, and the Gloster E28/39 first flew in May 1941.

A later engine, the W1X, made of spare parts for the WU and scrap parts from the W1, which had exploded, was crated and put in the bomb bay of a B-24 bound for the US on October 1, 1941. This engine, along with the engineering drawings



It was fifty years ago in April that Sir Frank Whittle powered up the first practical jet engine. Here, Sir Frank is pictured at the National Air and Space Museum standing next to a W1X engine, which became the basis of jet engine work in the US when it was brought here in 1941. (Photo by Mark Avino)

for the W2B engine, became the basis of General Electric's work on the engines for the Bell P-59 Airacomet, the first US jet aircraft.

Sir Frank, now eighty, lives in Columbia, Md. Early in his RAF career, he was assigned to test survivability on aircraft by purposely crashing them into the sea. He survived those adventures and went on to become an Air Commodore. He retired from the RAF in 1948. He then served stints as a technical advisor to British Overseas Airways Corp. (BOAC), the first airline to fly the jet-powered Comet, and to a Dutch petroleum company. He also worked with Bristol Siddeley Engines and Rolls-Royce until his retirement in 1970.

His family has an aeronautical bent, as his wife Hazel is an ex-stewardess, and both his sons are commercial airline pilots.

★ While it is unknown which of the two competing teams will build the Air Force's new Advanced Tactical Fighter, one thing on the ATF is for certain—the plane's radar will be built by the team of Westinghouse and Texas Instruments. Both Boeing, the radar integrator for Lockheed's YF-22A team, and McDonnell Douglas, which is the avionics integrator for Northrop's YF-23A team, awarded contracts to the Westinghouse/TI partnership. Hughes and General Electric formed the other competing team.

The contracts, for which no dollar values were announced, call for Westinghouse and Texas Instruments to develop, build, and test an active-element phased-array radar over the next forty-five months. One major aspect of this demonstration/validation phase contract calls for Westinghouse and TI to show that the radar system is producible and affordable and that potential problems have been reduced to a point where full-scale development can be entered with a low level of risk.

Westinghouse and Texas Instruments are also competing against Hughes and GE for the ATF's electro-optical systems development.

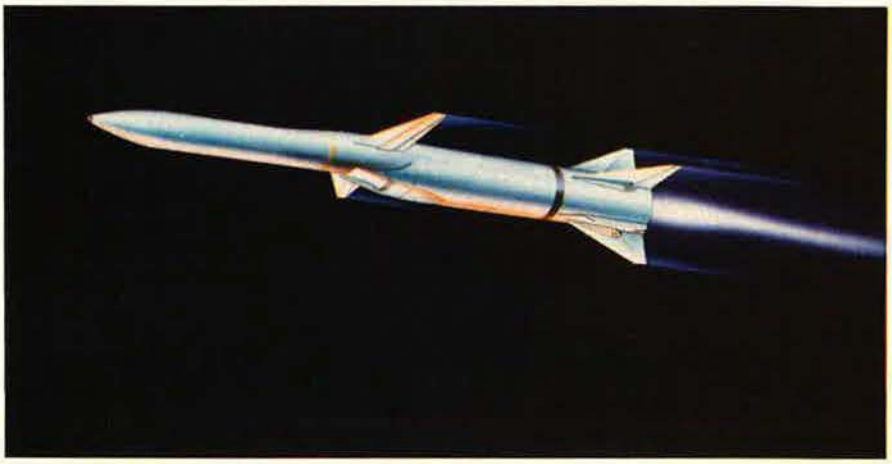
In other ATF notes, Lockheed announced the division of work for its YF-22 team of Boeing and General Dynamics in late March. Lockheed will have responsibility for overall weapon system integration, development and construction of the forward fuselage and cockpit, and avionics architecture and will also have charge over testing, evaluation, and training. Work will be centered at the company's Palmdale, Calif., plant.

Boeing will develop and construct the wings and aft fuselage and be responsible for engine installation and for providing the radar and infrared search and track (IRST) systems. Boeing will also provide an avionics flying laboratory in the form of their company-owned 757 aircraft. Subassembly work will be done at the firm's Wichita, Kan., facility.

After a thirty-four-year hitch in the Nebraska Air National Guard, MSgt. John H. Foster retired in April. Sergeant Foster enlisted in the Marines in 1944 at the age of sixteen and saw action on Okinawa. He became a Marine Reservist, but was recalled to active duty during the Korean War. He is believed to have been one of the last enlisted troops still in uniform to have seen action in World War II. (NEANG photo by TSgt. Vicky Cerino)

General Dynamics will develop and build all mid-fuselage structures, the tail assembly, and landing gear. GD will also have charge of such key systems as flight control and fuel management and will oversee the integrated electronic warfare and inertial navigation systems. All of GD's subassembly work will be done in Fort Worth, Tex.

And finally, a preliminary Navy report finds that there are no significant barriers to converting the ATF to shipboard use. The Navy is likely to buy more than 500 examples of a variant of the ATF as a replacement for its F-14D Tomcats by the end of the century. Likewise, the Air Force may buy a land-based version of the Navy's Advanced Tactical Aircraft in the same time frame.



Hughes and Raytheon have teamed up to compete for the Navy's Advanced Air-to-Air Missile (AAAM) contract. The AAAM, shown in this artist's conception, will have a dual-mode infrared and radar guidance with ramjet propulsion. The AAAM will replace the AIM-54 Phoenix missile in the 1990s. General Dynamics and Westinghouse are the other competing team.

★ Two teams of contractors will be competing to build the Navy's new Advanced Air-to-Air Missile (AAAM), which will replace the long-range AIM-54 Phoenix missile in the late 1990s. The teams—Hughes and Raytheon on one team and General Dynamics and Westinghouse on the other—are expected to get contracts for the demonstration/validation

AEROSPACE WORLD

phase of the AAAM program later this year.

The dem/val phase will last until 1992, when the Navy will select one of the teams to proceed with the missile's full-scale engineering development. By 1996, the schedule calls for the teammates to be split and then compete for annual production contracts as individual companies.

The Hughes and Raytheon team, called "H & R Company," has proposed a missile that will have dual-mode infrared and radar guidance with ramjet propulsion. The GD/Westinghouse AAAM proposal will have a semiactive radar and a solid-rocket propulsion system. Hughes is the prime contractor for the AIM-54, while Raytheon is the second-source manufacturer.

The aircraft identified as candidates to carry the AAAM are the Navy's F-14D, F/A-18C/D, and A-6F as well as the Air Force's F-15C/E aircraft. The Navy's Advanced Tactical Aircraft and the Air Force's Advanced Tactical Fighter have also been identified as potential carriers. Currently, the Navy's F-14 Tomcat is the only aircraft using the Phoenix missile.

With such a wide range of aircraft to be used as platforms for the new missile, the AAAM will have to be much smaller and lighter than the AIM-54, which has a fifteen-inch diameter and weighs nearly 1,000 pounds. The H & R Company proposal for the AAAM is a missile twelve feet long, a full foot shorter than the Phoenix.

The Navy predicts that up to 4,000 AAAMs will be built. Because of its role as the next outer air battle weapon, range of the AAAM will likely be greater than the 100-or-more-mile range of the Phoenix.

★ Part of the veil of secrecy surrounding one of the most highly classified defense programs was lifted on April 6 when Northrop publicly displayed the AGM-136A Tacit Rainbow autonomous, loitering, antiradar missile for the first time. The unveiling was part of the groundbreaking ceremonies for Northrop's new plant in Perry, Ga., where the missile will be made.

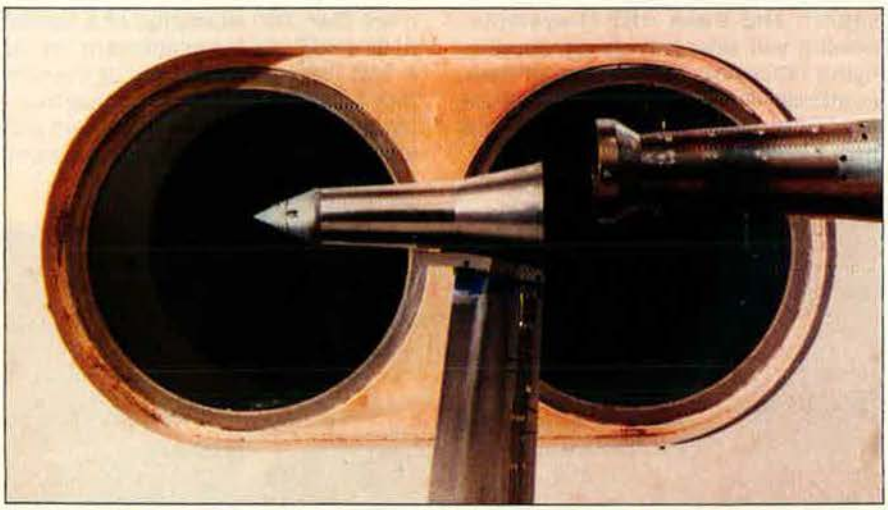
The AGM-136A missile carries programmed flight instructions that allow it to loiter over a battlefield until an enemy radar emitter is turned on. The missile then homes in for the kill. Because of the reported relatively low cost of Tacit Rainbow, a number of missiles can be launched into the battlefield area, each preset to lock on to different emitter frequencies.

The 100-inch-long missile features a single-piece, spring-loaded wing that is stored under the fuselage before launch and that rotates and locks into place on release. The missile's horizontal stabilizers and a dorsal tail fin also pop out after launch. Carrier aircraft have been identified as the B-52G for the Air Force and the A-6E for the Navy.

The AGM-136A is designed to complement the AGM-88A HARM (High-Speed Antiradiation Missile), which was used to knock out radar sites in the April 1986 US raid on Libya.

Full-scale development of the missile is expected to be completed in FY '88. FSD is being supervised by Northrop's Ventura Div. in Newbury Park, Calif. The new $100 million plant in Georgia, which will eventually employ 750 people, is also expected to be completed in 1988.

Major subcontractors on the AGM-136A are Boeing Military Aircraft Co., Delco, Singer-Kearfott, Texas Instruments, and Williams International. The joint Air Force/Navy Tacit Rainbow program is managed by Air Force Systems Command's Aeronautical Systems Division's Deputy for Tactical Systems at Wright-Patterson AFB, Ohio.



A model of the Army's proposed High Endoatmospheric Defense Interceptor (HEDI) is shown prior to testing in the hypersonic wind tunnel at the Arnold Engineering Development Center in Tennessee. The second stage (right) of the missile is supported by AEDC's computer-controlled Captive Trajectory System that allows stage-separation tests to be conducted at simulated hypersonic speeds.

★ Three Hughes AGM-65D Imaging Infrared (IIR) Maverick missiles were recently fired in two milestone tests of the Martin Marietta LANTIRN (Low-Altitude Navigation and Targeting Infrared for Night) dual-pod system. The late March tests were conducted on the ranges at Eglin AFB, Fla., by members of the F-16 Combined Test Force at the Air Force Flight Test Center at Edwards AFB, Calif.

In the first test, Maj. Glyn D. Martin scored a direct hit on an M47 Main Battle Tank in the first successful night test of the Maverick/LANTIRN system. The missile was fired from an F-16B at approximately 500 feet above ground level at a speed of 550 miles per hour.

That single night launch was a critical first step for the test that took place the next evening, when two AGM-65Ds were fired simultaneously. This was the first-ever two-at-a-time launch of IIR Mavericks.

Maj. Ronald S. Willke, flying the same F-16B, chose the targets, again M47 tanks, then handed off to the LANTIRN targeting pod, which selected the missiles to be fired and locked on to the tanks. Both missiles scored direct hits, although only one missile had a warhead. The second Maverick had a telemetry package to monitor the effects of the first missile on the second's IIR seeker.

The tests were conducted at Eglin because of the presence of high humidity and inclement weather needed for continued evaluation of the LANTIRN system.

In a related note, Martin Marietta delivered the first of 700 planned pro-


"Without the Osprey, the hostages might still have been with the hijackers."
"First word of the hijacking set a fast chain of events into motion . . .
"Although the airport was many miles away, the Air Force CV-22s slipped up on them quickly, quietly. In fact, we were on top of them before they could react. The Ospreys gave us clandestine precision and surgical accuracy. There was not one casualty among the hostages.
"Maybe, just maybe, this kind of response will send terrorists a message: Using innocent people for your purposes just won't work any more."
It's possible. This Department of the Navy program is producing an aircraft that streaks forward at turboprop speeds, providing unmatched rapid-response capability at very long ranges. Yet, it takes off, hovers and maneuvers like a helicopter.
Credit the Bell Boeing TiltRotor Team for turning a challenging concept into a startling reality. The TiltRotor will bring speed and range you'd need in a fast combat transport. It can reach up high or race across the terrain at treetop level.
And it will rewrite mission profiles like no other aircraft in the world, ushering in a new era in special operations aviation.
Bell Boeing
THE TILTROTOR TEAM

duction LANTIRN navigation pods to the Air Force in ceremonies at the company's Orlando, Fla., plant. The April 1 delivery was a month ahead of schedule.

Martin Marietta will deliver one navigation pod per month by late 1988, with deliveries increasing to twenty per month by late 1990.

The targeting pod, now in low-rate initial production, is scheduled to enter full-rate production in January of next year. The first production targeting pod is scheduled for delivery in July 1988.

★ Interservice cooperation, or "jointness," is a buzzword in defense circles these days, and personnel who serve in joint assignments are said to wear purple suits. One man who can truly say he's worn a purple suit is Chuck Yarbrough, who at various times over the past twenty-three years has been a sailor, Marine, soldier, and airman.

Now-Mr. Yarbrough, who recently retired as a technical sergeant in the Air Force, began his military career(s) in 1964 as a sixteen-year-old sailor who "fudged" about his age so he could get in the Navy.

After assignments in Nassau, Bermuda, and Guantanamo Bay, Cuba, but very little sailing on the high seas, Seaman First Class Yarbrough transferred to the Marine Corps. He served two tours in Vietnam as an infantryman, and he saw action during the Tet offensive in 1968.

Sergeant Yarbrough then gave civilian life a try, but a chance to be a warrant officer helicopter pilot for the Army brought him back into the armed forces. After washing out of flight school, Sergeant Yarbrough went back to his "civvies."

He still wanted to be around airplanes, so he joined the Air Force. Because of the break in his service time, he started out as an airman basic. He rose to tech sergeant, and his last assignment was as chief of public service at the base personnel office at Osan AB, Korea, before he saluted himself out of the service.

Rather than give the Coast Guard a try, Seaman/Sergeant/Warrant Officer Candidate/Tech Sergeant Yarbrough says he will stay a civilian this time.

★ The latest test of the AIM-120A Advanced Medium-Range Air-to-Air Missile (AMRAAM) on March 31 proved to be a case of "you can run, but you can't hide." The unarmed missile intercepted a maneuvering target at the Pacific Missile Test Range at Point Mugu, Calif.

The target, a QF-86F drone, executed a maximum-G maneuver at very close range to the missile as it was boring in. Despite the jink and the presence of sea return clutter, the missile passed within lethal range of the drone.

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SENIOR STAFF CHANGES

PROMOTIONS: To be **General:** Alfred G. **Hansen;** Bernard P. **Randolph.**
To be **Lieutenant General:** Michael P. C. **Carns;** Charles R. **Hamm;** Buford D. **Lary.**
To be **Brigadier General:** Michael D. **Pavich;** Erlind G. **Royer.**

RETIREMENTS: B/G Anthony J. **Farrington,** Jr.; M/G Peter W. **Odgers;** L/G John L. **Pickitt;** L/G Winston D. **Powers.**

CHANGES: L/G Spence M. Armstrong, from Vice CINC, Hq. MAC, Scott AFB, Ill., to Vice Cmdr., Hq. AFSC, Andrews AFB, Md., replacing L/G George L. Monahan, Jr. . . . **M/G Thomas A. Baker,** from Cmdr., 16th AF, USAFE, Torrejon AB, Spain, to Vice Cmdr., Hq. ATC, Randolph AFB, Tex., replacing M/G (L/G selectee) Charles R. Hamm . . . **M/G (L/G selectee) Michael P. C. Carns,** from Cmdr., 13th AF, PACAF, Clark AB, the Philippines, to Dep. CINC, Hq. USPACOM, and C/S, Hq. USPACOM, Camp Smith, Hawaii . . . **B/G John M. Davey,** from Cmdr., 26th AD/NORAD Region, TAC, March AFB, Calif., to Cmdr., 25th AD/NORAD Region, TAC, McChord AFB, Wash., replacing retiring B/G Alan P. Lurie . . . **B/G William P. Hallin,** from Air Force Competition Advocate General, OSAF, Washington, D. C., to Dep. Dir., Planning and Resources (J-4), OJCS, Washington, D. C., replacing retiring B/G Richard L. Stoner . . . **M/G (L/G selectee) Charles R. Hamm,** from Vice Cmdr., Hq. ATC, Randolph AFB, Tex., to Superintendent, Hq. USAFA, Colorado Springs, Colo., replacing retiring L/G Winfield W. Scott, Jr.

L/G (Gen. selectee) Alfred G. Hansen, from Dir. of Logistics (J-4), OJCS, Washington, D. C., to Cmdr., Hq. AFLC, Wright-Patterson AFB, Ohio, replacing retiring Gen. Earl T. O'Loughlin . . . **B/G Grover E. Jackson,** from Vice Cmdr., Hq. ESC, Kelly AFB, Tex., to Associate Dep. Dir. of Ops. for Military Support, NSA, Ft. Meade, Md., replacing B/G Gary W. O'Shaughnessy . . . **B/G Donald L. Kaufman,** from Vice Dir., NORAD Combat Ops. (J-31), Hq. NORAD, Peterson AFB, Colo., to Dir., Int'l Prgms., and Chmn., Security Assistance, DCS/Prgms. & Resources, Hq. USAF, Washington, D. C., replacing B/G Robert S. Delligatti . . . **M/G (L/G selectee) Buford D. Lary,** from Cmdr., 1st AF, Hq. TAC, Langley AFB, Va., to Inspector General, Hq. USAF, Washington, D. C., replacing L/G Robert D. Springer . . . **M/G Robert P. McCoy,** from DCS/Materiel Mgmt., and Commander's Ass't for R&M, Hq. AFLC, Wright-Patterson AFB, Ohio, to Cmdr., Ogden ALC, AFLC, Hill AFB, Utah, replacing M/G (L/G selectee) Charles McCausland . . . **L/G George L. Monahan, Jr.,** from Vice Cmdr., Hq. AFSC, Andrews AFB, Md., to DCS/RD&A, Hq. USAF, Washington, D. C., replacing L/G (Gen. selectee) Bernard P. Randolph.

B/G (M/G selectee) Fred R. Nelson, from Dep. Dir., Operational Plans and Capabilities (J-3), OJCS, Washington, D. C., to DCS/Air, Allied Forces Northern Europe, Kolsaas, Norway, replacing retiring M/G Gerald D. Larson . . . **B/G Gary W. O'Shaughnessy,** from Associate Dep. Dir. of Ops. for Military Support, NSA, Ft. Meade, Md., to DCS/Intel., Hq. USAFE, Ramstein AB, Germany, replacing retiring B/G Larry D. Church . . . **Col. (B/G selectee) Michael D. Pavich,** from Dir., Materiel Mgmt., Ogden ALC, AFLC, Hill AFB, Utah, to Cmdr., AFLC Logistics Operations Center, Hq. AFLC, Wright-Patterson AFB, Ohio, replacing retired B/G Anthony J. Farrington, Jr. . . . **L/G (Gen. selectee) Bernard P. Randolph,** from DCS/RD&A, Hq. USAF, Washington D. C., to Cmdr., Hq. AFSC, Andrews AFB, Md., replacing retiring Gen. Lawrence A. Skantze . . . **B/G David C. Reed,** from Command Dir., NORAD Combat Ops. (J-31), NORAD, Cheyenne Mt. Complex, Colo., to Vice Dir., NORAD Combat Ops. (J-31), Peterson AFB, Colo., replacing B/G Donald L. Kaufman . . . **B/G Paul L. Roberson,** from Cmdr., Goodfellow TTC, ATC, Goodfellow AFB, Tex., to Vice Cmdr., Hq. ESC, Kelly AFB, Tex., replacing B/G Grover E. Jackson.

Col. (B/G selectee) Erlind G. Royer, from Permanent Professor and Head of Dept. of Electrical Engineering, Hq. USAFA, Colorado Springs, Colo., to Dean of Faculty, Hq. USAFA, Colorado Springs, Colo., replacing B/G Ervin J. Rokke . . . **B/G (M/G selectee) Richard D. Smith,** from DCS/Contracting & Mfg., Hq. AFLC, Wright-Patterson AFB, Ohio, to DCS/Materiel Mgmt., and Commander's Ass't for R&M, Hq. AFLC, Wright-Patterson AFB, Ohio, replacing M/G Robert P. McCoy . . . **L/G Robert D. Springer,** from Inspector General, Hq. USAF, Washington, D. C., to Vice CINC, Hq. MAC, Scott AFB, Ill., replacing L/G Spence M. Armstrong . . . **B/G Robert F. Swarts,** from Dep. Dir., Operating Appropriations, Office of the Comptroller, Hq. USAF, Washington, D. C., to DCS/Contracting & Mfg., Hq. AFLC, Wright-Patterson AFB, Ohio, replacing B/G (M/G selectee) Richard D. Smith . . . **M/G Gordon E. Williams,** from Ass't DCS/Prgms. & Resources, Hq. USAF, Washington D. C., to Dir., Plans & Policy (J-5), USEUCOM, Vaihingen, Germany, replacing M/G Thomas L. Craig.

SENIOR ENLISTED ADVISOR CHANGE: SMSgt. (CMSgt. selectee) Roy Boudreaux, to SEA, Hq. Air University, Maxwell AFB, Ala., replacing retiring CMSgt. Robert H. Waldrup. ■

The AIM-120 was launched from a McDonnell Douglas F/A-18 Hornet traveling at Mach 0.80 at 15,000 feet in a look-down/shoot-down nose-on attack. The QF-86 was traveling at the same speed as the F/A-18 but at 10,000 feet lower.

The AMRAAM was launched in its active mode and locked on to the drone with its on-board radar. The missile then guided itself to the target.

This latest test was the seventh from an F/A-18, and it marked the twenty-fourth success in twenty-eight tries. The joint Air Force/Navy AMRAAM program is managed by Air Force Systems Command's Armament Division at Eglin AFB, Fla.

★ If a military organization can propose a more productive way of doing things, then DoD's Productivity Investment Fund (PIF) program can make good ideas pay off.

The PIF program funds projects costing more than $100,000 that will increase an organization's productivity and generate enough savings to pay for themselves within four years. Although Congress includes PIF money in DoD's budget, military services must compete for these funds. As a result of the recent FY '88–89 PIF competition, the Air Force will receive $84.7 million in PIF money.

Air Force Logistics Command (AFLC) will receive the lion's share of the total, with approximately $57 million slated to fund eight projects during FY '88–89. "AFLC did very well in comparison with the other major commands. More AFLC projects were funded because they made good dollar sense, and the economic payback was higher," according to Paul Keller, a program analyst in the Deputate of Plans and Programs at AFLC headquarters, Wright-Patterson AFB, Ohio.

One such AFLC project slated for PIF funding in FY '88 is a new Consolidated Avionics Integration Support Facility at Ogden Air Logistics Center, Hill AFB, Utah. The estimated cost of the new facility is $12.5 million, but it will result in an impressive savings of $7 for every dollar invested. The facility will house all the equipment, test stations, simulators, and personnel needed to accomplish the critical software support for such prime weapon systems as the F-16 and the Peacekeeper missile. Directorate of Maintenance officials estimate a total savings of $240 million over the life of the new facility.

"In a time of reduced funding and manpower authorizations, the PIF program offers a means of funding 'good ideas' without having to compete in the regular budget cycle for scarce funds," added Mr. Keller. "Since PIF funds are included as a separate item in the budget process, funding is provided for those projects with the best economic analysis."

PIF is a part of the overall Productivity Enhancing Capital Investment (PECI) program. "If the economic analysis proves certain projects will produce high manpower savings, a return on investment, or internal rate of return, then they can be funded under PECI programs," according to Lt. Col. James Wendt, chief of the Productivity and Innovation Division at AFLC headquarters. "The goal is to be less labor intensive in accomplishing the mission, yet be more productive by using either newer equipment or better facilities," Colonel Wendt added.

★ Some highlights of recent congressional testimony given by Air Force and government officials:

Defense Advanced Research Projects Agency Director Robert C. Duncan told the Defense Subcommittee of the House Appropriations Committee that "under the auspices of strategic computing, we [DARPA] are developing computer hardware vastly more powerful than that currently available. We expect that, by 1992, this hardware could be up to a million times more powerful than what we have now. We

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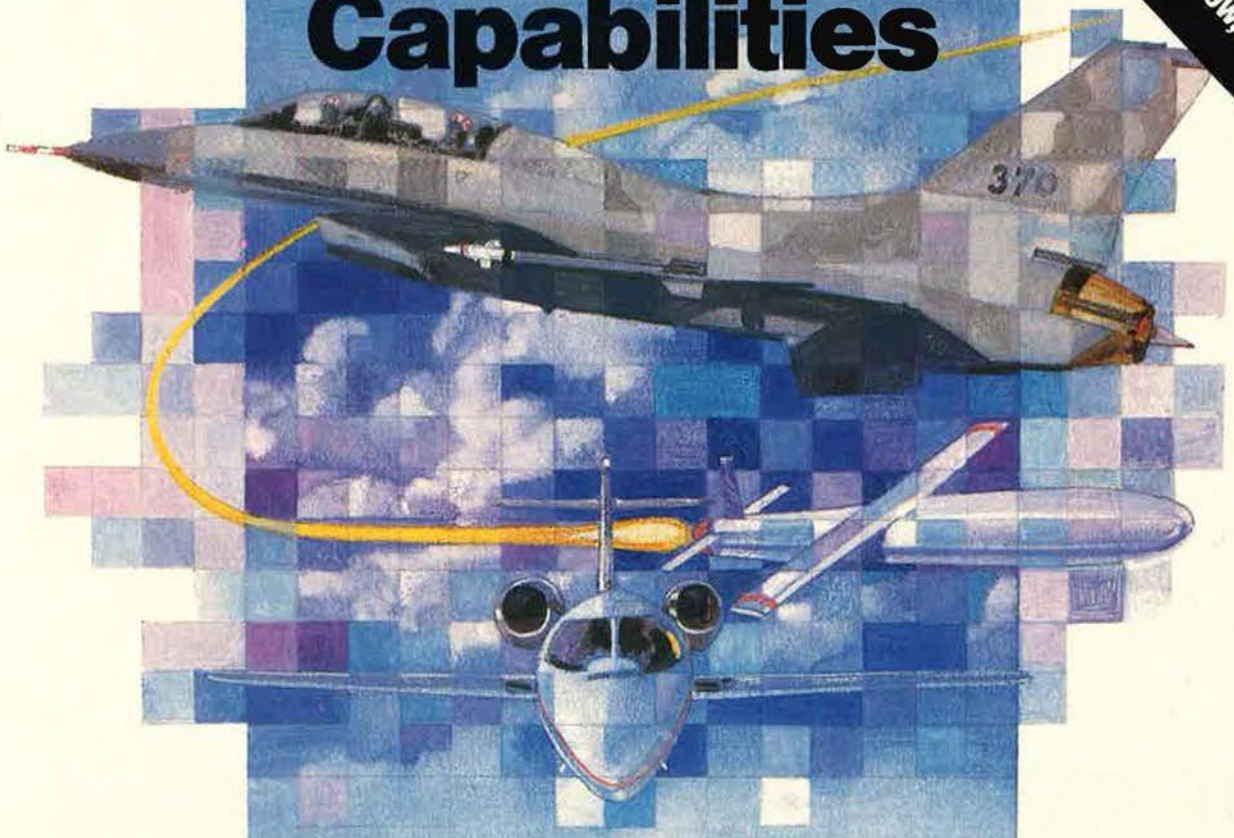

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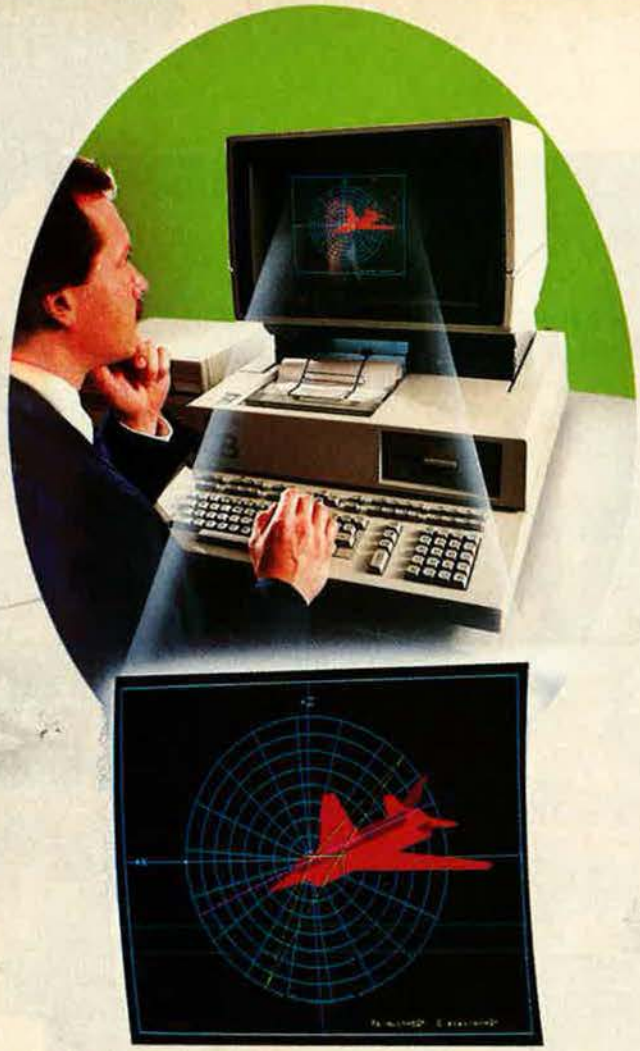

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are developing computer software systems for vision, speech, natural language, planning, and knowledge-based, expert reasoning systems."

Maj. Gen. Thomas A. LaPlante, Air Force Director of Logistic Plans and Programs to the Deputy Chief of Staff for Logistics and Engineering, described a new munitions storage program to the House Appropriations Committee.

"Another new [program] start, Mechanical Diverters, also known as . . . Have Block . . . begins in FY '88 and will provide an urgently needed solution to the critical problem of insufficient and malpositioned storage in Europe. The Have Block project results from research and testing that demonstrated the potential for use of blast and fragment diverters to prevent sympathetic detonations of high explosives.

"The availability of 31,000 Have Block bomb pallets will increase USAFE's total munitions storage capability by ten percent overall, but more significantly, by twenty-seven percent at the actual sortie-generation bases. This translates into an increase of approximately 12,000 additional sorties of combat capability at the USAFE main and collocated operating bases."

Brig. Gen. Thomas E. Eggers, Air Force Deputy Director of Operations to the Deputy Chief of Staff for Plans and Operations, described the dire need for new gunships to the House Armed Services Committee's Subcommittee on Procurement and Military Nuclear Systems.

"Twelve new AC-130 gunships [to be designated AC-130U] are needed to maintain the current force structure while retiring the old AC-130A gunships. The AC-130As include some of the oldest (1950s vintage) C-130 airframes in operation, and the aircraft have not been modified or improved to keep pace with the current gunships. The 1960s technology used to develop the unique gunship subsystems requires extensive maintenance and logistical support. In many cases, suppliers and parts are no longer available, and we must resort to local manufacture and/or repair.

"The A model's defensive equipment is antiquated and does not provide sufficient protection against existing or planned threat systems. The sensor equipment does not provide the field of view, search pattern, or range required. The aircraft is extremely limited in its capability to locate and destroy targets in adverse weather conditions, lacks an adequate fire control radar, and uses computers and components that are no longer being produced or are in short supply.

"The A model lacks in-flight refueling, and their communications suite does not provide the positive command and control required for special operations. The AC-130A can no longer satisfy the mission requirements, and without the AC-130As, the AC-130H fleet of ten aircraft is too small to meet current SOF [Special Operations Forces] contingency or wartime tasking."

★ In early April, Transportation Secretary Elizabeth H. Dole announced recommendations designed to tighten security in and around airport perimeters.

Secretary Dole said that the recommendations call for tighter control of access permits to airport employees, a review of employee hiring and employment procedures, and review of access procedures for employees to restricted airport areas.

The Transportation Secretary also identified areas where there is no clear distinction of responsibility for security between an airport operator and air carriers. For example, where carriers have exclusive use of an airport area, the carriers should structure their security program to the same strict standards the airport must meet.

Other highlights of Secretary Dole's recommendations include the verification of employee's work records for the previous five years, specific enforceable procedures to protect aircraft from unauthorized access, checks of an unattended aircraft before it is returned to service, and a requirement to challenge persons in restricted areas who do not show evidence that they are entitled to be there.

In a related note, the Federal Aviation Administration began enforcing a temporary Special Federal Aviation Regulation (SFAR) to restrict flights in the area of the Grand Canyon in late April. The SFAR establishes an area from the canyon floor to 9,000 feet above mean sea level (MSL) to be used only with special authorization. Once authorized, aircraft flying in that area are required to follow specific routes and will not be able to fly below the lowest level of the canyon's rim.

Pilots operating in the restricted area are also required to monitor certain common radio frequencies and provide position reports. These rules apply to licensed commercial tour operators who provide aerial views of

the canyon. Other sightseeing traffic and military flights (which number nearly 90,000 a year) are restricted to operation above 9,000 feet MSL. The FAA is currently working on a permanent rule that will replace the SFAR, which is scheduled to expire on June 15.

★ **MILESTONES**—The **4,000th Pratt & Whitney F100 jet engine** built **was delivered** to the Air Force in ceremonies held at the company's East Hartford, Conn., plant on March 26. The F100 engine was introduced in 1972, and since that time the type has accumulated nearly 4,000,000 hours. The F100 is used in the Air Force's F-15 and F-16 fighters as well as in the aircraft of eleven other countries.

On April 7, **McDonnell Douglas delivered the 100,000th rocket for the Shoulder-launched Multipurpose Assault Weapon** (SMAW) used by the Marine Corps to destroy such battlefield targets as earth and timber bunkers. The SMAW rockets are sealed in a disposable fiberglass tube that is attached to a reusable launcher that is equipped with external battle sights, a telescopic sight, a spotting rifle, and the firing mechanism.

On March 19, the **Navy's first SH-60F Sea Hawk** antisubmarine warfare (ASW) helicopter **undertook its maiden flight** at the Sikorsky Aircraft Co. plant in Stratford, Conn. The new helicopter incorporates many proven features of the SH-3H and SH-60B ASW platforms, and it also sports an improved Tactical Data Management System (TDMS) and a Bendix AN/AQS-13F active, dipping sonar capable of operating at much greater depth than its predecessor. The Navy plans to acquire 175 SH-60Fs to replace the SH-3H fleet for inner-zone defense of carrier battle groups.

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★ **NEWS NOTES—The length of the Undergraduate Pilot Training course,** in which Air Force officers are taught to fly, **will be increased to fifty-two weeks** this October. Air Training Command decided to lengthen the course from the current forty-nine weeks to provide a more flexible and less hectic course of instruction for the students. The T-37 phase of the training will be lengthened from eighty-one to ninety days, and the T-38 phase will now be 120 training days instead of the present 108. Class sizes will also be cut in half, and UPT bases will now turn out fifteen classes a year instead of eight.

Boeing Military Airplane Co. in Wichita, Kan., **was awarded a $49.8 million contract on April 8 to upgrade ten KC-135A tanker aircraft to KC-135E standard.** The upgrade consists of replacing the original J57 engines on the KC-135As with JT3D engines taken from used commercial 707 passenger aircraft. The upgrade boosts performance and lowers noise levels for the KC-135s considerably. The contract covers the purchase of ten used 707s, the reengining kits, and refurbishment and installation of the engines on the KC-135As. The ten KC-135Es will be assigned to Air National Guard squadrons. The first three modified aircraft will be delivered in September.

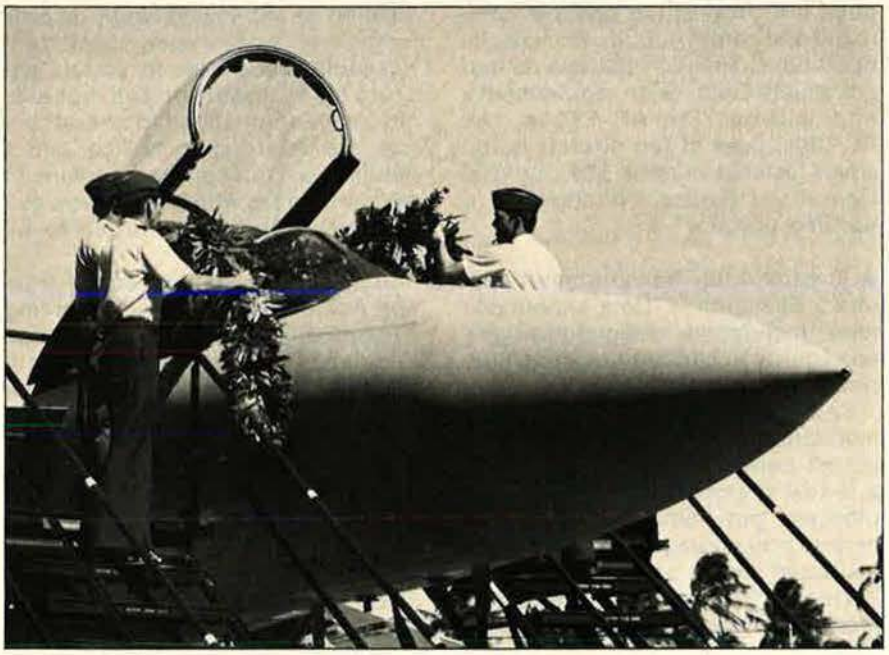
The **Air Force Rocket Propulsion Laboratory** at Edwards AFB, Calif., **was renamed the Air Force Astronautics Laboratory** in ceremonies held in mid-March. The redesignation better reflects the lab's commitment to interdisciplinary space technology development and its distinction as a center of expertise for advancing Project Forecast II space technologies. The lab was created in 1947 to provide rocket-propulsion technology for space systems, ballistic missiles, and tactical weapons.

★ **DIED—Gen. Maxwell D. Taylor, USA (Ret.),** on April 19. He was eighty-five. The General had been hospitalized at Walter Reed Army Medical Center since January and suffered from amyotrophic lateral sclerosis, or "Lou Gehrig's disease."

A paratroop hero in World War II, General Taylor was part of the nucleus that formed the 82d Airborne Division, the first of its kind in the Army. Later in the war he took command of the 101st Airborne Division and led his troops on the D-Day invasion on June 6, 1944. He also led the division during the Battle of the Bulge later that year. After the war, General Taylor was named Superintendent of the US Military Academy at West Point. Assignments that followed included Deputy Chief of Staff of the Army, Chief of all United Nations forces in the Far East, and Army Chief of Staff from 1955 to 1959, when he retired.

General Taylor's ideas on strategy so appealed to President John Kennedy that the President brought him back into service in 1961. From 1962 to 1964, he was Chairman of the Joint Chiefs of Staff and served President Lyndon Johnson as US Ambassador to Saigon during 1964 and 1965.

In 1959, General Taylor published *The Uncertain Trumpet,* which was a staunch criticism of the US policy of relying almost exclusively on the nuclear threat to deter communism. It was in this book that his idea of "flexible response" was defined. ■



The Hawaii Air National Guard recently became the third Guard group to convert to the McDonnell Douglas F-15 Eagle. The first two F-15s to be received by the unit were greeted in the traditional Hawaiian manner—with leis draped around their necks (or cockpits, in this case). There was also a "blessing of the fleet" ceremony. The Hawaii Air Guard will eventually get twenty-six of the air-superiority fighters. (HIANG photo by SSgt. George Galasinao)

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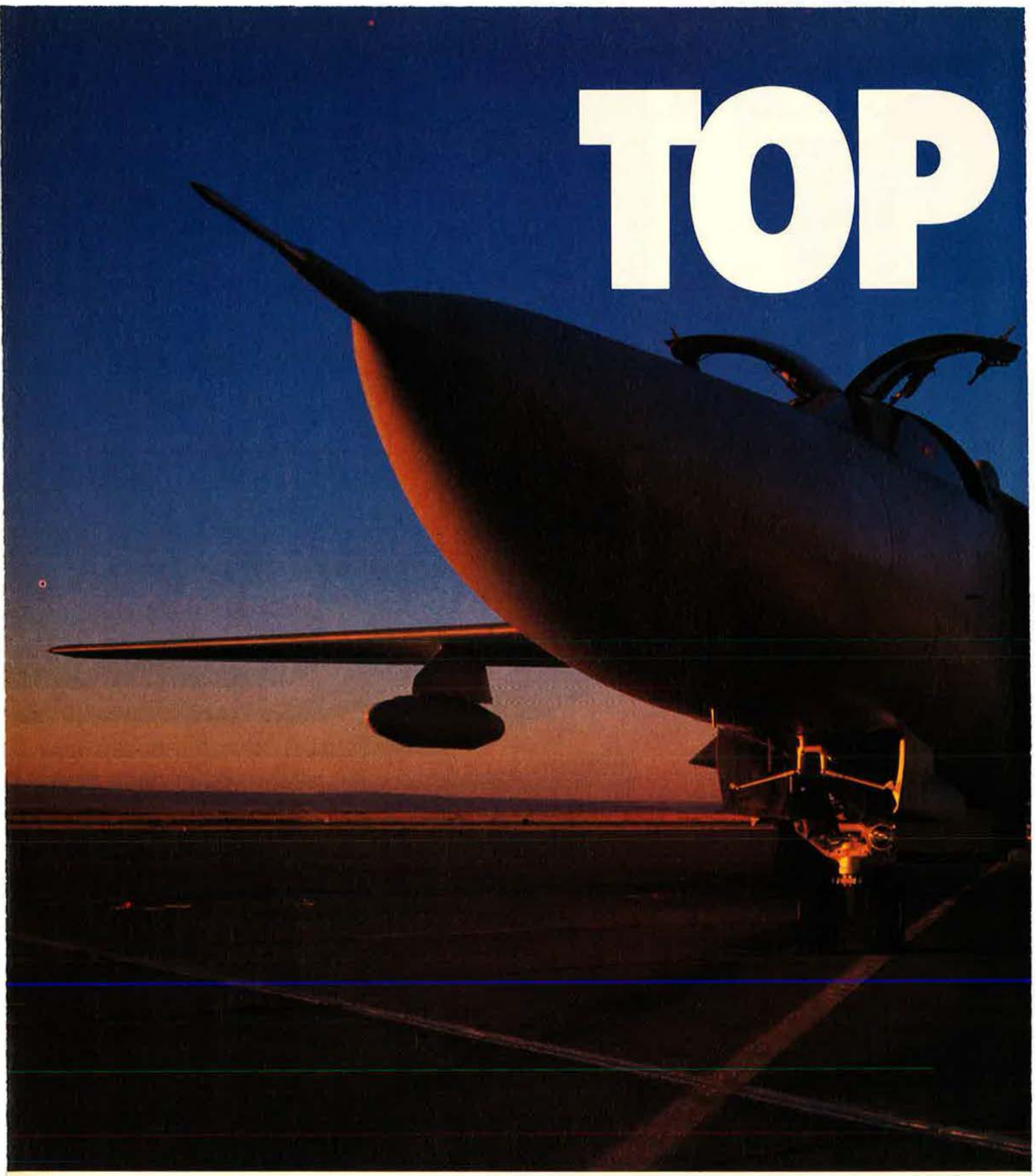

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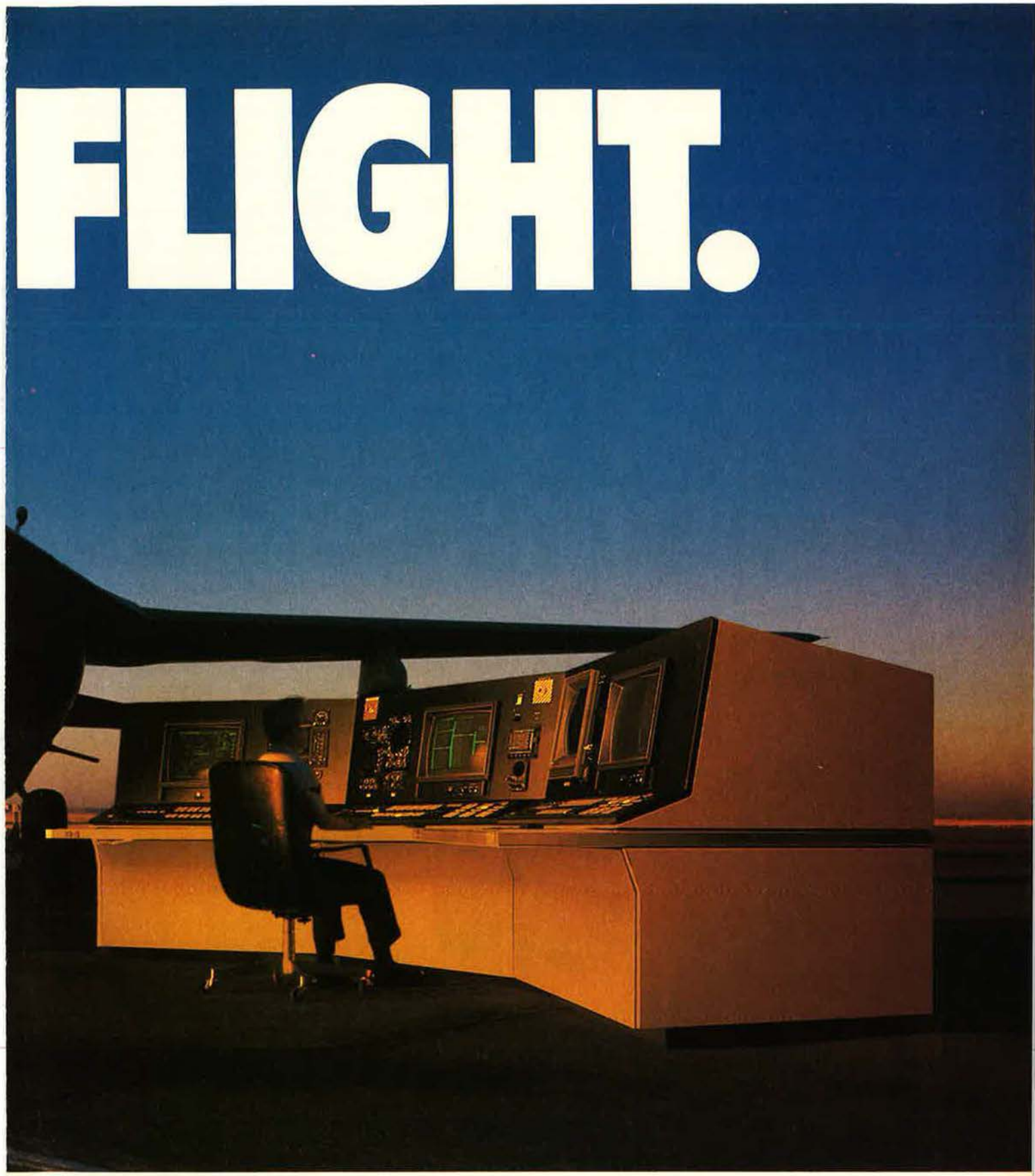

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THE SENSIBLE SOLUTION

C³I was the top priority in the President's strategic modernization program. Six years later, there is some progress—but much remains to be accomplished.

Steady Steps in Strategic C³I

BY JAMES W. CANAN
SENIOR EDITOR

NEXT winter, an Air Force NC-130 aircraft flying over the Atlantic Ocean will launch a remotely piloted drone resembling a Soviet cruise missile toward the US east coast. The objective of this test flight will be to determine how well the dragnet of electromagnetic signals emitted by the Air Force's far-range, over-the-horizon backscatter (OTH-B) radar in northern Maine can detect and track the drone.

The flight will be the first of about forty such forays by air-launched drones against the Maine-based radar at distances of 1,000 miles and more and at various altitudes and aspect angles relative to the mainland.

Air Force Systems Command's Electronic Systems Division at Hanscom AFB, Mass., the overseer of USAF's OTH-B radar program, will run the tests in order to determine what it may need to do to fine-tune the Maine radar and to build three others elsewhere in the US to be equally capable.

"We need a great deal of experimental data from the tests to decide what we must do to get an adequate, dependable capability against the smaller targets," explains Anthony D. Salvucci, ESD's Assistant Deputy Commander for Strategic Systems. "We have to be confident we can see cruise missiles."

The partially functional OTH-B radar in Maine is the outgrowth of an experimental radar built there several years ago. It was designed to detect and track Soviet bombers, but not necessarily to be capable also of detecting and tracking the relatively small, low-flying cruise missiles that those bombers are now capable of launching at strategic standoff ranges.

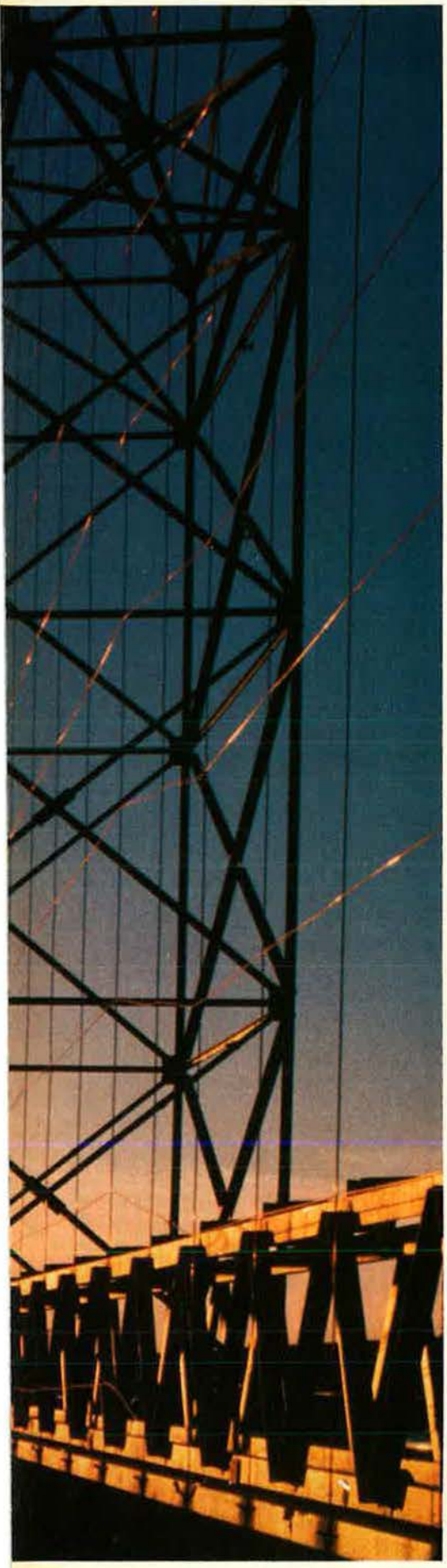
More Menacing Threat

The threat from those cruise missiles is much worse today than it was when the OTH-B radar was designed, and it will become even more menacing.

ESD must make sure that the Maine OTH-B radar, another one under construction in the far west, and a third and fourth destined for the central US and Alaska respectively, will be able to stay on top of the threat.

Attending to the cruise missiles—

Its gridwork glinting in the sunlight, a vast transmitter antenna of USAF's over-the-horizon backscatter (OTH-B) radar in Maine is inspected at dawn. Three such transmitter arrays near Moscow, Me., and three receiver antenna arrays near Columbia Falls, Me., will make up an OTH-B radar system capable of detecting bombers and cruise missiles coming at the North American east coast from 2,000 miles away.



those launched by submarines as well as those launched by aircraft—has prompted ESD to refine its original OTH-B radar design and to revamp its originally planned positioning of one of the OTH-B radar sites.

The OTH-B radar program is a major one among ESD's many undertakings to fulfill the command control communications and intelligence (C^3I) goals of the strategic modernization program promulgated by the Reagan Administration six years ago.

At that time, it had become alarmingly apparent that US strategic C^3I systems were all too vulnerable to attack, were spread far too thin, had scary gaps, and were, in some instances, only marginally capable. In consequence, programs to improve them were given top-priority status in the strategic modernization program.

Despite hitches here and there, USAF has come a long way toward meeting its goals in the weapons portions of that program. It has built and is deploying the Peacekeeper ICBM, the B-1B bomber, and the air-launched cruise missile (ALCM). It is well along in developing the small intercontinental ballistic missile (SICBM), the advanced technology bomber (ATB), and the advanced cruise missile (ACM).

However, USAF's progress in developing and deploying C^3I systems that are fundamental to strategic surveillance and communications "connectivity"—to making it possible for US commanders to get and stay in touch with retaliatory bomber and missile units during and after a nuclear attack—has been much spottier.

Notable examples of C^3 programs that have fallen behind schedule are the Ground Wave Emergency Network (GWEN), the Strategic Air Command Digital Information Network (SACDIN), terminals for receiving messages from Milstar communications satellites, and "miniature receive terminals" (MRT) for bomber radios.

All now seem to be making comebacks, however, even though their funding remains problematical from year to year and their full deployments will not take place until long after the dates originally envisioned in the strategic modernization program.

Full installation of the Maine OTH-B radar was deferred until ESD could certify to Congress that it will be capable of spotting and tracking cruise missiles. This has had a domino effect on the deployment of a full-up OTH-B radar network to provide blanket coverage of the eastern, western, and southern approaches to North America against atmospheric weapons.

Problems of integrating the final portion of the Maine OTH-B radar software, which is copious and complicated, have also caused delays. However, the prime contractor, General Electric, now seems to be on top of that problem, ESD officials say.

Col. James A. Lee, ESD's OTH-B system program director, predicts that the Maine radar will be ready for operation next year and that the OTH-B radar to cover the west coast—with elements in Idaho, California, and Oregon—"will be up and running, fully operational, by sometime in 1990."

About two years later, the new North Warning System (NWS) of fifty-two radar stations should also be completely operational. It will have replaced the thirty-one electronically geriatric Distant Early Warning (DEW) Line radars now extending from Alaska through upper Canada to southern Greenland.

The NWS radars and the OTH-B radars, overlapping in coverage at Labrador in the northeast and at the Aleutian Islands in the northwest, will work together to give North America by far the best—in fact, the only—early-warning webbing against air attacks it has ever had. This will enable the Air Force to take maximum advantage of the capabilities of its E-3 Airborne Warning and Control System (AWACS) aircraft and of its air defense interceptors, all operating in concert.

Those capabilities are also being upgraded. ESD is giving the AWACS radars extra shots of computing power and speed, thus enhancing their selectivity and sensitivity. Tactical Air Command is moving to build up its mixed fleet of air defense fighters with F-16As to be specially modified for the air defense mission.

The US is already in much better

shape than ever before to watch out for ballistic missiles, particularly those approaching over the seas.

Putting Pave Paws to Work

Operation of the last of four towering, sweeping Pave Paws phased-array radars positioned to catch sight of submarine-launched ballistic missiles to the east, south, and west was scheduled to begin last month near Goodfellow AFB, Tex. The first three Pave Paws radars went into operation in recent years at, consecutively, Otis ANGB, Mass., Beale AFB, Calif., and—just last year—Robins AFB, Ga.

Next year, the Air Force will increase the power and broaden the coverage of the Beale AFB and Robins AFB radars. The one at Robins will take over the satellite-tracking mission of the aged warning radar at Eglin AFB, Fla., which will then be shut down.

Having the Pave Paws radars fully in place is a profoundly comforting state of affairs for the US. They and the Perimeter Acquisition Radar Attack Characterization System in North Dakota now form a five-site phased-array cordon to catch submarine-launched ballistic missiles coming at the continent completely around the compass.

Until the Pave Paws radars began coming into play, the US had virtually no protection against surprise attack from such Soviet SLBMs. It also had some tense moments in that regard. Off and on, beginning in the late 1970s, Soviet Yankee-class ballistic missile submarines approached to within a few hundred miles of the US east and west coasts. At such range, without warning, they could have obliterated many US strategic bomber bases and strategic command and control centers almost before US commanders knew what was happening.

Now the Soviets have deployed submarine-launched ballistic missiles of such great range that their newer ballistic-missile subs can strike the US from nearly anywhere under the seas.

Many of the older Yankee-class boats now can carry cruise missiles instead of ballistic missiles, and they still cozy up to US coasts.

Things are looking up on other ballistic-missile monitoring fronts as well, with emphasis on guarding against ICBMs launched from inside the Soviet Union as well as against those launched from submarines near Soviet shores.

ABOVE: An Air Force operator keeps track of airborne traffic displayed in the OTH-B radar operations center at the Maine ANG base in Bangor. BELOW: E-3A Airborne Warning and Control System (AWACS) aircraft such as this will work with OTH-B radars and North Warning System (NWS) radars in the air defense mission.

Under an ESD contract, Raytheon, which built all the Pave Paws radars, was scheduled to have finished work this month on a new, two-sided phased-array radar at the US Ballistic Missile Early Warning System (BMEWS) site near Thule, Greenland. That new, electronically steered radar can do a vastly better job of detecting and tracking ICBMs than could the four detection radars and one tracking radar—all mechanically steered and comparatively sluggish—that it replaces.

ESD hopes to award a contract for a comparably modern, three-sided phased-array BMEWS radar at Fylingdales, England, later this year. In the meantime, it is planning to complete its long-planned upgrading of the BMEWS network by building a Thule-like replacement for the old BMEWS radar at Clear AFS, Alaska, beginning in 1989. There is a possibility that the new BMEWS radar destined for Alaska will be built at Eielson AFB instead.

Early-Warning Satellites

Without fanfare, the Air Force has been improving the performance and survivability of its newer early-warning satellites assigned to sentry duty in geosynchronous orbits against ballistic missile attack. It is also integrating sensors for detecting and locating nuclear blasts into its Navstar Global Positioning System (GPS) satellites, for which it is developing and acquiring dedicated space launchers.

Those sensors are extremely important to US strategic C^3I. In the event of a nuclear onslaught, US commanders would need to know

right away what got hit and what remained. Otherwise, lacking such capability for post-attack damage assessment, they would be left in the dark about which forces they had available for immediate retaliation and for continuing to wage war in the days, weeks, or months to come.

There is a problem, however, with getting the nuclear detection system (NDS) into space. The severe slowdown of the US spacelaunch program in the aftermath of the January 28, 1986, *Challenger* disaster forced USAF to scrap its original schedule for deploying the entire GPS constellation in space by the end of next year. That constellation, complete with NDS sensors, will probably not be operational until sometime in the early 1990s.

USAF's spacelaunch program is making a comeback, and ESD's strategic C^3 programs are also beginning to produce their long-sought systems. Next fall, ESD and its prime contractor, RCA, will begin testing the "thin line" of fifty-six tower relay stations, called nodes, which have now been installed as the initial portion of a much larger GWEN network.

GWEN, made up of fully automated transmitters and receivers, should be unaffected by electromagnetic pulse (EMP). It was conceived as such in order to relay last-ditch emergency-action messages

New systems for surveillance and communications should cut through the electronic density of modern battle.

Stronger Links for the Tactical Net

Piece by piece, Electronic Systems Division's programs are falling into place for tactical C^3I systems that would be able to cut the mustard in exceedingly dense electromagnetic combat environments.

Many such systems have been years in the making. Now they are beginning to show up in the field, affording US tactical air forces and ground troops the increasingly interconnected C^3I capabilities that will enable them to coordinate their firepower and bring it to bear more potently.

"We've been fortunate," says Matt L. Mleziva, ESD's Assistant Deputy Commander for Tactical Systems. "We have a number of new systems in the hands of the troops and more ready to go, and they're working well."

Within the next few months, for example, Tactical Air Command, US Air Forces in Europe, and Pacific Air Forces will begin using terminals and antennas that ESD developed to enable all their units everywhere to link up in a jiffy via satellite communications.

The main elements of this "quick-reaction" tactical system are a twenty-foot dish antenna built by Harris Corp. and two types of terminals—one embodying twenty-four communications channels and the other, seventy-two such channels.

The whole affair fits handily into airlifters and trucks, can be taken anywhere USAF operates around the world, and can be hooked up on the spot with cables from all kinds of field communications equipment. Now, for the first time, battlefield forces will be able to communicate with command posts and other forces continents away.

Less cosmic but no less important is the ultralow sidelobe antenna (ULSA) that Westinghouse is now producing for ESD. It will replace the curved, mesh antenna on USAF's main tactical surveillance radar—the "Tipsy 43" (AN/TPS-43E) of mid-1970s vintage. The ULSA is much harder to jam because, unlike the Tipsy 43, it radiates almost no stray—sidelobe—energy. By the same token, it is also much less vulnerable to radiation-homing missiles.

Thwarting such missiles is the goal of two other important ESD endeavors—the antiradiation missile (ARM) decoy program and the ARM alarm program. The ARM alarm is a pulse Doppler radar about the size of a kitchen chair that detects ARMs of small cross section coming in at high speeds. Sanders builds it, and its operational testing at Eglin AFB, Fla., was "absolutely superb," Mr. Mleziva says. "It detected every single target it was supposed to." Production will begin next November.

The ARM decoy is being developed by three competing contractors to simulate the signatures of US land-based radars and—when deployed at safe distances from them—to lead incoming ARM missiles to it instead of to them. Such decoys could be in production within two years.

A major development by ESD is new Modular Control Equipment (MCE) to bring USAF's ground-based Tactical Air Control System (TACS) into the late twentieth century. TACS, first deployed nearly twenty years ago, is shopworn. Built by Litton, state-of-the-art MCE hardware will soon replace the vintage equipment now in TACS control and reporting centers and posts, in message-processing centers, and in forward air control installations.

The MCE serves another crucial purpose as well, that of providing the hardware surroundings for USAF's Ground Attack Control Capability (GACC) program, a software development effort to enable TACS to control air attacks against mobile ground targets in real time. Modular control equipment will also make it possible for USAF to disperse its C^3 operations centers to make them harder to find and destroy.

Radios, without which tactical forces cannot make do, are big players in ESD's high-stakes C^3I arena. Procurement of Have Quick II UHF radios by Magnavox is in the immediate offing. They will be harder to jam than the original Have Quick radios are.

ESD's SINCGARS program to develop single-channel airborne and ground VHF radio system sets has been transformed from an also-ran into a winner, and production of such sets is now assured.

ESD has already moved into production much of the switching equipment and other gear developed in the joint services' TRI-TAC program, which was set up years ago to provide all-digital messaging capabilities.

As part of this, ESD's new digital troposcatter radios, built by Raytheon, provide point-to-point communications over a 150-mile range by bouncing signals off the troposphere. Tropo radios are replacing old analog radios that have far less range, perform desultorily, and are far from secure. More than 100 tropo radios have been delivered.

Meanwhile, the radio terminals that ESD prizes above all for their performance and strong resistance to jamming are doing exceptionally well. These are the Class II terminals for the Joint Tactical Information Distribution System (JTIDS).

In six months of operational testing through last April at Eglin AFB, the terminals produced "spectacular results," Mr. Mleziva says. The testing involved communications among four F-15 fighters, an AWACS aircraft, and an Army Hawk antiaircraft missile battery.

Built by Rockwell Collins and Singer Kearfott, the JTIDS Class II terminals are no bigger than bread boxes and are destined to be deployed initially on F-15Cs. Older, refrigerator-size Class I terminals are now aboard AWACS aircraft.

ESD is preparing to make JTIDS terminals even smaller—down to one-half cubic foot—by incorporating high-density microchips.

The Class II terminals are just about ready for production. A production decision is scheduled to be made this month.

from the national command authorities (NCA) to SAC bases and launch-control centers via ground-hugging, low-frequency radio waves—should EMP from nuclear bursts ever blink out all other means of sending such "go" messages.

In this context, the new ultrafast, supersecure SAC digital information network is also being deployed. Under ESD's supervision, the SACDIN prime contractor, ITT, and major subcontractor, IBM, had to overcome severe software problems in a system that can brook no computer-programming "bugs" whatever. SACDIN software is made up of a half-million lines of code, about one-fifth of which is described as "trusted code" of unimpeachable security and integrity.

Keeping bomber crews from going radio-deaf under nuclear and electromagnetic duress is also an imperative. To that end, Rockwell Collins is building miniature receive terminals for ESD that are designed to be all but impervious to nuclear effects and to jamming.

The first test of an MRT took place last spring aboard a SAC B-52, and "went just perfectly—we were absolutely delighted," declares ESD's Mr. Salvucci.

Indispensable to the C^3I segment of the strategic modernization program are the third-generation Defense Satellite Communications System (DSCS) III satellites being produced by GE and the Lockheed Milstar EHF satellites to be deployed later in this decade and well into the 1990s.

ESD is responsible for developing and acquiring Milstar terminals for aircraft of all US military services and for some Air Force ground stations as well as for "special customers." Its prime contractor is Raytheon, teamed with Bell Aerospace and Rockwell Collins in a leader-follower procurement arrangement.

Production of the Milstar terminals, each of which embodies fifteen black boxes and a variety of antennas, is scheduled to begin in 1991 or 1992. They will be much later and much fewer than originally planned.

In juggling its priorities under budgetary down drafts, the Air Force is having a hard time keeping the MRT and Milstar terminal programs in the air. Both have been buffeted in the US defense budget this year. As a result, ESD may be forced to renegotiate its MRT production contract and may be forced to pay much higher prices for far fewer terminals than it had planned.

ESD may also have to settle for only 200 or so Milstar terminals into the early 1990s, instead of the several thousand it had hoped to be able to acquire.

"I look on it as a crying shame," Mr. Salvucci asserts, "but there are many other Air Force programs taking the same kinds of cuts because the budget is getting tighter."

The Air Defense Initiative

Major money in the US defense budget is earmarked for the Strategic Defense Initiative (SDI) program that the Administration folded into its strategic modernization program four years ago. Subsequently, USAF inaugurated its Air Defense Initiative (ADI) program as a logical corollary to SDI. The reasoning behind ADI is that it makes little sense for the US to defend against ballistic missiles while at the same time neglecting defenses against bombers and cruise missiles.

ESD has prominent roles in the SDI and ADI programs. Its Rome Air Development Center (RADC) at Griffiss AFB, N. Y., is instrumental in developing new technologies that will be applicable to both.

Central to the ADI effort is ESD's Atmospheric Surveillance Technology (AST) program. It deals with the development of sensors that, in the future, will augment the OTH-B radars and the NWS radars as lookouts against bombers and cruise missiles.

An example of such a device is the Teal Ruby mosaic infrared sensor to be deployed in space. Teal Ruby had been scheduled for testing aboard the first Space Shuttle to be flown from Vandenberg AFB, Calif., last year, but never got up once *Challenger* went down.

Another ADI concept being pursued at RADC is that of space-based "sparse array" radars. Air Force Space Technology Center is working up concepts for passive and active "sparse aperture" infrared sensors that would also operate in space.

The Air Force has become much less vocal about its ADI program in recent months. One reason may be that much of the ADI technology work is aimed at offsetting possible Soviet advances toward stealthy bombers and cruise missiles and must be kept mum. Another reason, however, is that the Air Force does not want its futuristic ADI technology programs to detract from the here-and-now programs that ESD has in hand to improve the nation's atmospheric surveillance of Soviet air-breathing weapons.

It might be said that the OTH-B and NWS radars were the original ADI programs—long before there ever was an ADI. By its very nature, an OTH-B radar can pick up airborne targets far beyond the line-of-sight ranges of conventional radars, but it cannot detect such targets up close.

The transmitter antennas of an OTH-B radar send high-frequency signals up to the ionosphere, an atmospheric layer fifty to 250 miles above the planet's surface. Those signals are reflected and refracted back to earth as far as 2,000 miles from the transmitters.

When they strike airborne targets at any altitudes, they bounce back and follow return paths up to the ionosphere and down again to the radar's receiving antennas.

The Maine OTH-B radar is composed of three transmitting antennas and three receiving antennas. They are laid out as horizontal arrays, with the transmitter antennas stretching more than 3,500 feet and the receiving antennas nearly 5,000 feet.

The radar operates in the form of transmitter-receiver pairs, each pair covering a sixty-degree sector. Transmitters and receivers are separated by many miles so as not to interfere with one another, but are linked electronically.

With all three of its sixty-degree transmitter-receiver pairs in operation, the Maine radar will be able to sweep the skies in three sectors from the northern tip of Labrador to beyond the southern tip of Florida.

OTH-B Limitations

As grand as they are in range and sweep, however, the OTH-B radars cannot spot airborne objects within 500 miles of their transmitter sites. This means that cruise-missile submarines will be able to steal into

such "blind spots" to escape detection of their missiles by the Maine radar and the one to be built in the far west. This is why ESD plans to build an OTH-B radar nowhere near any US coastline, but in the north-central US, instead, with its operations center at Grand Forks AFB, N. D. Its signals will cover the US to the south and will also plug coverage gaps that the east coast and west coast radars leave, as it were, on their doorsteps.

The operations center, transmitting antennas, and receiving antennas of the Maine OTH-B are situated, respectively, at the Maine Air National Guard base in Bangor, near Moscow, Me., and near Columbia Falls, Me.

The operations center of the western OTH-B radar will be built at Mountain Home AFB, Idaho, with transmitters at Buffalo Flat, Ore., and receivers at Rimrock Lake, Calif.

The OTH-B radar to be centered in North Dakota will be made up of four transmitters and four receivers to enable it to cover 240 degrees. The Alaskan OTH-B radar will cover 120 degrees by virtue of two pairs of such sites. Its operations center is destined for Elmendorf AFB.

The performances and dimensions of all the antennas of all the OTH-B radars yet to be built will be dictated by the drone-penetration tests that ESD will begin running next winter against the southeastern sector of the Maine radar—the only sector now in operation.

Those tests, says Mr. Salvucci, will determine "how much farther we have to go in increasing the power of the transmitters or the sensitivity of the receive antennas, or both."

Teamed up with the OTH-B radars, the North Warning System will be made up of fifteen long-range radars, developed by GE in ESD's Seek Igloo program, that will require minimal operational attention, and of thirty-nine short-range radars, built by Sperry, that will be fully automated and require no tending at all.

The US and Canada have agreed to split the cost of acquiring the NWS on a sixty-forty basis. The NWS radars are needed to cover bomber and cruise missile approaches straight from the north. OTH-B radars cannot do that. Their ionosphere-reaching signals would be disturbed by the aurora borealis.

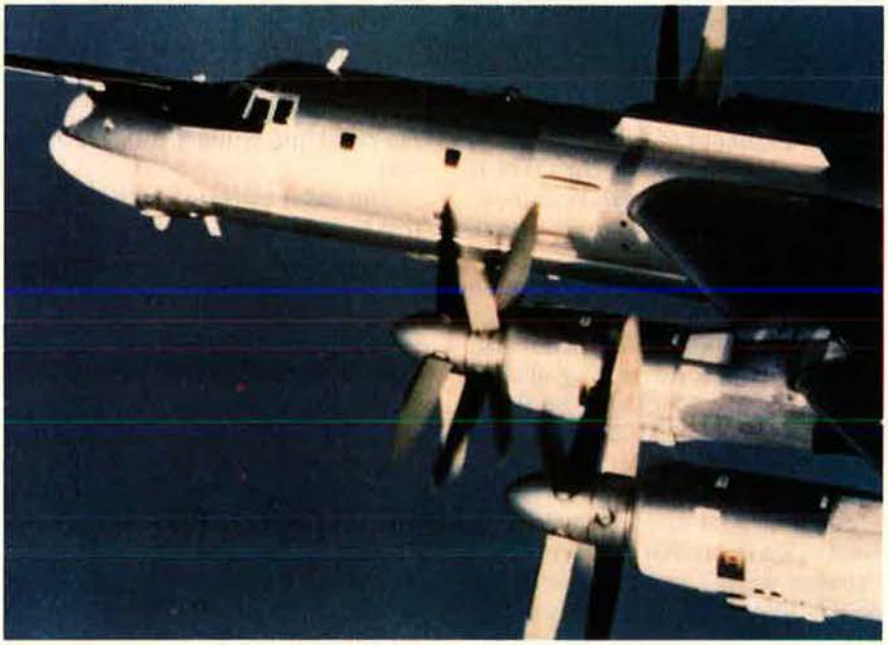
ESD's Colonel Lee notes that there may be occasions when the aurora borealis interferes with the northernmost sectors of the Maine OTH-B radar and the Alaskan OTH-B radar—"when it dips down our way during its rotation around the geomagnetic pole."

ESD can do nothing about that, but is satisfied, nonetheless, that its OTH-B and NWS radars will gird the continent tightly enough.

Those radars are urgently needed. The small, subsonic, low-altitude Soviet AS-15 cruise missile is worrisome indeed. With a range of about 2,000 miles, the AS-15 could be launched against US seaboard targets by bombers that would barely need to penetrate OTH-B radar coverage. The AS-15 is now deployed on Soviet Bear-H turboprop bombers and is expected to be carried on Soviet Blackjack jet bombers once they go operational, probably in 1988.

A submarine-launched variant of the AS-15 is in the late stage of development. Called the SS-NX-21, it is described in the 1987 edition of the Defense Department publication *Soviet Military Power* as "small enough to be fired from standard Soviet torpedo tubes" and as imminently operational.

Moreover, a larger, submarine-launched cruise missile—the SS-NX-24—"has been flight-tested from a specially converted Yankee-class nuclear-powered cruise missile attack submarine" and "could become operational by 1988," the publication says. ■



TOP: OTH-B radar operators in Maine pinpoint a potential airborne threat off the US east coast. Such threats are represented by the Soviet Bear-H turboprop bomber (above), which is capable of carrying small, low-flying AS-15 cruise missiles of 2,000-mile range. Soviet Blackjack jet bombers will also be able to launch AS-15s. USAF is making sure that the Maine OTH-B radar and others to be built elsewhere in the US will be up to the job of detecting them.

Technologies of Survivability:

From take-off to touchdown, TI airborne radar charts the safest course.

Next to his aircraft's power plant and flight instruments, a pilot's most valuable equipment for night/adverse weather operations is his radar system. It puts him on course, keeps him out of danger, helps him complete the mission sucessfully, then guides him home again safely.

Texas Instruments plays a leading role in this drama. Since 1959 TI has been the world leader in designing and manufacturing terrain-following radars (TFR), advanced TFR, multi-mode forward-looking radars, and navigation and attack radars. Today these radar systems are operating on a variety of U.S. Air Force, U.S. Navy and Allied aircraft.

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- RF-4C — AN/APQ-99 or AN/APQ-172 multi-mode, forward-looking radar for low level TF/TA and ground mapping.
- A-7 — AN/APQ-126 variable configuration TF/TA navigation and attack radar.
- F-111 — AN/APQ-171, an upgraded version of F-111 series TFR's with new transmitters and computer LRU components.
- Tornado nose radar — terrain-following, terrain-avoidance, ground mapping and attack targeting, with a digital scan converter advanced radar display.

All these current systems demonstrate TI's broad range of radar experience and technical development. And the future looks just as bright, with development programs such as solid state phased array (SSPA) and covert penetration radar. It's technology at work, enhancing flight crews' survivability.

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TEXAS INSTRUMENTS

What's Happening in Electronics at ESD

A CHECKLIST OF MAJOR ELECTRONICS PROJECTS

(As of March 31, 1987)

NAME AND MISSION	STATUS	CONTRACTOR
Deputy Commander for International Programs (FA)		
Egyptian Air Defense System Engineering and management assistance to the Government of Egypt Air Defense Command in integration of air defense system components into a homogeneous C^3 system.	Ongoing	MITRE
Japanese BADGE Engineering technical support to the Japan Air Self-Defense Force for the Base Air Defense Ground Environment (BADGE) upgrade.	Ongoing	MITRE
Royal Saudi Air Force Alternate Command Operations Center (ACOC) Acquisition of a Royal Saudi Air Force Alternate Command Operations Center. The Center will use commercially available equipment and software.	Complete	Hughes Aircraft Co.
Royal Saudi Air Force C^3 System (PEACE SHIELD) Acquisition of a ground command control communications system for the Royal Saudi Air Force. The system includes equipment, facilities, and support elements to interface existing tactical radars, the Saudi E-3 AWACS, and elements of other Saudi military organizations.	Acquisition	Boeing; General Electric
Royal Thai Air Defense System Automation and upgrading of the existing Royal Thai Air Force (RTAF) Air Defense System and upgrading and expansion of its supporting long-haul communications network.	Development and Acquisition	System Development Corp.
Somali Command Control and Communications Programs (PEACE CUBE) Activation of the Somali Ministry of Defense Command Center, installation of large-screen display as well as local and long-haul communications subsystems, and repair/overhaul of radar systems.	Acquisition	Contel Page Systems
Sudan Air Defense System Reengineering and repair of air defense radars and acquisition of communications equipment and support equipment.	Acquisition	EG&G
Turkish Air Defense Master Plan Evaluation of requirements and resources and preparation of a plan for modernization of the Turkish Air Defense System.	System Definition	None
Deputy Commander for Intelligence and C^3CM Systems (IC)		
COBRA DANE Upgrade COBRA DANE, a land-based phased-array radar at Shemya AFB, Alaska, provides intelligence and space-track data to a variety of users and has a tertiary early warning mission. This upgrade will replace the aging computers and software in the system as well as improve data-collection and processing capabilities.	Concept Definition	None
COMFY SWORD A ground-based jamming and deception system for training friendly aircrews to operate in a hostile electronic environment.	Production	Tracor
C^3 Countermeasures Support Data Base A C^3CM Support Data Base under construction to support Compass Call. The data base will also be used for studies and simulation. It will be made generally available to DoD users involved with electronic combat.	Continuing	PRC; ISN Corp; BETAC Corp.
C^3CM Advanced Systems Objective of this program is to coordinate the development and testing of concepts and technologies necessary for an integrated C^3CM capability, concentrating on identifying voids in C^3CM capabilities and ensuring the technology is available to fill those voids. Major project areas are C^3CM exploitation, high-power microwave, battle management, electronic jamming, and C^3 jammers.	Conceptual	Many
Intelligence Work Station (IWS) Intelligence Work Station (IWS) is a joint ESD/RADC project designed to replace the present standard intelligence terminal, the OJ-389. The modular, upgradable, standalone IWS will perform message handling, data base update, and mapping for intelligence users worldwide.	Production	Eaton
Interface Processor for Imagery Exchange (IPIX) This is a hardcopy imagery dissemination system using the tactical digital facsimile equipment being developed by ESD under the TRI-TAC program. The IPIX program allows the tactical air forces to transmit photographs and other intelligence information rapidly to high-priority users via electronic means.	Development/ Production	Litton Amecom
Joint Service Imagery Processing System A ground station for the integration of a deployable capability for multisensor, multispectral receipt, processing, exploitation, and dissemination of national, strategic, and tactical imagery and related intelligence reports to combat commanders. This includes the Advanced Tactical Air Reconnaissance System, a tactical software imagery exploitation system to support the upgrade of the RF-4C and future tactical reconnaissance platforms.	Acquisition	General Dynamics; E-Systems; Lockheed
Joint Tactical Fusion Program Evolutionary joint development and acquisition of the Air Force Enemy Situation Correlation Element and the Army All-Source Analysis System. The systems will exploit to the greatest possible degree hardware and software commonality and intensive interoperability.	Development	Jet Propulsion Lab
Sentinel Aspen This program will provide a General Imagery Intelligence Training System (GIITS) for Air Training Command. This generic trainer incorporates computer-aided instruction to prepare imagery analysts for operational hardcopy and softcopy exploitation systems.	Development	Goodyear Aerospace
Sentinel Bright I This program is to design, develop, and acquire a voice-processing training system that features 460 workstations for the training of cryptologic linguists.	Development and Acquisition	Engineering Research Associates

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Sentinel Bright II This effort will design, develop, and acquire a classified training system that will use 275 workstations and an unclassified training system that will use 113 workstations. These will be used to train operators, analysts, and maintenance technicians for modern operational cryptologic systems.	Definition	AAI; American Systems Corp.
Sentinel Byte Intelligence initiative-conceptual concept/prototype for unit-level automation for tactical air forces. Primary focus is on intelligence support, C^2, and functions at operational units.	Conceptual	None
Deputy Commander for Joint STARS (JS)		
Joint Surveillance Target Attack Radar System (Joint STARS) An Air Force/Army program to provide battlefield commanders with real-time data to identify the disposition of enemy ground forces and assess their intentions. This force-multiplication system consists of an airborne segment on board an E-8A (modified Boeing 707-300) aircraft with the ability to detect, track, classify, and direct weapons against stationary or slow-moving ground targets and a mobile ground segment with the ability to display and pass data through appropriate command and control nodes.	Development	Grumman (prime); Norden; Boeing; Cubic
Strategic Defense Initiative Office (MD)		
Strategic Defense Initiative Research This program supports the Presidentially mandated research effort for a ballistic missile defense. Work includes concept investigations to define Battle Management/C^3 and to initiate experiments for validating promising concepts and their associated technologies. Additional work as the lead organization for the National Test-Bed Joint Service Program Office includes support to design and implement a National Test-Bed environment for system and Battle Management/C^3 evaluation and verification.	Planning	Infotech; IBM; Ford Aerospace; McDonnell Douglas; Bolt, Beranek and Newman; GTE; H. H. Aerospace Design; MITRE
Deputy for Product Assurance and Acquisition Logistics (PL)		
Electronic Sector (Pursuit 2000) A continuing analysis project intended to identify projected needs for Air Force actions regarding the electronics sector of the US industrial base. Electronic Systems Division is pursuing this effort under assigned responsibilities as the AFSC electronics sector manager.	Continuing	General Research Corp.
GET PRICE A program to reduce the production cost of Air Force electronic command control communications systems by encouraging contractor capital investment in modern technology. Increased productivity and improved product quality are key objectives. Contractor direct and indirect manufacturing areas are analyzed; specific, required manufacturing technologies are demonstrated; and capital investment incentives for new technology acquisition are negotiated.	Continuing	Hazeltine; Rockwell Collins; Singer Kearfott; Westinghouse Electric Co., Defense & Electronic Systems Center; General Electric Co., Electronic Systems Div.; GTE Sylvania; Raytheon; Magnavox; Boeing; Bell; Grumman
Deputy Commander for Strategic Systems (SY)		
Aircraft Alerting Communications EMP (AACE) Upgrade Program The AACE Upgrade Program is to provide assured, electromagnetic pulse (EMP) hardened, end-to-end communications from the Commander in Chief of Strategic Air Command (CINCSAC) to his alert aircraft forces. It will also provide CINCSAC and the SAC Main Operating Base (MOB) Commanders with indications of an EMP event so that appropriate actions may be taken.	Full-Scale Development	BDM Corp.
Alternate Space Defense Operations Center The Alternate SPADOC will perform a critical portion of the functions of the SPADOC in the event that a natural disaster or emergency causes a SPADOC failure. Alternate SPADOC will be an austere facility.	Conceptual	Ford Aerospace and Communications Corp.
Attack Warning Processing and Display System (AWPDS) The AWPDS, a small, intelligent processing and display system, will receive fused data directly from the NORAD Fusion Centers (Cheyenne Mountain Complex and NORAD-Offutt) and data, both discrete and summary messages, direct from selected ballistic missile sensor systems via the Survivable Communications Integration System (SCIS). There will be fixed, ground-mobile, and airborne versions of the AWPDS.	Conceptual	None
Berlin Radar System This program will modernize the Berlin Air Route Traffic Control System by consolidating air traffic control operations at Tempelhof Central Airport, by replacing the current long-range radar system with a modern 3-D AN/FPS-117 radar, and by automating the associated operations center.	Deployment	Sanders Associates; General Electric
BMEWS Modernization Program Upgrade of the two operational sites (Greenland, England) operated by Air Force Space Command and the Royal Air Force. The existing BMEWS radar in Greenland is being replaced with a modern, solid-state phased-array radar. Replacement of the radar in England with a solid-state phased array is scheduled to begin in 1987. The modernization of the radar in Alaska is being planned. These new radars will meet the threat in the 1990s.	Acquisition	Raytheon Co., Equipment Div.
Command Center Processing and Display System Replacement (CCPDS-R) As part of the ballistic missile warning network, CCPDS-R will receive warning information from ballistic missile sensors and determine if a threat exists. This system will produce integrated warning and attack assessment displays for the Cheyenne Mountain Complex and Hq. SAC and integrated warning information to other designated military command centers.	Entering Full-Scale Development	None
Communications System Segment Replacement (CSSR) Improvement of the reliability, capacity, maintainability, and flexibility of the Cheyenne Mountain Complex communications processing function by replacement of the Communications System Segment (CSS) acquired through Program 427M. The CSS handles message processing, formatting, technical control, line code conversion, and routing of internal and external messages.	Full-Scale Engineering Development	GTE Communications Systems Div.

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Deep Space Warning Radar (DSWR) DSWR will provide surveillance and warning information on our critical synchronous-altitude space assets. DSWR will be a standalone radar system with an interface directly to the NMCC.	Conceptual	None
Diversity Reception Equipment (DRE) The Diversity Reception Equipment will provide improved low-frequency communications capability for the Worldwide Airborne Command Post fleet. Improvements will include a new transmit processor and new receivers. Resulting improvements in operational capability will include reduced message delivery time, enhanced survivability, and interoperability with the Navy's low-frequency network.	Full-Scale Development	Sonicraft
E-4 Airborne Command Post A survivable Airborne Command and Control System that will operate under the direction of the National Command Authorities and the Commander in Chief, Strategic Air Command, during the pre-, trans-, and postattack phases of a nuclear war. Used by OJCS/NEACP with Offutt AFB as the main operating base, the E-4B is a survivable emergency extension of NMCS and SAC ground command and control centers and provides high confidence in US ability to execute and control SIOP forces in a nuclear environment. ESD's current effort is directed toward upgrading the SHF communications to ensure aircraft compatibility with the existing and evolving Worldwide Military Command and Control System (WWMCCS).	Full-Scale Development, Production/Operational	Boeing Aircraft Co.
FAA/Air Force Radar Replacement (FARR) This program is a joint FAA and USAF effort to replace 1950s' technology, two-dimensional surveillance and height-finding radars with forty-seven modern, highly reliable, unattended three-dimensional radars. Forty-four radars will be located in CONUS, one will be used for training at the FAA Academy, and one each will be located on Guam and Hawaii. Once fully operational, the FAA will operate and maintain all sites, thus relieving TAC of 1,000 manpower requirements.	Conceptual/ Development	None
Ground-based Electro-Optical Deep Space Surveillance System (GEODSS) The GEODSS system will extend Air Force Space Command's spacetrack capabilities for detecting and cataloging space objects in the 3,000–20,000-nautical-mile range. This will be a global network of five sites to detect, track, and identify satellites optically in earth orbit. Four sites are operational; one is planned for Portugal.	Deployment	TRW Inc.
Ground Wave Emergency Network (GWEN) GWEN will provide US strategic forces with the ability to maintain critical CONUS long-range command and control communications connectivity despite atmospheric disturbances from a high-altitude nuclear burst. Communications continuity is achieved primarily by proliferated relay nodes using unmanned, ground wave radio equipment. Strategic forces units, equipped with compatible radio equipment, will interface with nearby nodes for participation in the overall network.	Fabrication/ Deployment	RCA
Milstar SATCOM System (USAF Terminals) Reliable, jam-resistant, survivable EHF satellite communications for the three services' tactical and strategic users is being developed. A common transmission format will be employed to provide for interoperability among the services. ESD is responsible for developing communications terminals for airborne platforms. As part of this development, the current AFSATCOM system is being upgraded to provide a transition for the SIOP forces from UHF to the EHF frequencies of Milstar.	Full-Scale Development	Raytheon Co., Equipment Div.
Miniature Receive Terminal (MRT) The MRT will provide highly survivable low-frequency communications from CINCSAC and the National Command Authorities (NCA) to the SAC bomber force. The MRT will employ diversity combining, jammer nulling, and advanced message-processing techniques to assure Emergency Action Message (EAM) connectivity in a hostile environment. Technical challenges include hardware miniaturization and implementation of embedded software using the Ada language.	Full-Scale Development	Rockwell Collins
NORAD-Offutt Terminal NORAD-Offutt will provide a geographically separated command center as a backup to the existing NORAD command center at the Cheyenne Mountain Complex. The NORAD-Offutt command center will be capable of performing all critical wartime attack warning/attack assessment C^3I functions necessary for CINCNORAD to complete the AW/AA mission in a HEMP-stressed environment.	Conceptual	None
North Atlantic Defense System This provides Air Forces Iceland with a modern surveillance and command control communications system that will enhance its ability to carry out its NATO mission of Icelandic air defense. An interim, stopgap system is now being installed to be operational in 1988. In 1989–90, modern, minimally attended, three-dimensional radars will replace aging radars. In 1992–93, a state-of-the-art, automated command control system will be operational.	Development/ Deployment	Hughes Aircraft; Techdyn Systems
North Warning System The North Warning program will replace the current DEW Line with a combination of long- and short-range radars for contiguous coverage from the northern slopes of Alaska across Canada and down the east coast of Labrador. Thirteen long-range radars and thirty-nine unattended gapfiller radars will be required. A new communications network will link the North Warning sensors with the Canadian and Alaskan JSS ROCCs.	Full-Scale Engineering Development/ Production	General Electric; Sperry Electronic Systems
Over-the-Horizon Backscatter (OTH-B) Radar A series of four radar systems to provide long-range tactical early warning and attack assessment of air threats approaching North America. The 180-degree-coverage East Coast Radar System is in final production, and the 180-degree West Coast Radar System began production in 1986. The environmental impact analysis process and site selection for the 240-degree-coverage Central Radar System and the 120-degree-coverage Alaskan Radar System will be completed this year to support production beginning in FY '88 and FY '89, respectively.	Full-Scale Engineering Development/ Production	General Electric Co.; SRI
PAVE PAWS Primary mission of PAVE PAWS is credible warning and attack characterization of sea-launched ballistic missiles penetrating the PAVE PAWS coverage. The warning and attack characterization data includes estimations of launch and impact points and times. Radars are operational at Otis ANGB, Mass., Beale AFB, Calif., and Robins AFB, Ga. The fourth is under construction near Goodfellow AFB, Tex.	Operational/ Full-Scale Engineering Development	Raytheon Co., Equipment Div.
SEEK IGLOO Replacement of all thirteen Air Force long-range radar sites in Alaska with solid-state, highly reliable radars that provide range, azimuth, height, and beacon data on all detected targets. Implements a minimally attended radar concept: maintenance by not more than three medium-skill radar technicians and no on-site radar operators. A major objective is a large-scale reduction in the life-cycle cost of Alaskan radar surveillance systems.	Deployment	General Electric Co.

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Space Defense Operations Center (SPADOC) SPADOC, to be located in the Cheyenne Mountain Complex, is the central command control communications and intelligence element of the Space Defense Command and Control System. It will consist of new ADPE, displays, interface equipment, software, and communications upgrades. It will act as the focal point for higher-echelon command and control and disseminate space-related information to other US commands. SPADOC will collect and disseminate real-time information on space status, warning, and operations direction.	Full-Scale Development	Ford Aerospace and Communications Corp.
Strategic Air Command Digital Network (SACDIN) A program to modernize Strategic Air Command's control and communications systems from both the operational and maintenance standpoints. SACDIN will provide two-way, direct, secure data communications with enhanced survivability from the National Command Authorities to the nuclear strike forces through the Commander in Chief, SAC. It will replace parts of the SAC Automated Command and Control System.	Production	ITT, Defense Communications Div.
Survivable Communications Integration System (SCIS) The Survivable Communications Integration System (SCIS) is a multimedia management and control system for missile warning data passing between sensor sites and the command authorities. The SCIS will receive and transmit critical message traffic simultaneously over all available communications media, thus ensuring that the most effective communications media is transmitting in any operational environment.	Full-Scale Development	E-Systems
World Wide Airborne Command Posts (WWABNCP) Replacement Program Replaces the existing EC-135 WWABNCP fleet with new aircraft and new command control communications systems. The WWABNCP fleet provides the Commanders in Chief (CINCs) of the military theaters worldwide with a survivable command post to direct their forces during the conduct of a general war.	Conceptual	None
WWMCCS Information System (WIS) This command and control system is directed to provide deliberate and crisis planning and execution aids to the National Command Authorities and specified and unified commands. Planned for completion in the post-1993 time frame, it will replace the current World Wide Military Command and Control System (WWMCCS) hardware and modernize and enhance its software. WIS encompasses technologies in local area networks, automated message handling, intelligent workstations, modern processors, data base management, and multilevel security systems. WIS is also a forerunner in the use of Ada for software applications and systems.	Acquisition/ Development	GTE Government Systems Corp.
Deputy Commander for Tactical Systems, JTIDS, and AWACS (TC)		
Airborne Warning and Control Systems (AWACS) *E-3 Airborne Warning and Control System (AWACS):* This system provides survivable airborne air surveillance capability and command control communications functions. Its distinguishing technical feature is the capability to detect and track aircraft operating at high and low altitudes over both land and water. Used by Tactical Air Command, with Tinker AFB, Okla., as the main operating base, these aircraft may deploy throughout the United States and overseas to provide surveillance, warning, and control in a variety of peacetime and wartime situations. Major upgrades now under way or being planned include additional sensors, antijam communications, radar system upgrades, and mission and flight simulator system advances.	Acquisition and Operational	Boeing; Westinghouse
NATO E-3: Acquisition of E-3 Sentry aircraft for the North Atlantic Treaty Organization (NATO), with special modifications to meet NATO requirements. Currently planned upgrades include additional sensor techniques undertaken in a unique cooperative R&D program with the United States.	Acquisition and Operational	Boeing; Westinghouse
Saudi Arabia E-3/KE-3: This effort involves development and acquisition of five modified E-3s and eight derivative tankers to fulfill United States government commitments to the Saudi Arabian government.	Development and Acquisition	Boeing; Westinghouse
AF Joint Interoperability of Tactical Command and Control Systems (JINTACCS) JINTACCS is a JCS-directed joint program to improve the operational effectiveness of the services' tactical C^2 systems used in support of joint tactical operations through the 1980s. JINTACCS is developing and testing the interoperable system architectures and is standardizing message structure, message language, and operation procedures employed in both computer-to-computer and person-to-person systems. The USAF program ensures that Air Force requirements are reflected in the developed and tested standards.	Acquisition/ Development	None
Airborne Battlefield Command and Control Center (ABCCC) III The ABCCC III will give the tactical air forces an automated airborne command and control system in the forward battle areas for offensive air support operations and an on-scene command center for special operations. The system will include an automated tactical battle management and display system, a communications switching system for internal/external voice and data distribution, recording, and playback, teletype systems, and cryptographic equipment.	Development	None
Caribbean Basin Radar Network A new program to upgrade US air surveillance and communications capability in the Caribbean basin. Data from a variety of geographically separated radar sites will be transmitted via land/satellite-based communications links to US-owned C^3 centers. These enhancements will improve, at a minimum, USSOUTHCOM's and USLANTCOM's ability to perform air surveillance and search-and-rescue missions.	Acquisition	None
Central Command and MAC Imagery Transmission System (CITS/MITS) A hardcopy imagery dissemination capability for US Central Command and Military Airlift Command for rapid transmission and receipt of reconnaissance and intelligence material via electronically secure communications networks.	Production	No commercial contractor (Tobyhanna Army Depot)
Combat Grande II Assistance to the Spanish Air Force for development and modernization of Spain's air defense system. This includes improvements in the areas of command and control, surveillance, communications, and operations and maintenance. Interoperability with NATO air forces will also be provided.	Acquisition	Hughes Aircraft Co.
Combat Identification System—Indirect Subsystem (CIS-ISS) A joint program to develop and deploy a worldwide, NATO-compatible system for accurate and timely target identification for battle commanders and weapons controllers. The program objective is to develop automated correlation and fusion of information from multiple ID sources and to develop a tactical electronic support measures (ESM) sensor to serve as a high-quality source of aircraft identification information.	Pre-Full-Scale Development	None
Communications Nodal Control Element (CNCE) The CNCE is a segment of the TRI-TAC family of ground-based tactical digital communications equipment. The CNCE is a technical control facility used at communications nodes to provide performance monitoring of communications equipment, rapid restoral capability for essential communications in the event of failure or	Production	Martin Marietta Aerospace

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battle damage, and the capability when deployed to reconfigure communications assets rapidly to meet changing user requirements.		
Digital BRITE (D-BRITE) The D-BRITE program will replace existing Air Force BRITE II display systems with new, more reliable equipment that can display alphanumeric beacon data, including Mode C altitude information.	Acquisition	Systems Development Corp.
Digital European Backbone Incremental upgrade of portions of the European Defense Communications System (DCS) from a frequency-division multiplex (FDM) analog system to a time-division multiplex (TDM) digital system with higher-reliability components. This will provide modern, wideband, digital communications with encryption capability and increased channel capacity over the current analog system.	Acquisition and Deployment	None
Digital Nonsecure Voice Terminal (DNVT) The DNVT is a low-cost, nonsecure digital telephone instrument that will interface directly with the TRI-TAC Army circuit switches to satisfy a variety of user needs and TRI-TAC system architectural requirements. The TA-954-( )-TT DNVT is a "ruggedized" model designed for field use.	Production	General Atronics Corp.
DoD Base and Installation Security Systems (BISS) An evolutionary RDT&E program to provide a DoD-standard electronic exterior physical security system for protecting DoD resources worldwide. The system's components include detection, assessment, entry control, and command and control equipments. The system concept emphasizes maximum commonality of major items and a variety of supporting subsystems. It offers a flexible choice of equipment (USAF developed/commercially available) that must be tailored to the unique physical characteristics of the location and to the threat.	Development	Many
Enhanced Ultra Low Sidelobe Antenna (ULSA) Modification Kit The Enhanced ULSA Modification Kit is an electronic countermeasures and performance improvement to the AN/TPS-43E Tactical Radar System. The installation of the modification kit makes the radar more resistant to enemy ECCM, increases the radar's range and sensitivity in both jamming and clutter environments, simplifies radar operation, adds monitoring and fault-isolation capabilities, improves the accuracy of the radar's height measurements, increases the survivability of the system in the event of an antiradiation missile attack, and provides reliability and maintainability improvements.	Production	Westinghouse
Ground Mobile Forces Satellite Communications (GMFSC) Terminal Program The GMFSC program provides the tactical air forces with highly mobile satellite communications terminals. The program will also provide equipment to Air Force Communications Command for support of rapid deployment forces and Air Force contingency missions. The GMF program is multiservice, with the Army as lead service. The GMFSC terminals operate through the Defense Satellite Communications System (DSCS) satellites located in synchronous orbits for continuous worldwide coverage.	Development, Acquisition, and Production	RCA; Lincoln Laboratory; Raytheon Co.
HAVE QUICK II A follow-on improvement to the HAVE QUICK modification program, HAVE QUICK II will improve the jam resistance of HAVE QUICK against the evolving threat and will also improve the operational utility of the radio.	Development/ Production	Magnavox
HAVE SYNC This program is to develop airborne SINCGARS systems for jam-resistant, secure, tactical VHF/FM/AM voice communications that will interoperate with the US Army-developed equipment and be a direct form, fit, and functional replacement of the AN/ARC-186 radio. Also, ground SINCGARS systems for jam-resistant, secure, tactical VHF/FM voice communications will be acquired from the US Army.	Development	ITT, Aerospace Optical Div.
JINTACCS Automated Message Preparation System (JAMPS) JAMPS is a program that will improve the generation and transmission of text messages through the use of stored templates, for which only a minimum number of variable entries need to be provided. The templates consist of a large number of specific action messages covering the many different kinds of actions that can only be interpreted by human operators. The variable entries identify particular agents, times, objectives, and the like.	Development	None
Joint Tactical Communications (TRI-TAC) Acquisition of ground-based tactical digital communications equipment for the multiservice area under the auspices of the DoD Joint Tactical Communications (TRI-TAC) program. This includes all trunking, access transmission, and switching equipment for mobile and transportable tactical multichannel systems, associated systems control and technical control facilities, local distribution equipment, and voice, record, data, and ancillary terminal and COMSEC devices.	Definition, Acquisition, Production, and Deployment	Martin Marietta; Raytheon Co.; General Atronics Corp.
Joint Tactical Information Distribution System (JTIDS) A program to develop a high-capacity, reliable, jam-protected, secure digital information distribution system that will enable a high degree of interoperability among data-collection elements, combat elements, and command and control centers within a military theater of operations.	Full-Scale Development/ Production	Hughes Aircraft Co.; Singer Kearfott; IBM, Federal Systems Div.
MCE Pre-Planned Product Improvements (P^3I) Several enhancements will be implemented in the MCE in order to optimize operation with the entire TACS community. The P^3I program will provide a capability to control air attacks against time-sensitive (moving and stationary) ground targets through a Ground Attack Control Capability (GACC), develop the capability to interface with the Joint Tactical Information Distribution System (JTIDS), add an antijam (AJ) communication capability (SINCGARS), update the Air Tasking Order in the MCE data base, and develop interfaces with the Ground Mobile Forces Satellite Communications System.	Development	None
Microwave Landing System (MLS) This four-part DoD program will develop, test, and produce landing systems to replace the existing Instrument Landing System (ILS) and Precision Approach Radars (PARs). Mobile MLS will provide tactical ground systems to support MAC/AFCC wartime missions. Fixed-base MLS will procure FAA-developed ground systems for DoD bases worldwide. ESD will obtain modified civil avionics for cargo, tanker, and transport aircraft and a militarized version for most other aircraft types.	Development	None
Military Airspace Management Systems (MAMS) MAMS will provide a system to manage and record utilization of DoD special-use airspace for the entire CONUS Operational Area. The proposed system will interface with the National Airspace System through the Federal Aviation Administration's Air Traffic Control Facilities.	Conceptual	None
Modular Control Equipment (MCE) The MCE is a transportable, modularized, software-intensive automated air command and control system. It will interface with the AN/TPS-43E radar for local area air surveillance and other TACS elements via tactical	Development	Litton Data Systems

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data links for remote sensor data. The MCE will replace elements of the 407L system located at the combat reporting center and forward air control posts. The system will dramatically improve operational capability and provide reliable and survivable operations into the twenty-first century.		
NATO Air Base SATCOM (NABS) Terminal Program The NABS terminals will enhance the survivability of critical wartime communications between and among NATO Air Operations Centers (AOCs) and allied airfields where USAF elements would deploy in their NATO wartime role.	Acquisition and Production	None
New Mobile Radar Approach Control (NMR) This program will provide a rapidly deployable Air Traffic Control (ATC) Radar System for forward operating locations in wartime environments. The program will develop a Mobile ATC Operations Shelter to be integrated with a Navy-acquired Tactical Surveillance Radar to provide quick restoral RAPCON services at main operating, bare base, and other contingency airfield operations worldwide.	Full-Scale Development	Sperry
Salty Net '82 The Salty Net '82 program provides a digital data link between the US Army Air Defense Command Center (AN/TSQ-73) and the German Air Defense Ground Environment (GEADGE) system on a short-term basis. The Buffer was developed in 1976 to accept, translate, and transmit air surveillance messages automatically between the US Tactical Air Control System (407L) in Germany and the European Command and Control Centers, which used the NATO 412L and NADGE systems.	Deployment	None
Surveillance Restoral/Tower Restoral Vehicles (SRV/TRV) The ATC program includes quick restoral equipment for control towers and surveillance capabilities to improve AFCC's ability to continue air traffic control services at USAF combat operating bases during a conventional war.	Development	None
System Trainer and Exercise Module (STEM) The STEM is a deployable trainer and exerciser utilized to train CRC/CRP AN/TSQ-91(v) operations personnel in various mission functions. The STEM will provide capability to prepare exercise scenarios containing simulated flights of aircraft performing various types of tactical missions.	Deployment	GTE Communications Systems Div.
Tactical Digital Troposcatter Radio Terminal A family of tactical digital troposcatter radio terminals to provide secure transmission and reception of analog and digital voice and digital data by means of line-of-sight and tropospheric modes of propagation over distances up to 200 miles.	Production	Raytheon Co.
USAF SAFE Program Procurement and deployment of DoD BISS program-developed and commercially available physical security equipment to approximately seventy USAF bases and 210 sites worldwide. These systems will protect such mission-critical/high-value resources as stored weapons, strategic/tactical alert aircraft, open- and closed-sheltered alert aircraft, special mission aircraft located on parking areas, specified command posts, and other specifically identified strategic resources.	Procurement/ Deployment	RACON; Morse Products; Aritech Corp.; Vindicator Corp.; Stellar Systems; Support Systems Associates; Sygnatron Protection Services; TERA Advanced Services; Analytical Systems Engineering Corp.; Canadian Commercial Co.
Weapons Storage and Security System RDT&E and production planning to provide dispersed, unattended, tactical nuclear weapons storage. Weapons will be collocated with tactical aircraft in hardened vaults beneath the floors of closed aircraft shelters.	Development	None
Deputy Commander for Development Plans and Support Systems (XR)		
Advanced Communication Development Planning Support This supports with communications planning such programs as "stealth" platforms, the National Aerospace Plane, and small/mobile missiles. Numerous other Vanguard mission area requirements are also included. Planning is both short-term and continuous to develop effective and survivable command and control communications in support of Air Force missions.	Planning	MITRE
Advanced Tactical Battle Management This effort will develop the Sensor Network Management Processor Software Prototype and a distributed data base design for the Tactical Air Control System. This program also investigates interoperability issues of tactical C^3I systems.	Planning	MITRE
Air Defense Initiative ADI provides for the demonstration of technologies for full-scale development of a future survivable air defense system for deployment in the late 1990s. ADI is directed at technologies to counter the cruise-missile and future low-observable, advanced-technology threats. Although it encompasses the functions of surveillance, engagement, and command and control, the paramount technology thrust is for broad area surveillance, particularly for assured tactical warning and attack assessment.	Conceptual	IBM, Federal Systems Div.; Syracuse Research Center; Alphatec; TRW, Space & Technology Group; Sensis Corp.; Eaton Corp.; Sparta; General Dynamics, Pomona; General Dynamics, Ft. Worth; ITT; Verac; TASC; General Dynamics, Huntsville; Lockheed
Air Force Tactical Shelter Systems Development Office (AFTSSDO) Air Force representative to the Joint Committee on Tactical Shelters. This office provides tactical shelter expertise to more than fifty USAF programs requiring shelterization and conducts research and development on shelters and shelter support, including specialized pallets and wheeled jacks for aircraft loading and chemical-biological protection.	Development/ Acquisition	Chamberlain Manufacturing Corp., Gard Div.

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Air Logistics Center Local Area Networks The largest local area network in the world, it will support 6,000 users at each of five ALCs for a total of 30,000 users. The systems will be interconnected between ALCs and AFLC Headquarters over the Defense Data Network.	Deployment	TRW Defense Systems Group
Alaskan HF Networking Demonstration An eleven-node HF networking and demonstration using Pacer Bounce radios, adaptive controllers, Z-150s, and ESD-generated software. Demonstration will show improved message throughput via networking and automatic frequency selection.	Continuing	Harris Corp.; MITRE
Assured Logistics Communications This will improve the probability of logistics information transfer within areas of conflict and between areas of conflict and AFLC. The system will access redundant modes of communication (DDN, Public Data Network Radio Satcom, etc.) and will exploit message/packet-switching and protocol-transfer technologies with applicable equipment in order to meet wartime or other stressed logistics information requirements.	Development	None
Automated Tactical Aircraft Launch and Recovery System (ATALARS) Development of a system to automate air traffic control and integrate aircraft systems. Benefits of future integrated ATC promise automated flight-guidance capabilities through complex air defense corridors and zones. ATALARS will be able to control many independent landing locations simultaneously, integrate battle management systems, and remove a major portion of ATC from the fixed ground-based environment.	Planning	H. H. Aerospace
Automated Weather Distribution System (AWDS) AWDS will enhance Air Weather Service's meteorological support for the Army and the Air Force. The system will reduce labor-intensive tasks by using advanced computer technology, color graphic displays, and sophisticated meteorological and graphic presentation software. A total of 165 automated Base Weather Stations worldwide and twenty transportable versions will interface with two communications networks for distribution of global alphanumeric and graphic meteorological data.	Development	MacDonald Dettwiler and Associates Ltd.
Avionics Intermediate Shop Mobile Facilities (AIS) This effort integrates automatic test equipment for F-16, F-15, A-10, and EF/F-111 aircraft into mobile tactical shelters to enable the worldwide deployment of the avionics support for these aircraft. This will reduce airlift requirements for AIS by fifty percent and provide improved facilities for avionics component repair.	Acquisition	Chamberlain Manufacturing Corp., Gard Div.; Medley Tool and Model Co.; B&M Technological Services
Base Recovery After Attack This effort will design, develop, and test a survivable network for Eglin AFB's Survivability Branch so that the Branch can demonstrate a means for quickly reconstituting air base operations, including runways, taxiways, and communications. The unique characteristic of the network is its ability to repair itself by routing around any damage it detects on any of its redundant links. The network will allow continuing communication to damage-assessment teams and various other repair teams so that air base reconstitution can be carried out.	Planning	Softech; MITRE
Command Center Evaluation Facility (CCEF) The CCEF will support ESD programs by evaluating, designing, and developing command center capabilities using existing and emerging technologies. Through the CCEF, ESD will provide near-term support and quick-reaction capability to users by addressing changes in current command center control systems that need to be taken care of outside the normal (classic/traditional) acquisition process. In addition, the CCEF will provide a central test-bed, or evaluation tool, that will merge technological advancements with evolving user needs and mission changes (both generic and specific) over the next decade or more.	Conceptual	MITRE
Computer Resource Management Technology Program This program exploits the results of advanced development programs, develops and applies techniques to reduce cost and increase reliability in complex automated defense systems, and provides users and system designers with software engineering and software management tools to specify, design, test, and support automated defense systems.	Engineering Development	Aerospace; H. H. Aerospace Design; MITRE
DoD Software Engineering Institute (SEI) Established and operated by Carnegie-Mellon University, the SEI is a Federally Funded Research and Development Center (FFRDC) jointly sponsored by the Under Secretary of Defense for Research and Engineering, the Army, the Navy, and the Air Force. The SEI brings the best professional thinking and the most effective technologies to bear on the goal of rapidly improving the quality of operational software in DoD mission-critical computer systems.	Ongoing	Carnegie-Mellon University
ESD/MITRE Software Center This program develops and maintains the ESD/MITRE Software Center as a responsive and effective organization that will satisfy the needs of the ESD system program offices. It monitors ESD/MITRE Project 5720 (Software Center) for manning, cost effectiveness, subtask work and assignments, and compliance with the TO&P and is the lead agent for Software RED Teams and Software Expert Assistance Teams (SEAT). The program develops the methodology by which state-of-the-art software can be transitioned to ESD programs. This includes the capability to provide information and insight to ESD program offices on existing and forthcoming state-of-the-art software so that its use by programs can be planned and accomplished.	Ongoing	MITRE
Global Decision Support System (GDSS) Directed by agreement between the Chairman of the Joint Chiefs of Staff, the Air Force Chief of Staff, the Commander in Chief of MAC, and the Director of DCA, GDSS is a rapid-development program to develop, install, and test the latest command and control technology in command and control systems. It consists of a wide area net connecting the top three echelons of MAC command and control with five local area nets.	Acquisition	JPL
Granite Sentry The Granite Sentry Program is a phased hardware/software modernization program that will replace the current NORAD Computer System (NCS) and Modular Display System (MDS) with a flexible, modular system using data-distribution capabilities provided by the Communications System Segment Replacement (CSSR) Program. The primary operations centers affected are the NORAD Command Post (NCP), Air Defense Operations Center (ADOC), Battle Staff Support Center (BSSC), and Weather Center (WC). The intent of the modernization program is to provide integrated attack-warning/attack-assessment information to the NCP and output to forward users.	Predevelopment	MITRE
HF Automated Communications Processor (ACP) This effort modernizes high-frequency radio communications by automating frequency selection, addressing, and address protection as well as adding slow-hop antijam capabilities to the AN/ARC-190 solid-state HF radio.	Development	Rockwell Collins

NAME AND MISSION	STATUS	CONTRACTOR
HQ Air Force Local Area Network (LAN) The HQ Air Force LAN program will provide a local area network to allow reliable, efficient, unclassified data, voice, and video communications between Air Staff offices in the Pentagon and the computer that supports them.	Installation	Clarence B. McCullough
Local On-Line Network System (LONS) The objective of LONS is to provide a system for AFSC product divisions, laboratories, and SOAs to communicate command-directed information over the DDN by using standardized office automation hardware, software, and base communications facilities.	Development/ Acquisition	Computer Sciences Corp.
Logistics C³I System This system is a complete AFLC command and control system, designed for battle staff crisis operations but capable of operating in peacetime. It will support the AFLC missions from readiness through reconstitution and serve as the command-unique subsystem of the WWMCCS Information System.	Conceptual	Unisys
Logistics Information Management Support System (LIMSS) This program provides a logistics information system architecture and recommendations for information systems integration (current and emerging) to assure rapid movement of accurate, precise information where and when it is needed. LIMSS will be key in aiding logistics and engineering management to keep the Air Force's weapons systems in a constant state of readiness worldwide.	Conceptual	Dynamics Research Corp.; Analytical Systems Engineering Corp.; DoT Transportation Systems Center; MITRE
MAC C² Information Processing System (IPS) This proposed system will automate the ground portions of MAC command and control from Hq. MAC down to deployed units and airlift control elements. It will consist of off-the-shelf hardware and software plus developed applications of software to automate airlift mission planning, execution, and monitoring.	Development	None
MAC C² Planning This is part of MAC C² upgrade and includes two separate tasks: COMSEC/TACS and aeromedical evacuation.	Planning	Analytical Systems Engineering Corp.
MACPLAN MACPLAN involves the development of an expert system with a natural language interface to augment the abilities of Hq. MAC deliberate and crisis airlift planners. The system will use state-of-the-art, proven artificial intelligence techniques. Users will be able to query a worldwide data base in a natural language, graphically construct and view plan concepts, and perform certain tasks 10,000 times faster than with present operational hardware and software.	Planning	MITRE
MILSATCOM This program encompasses a broad systems-level evaluation of MILSATCOM systems in close cooperation with the user command, Air Staff, Space Division, RADC, AFCC, and DCA, emphasizing the terminal segment and associated analysis of user requirements. This in-depth examination identifies MILSATCOM deficiencies and produces recommendations to Air Force managers making near-term and far-term MILSATCOM decisions. These are documented in a comprehensive architecture that also defines follow-on programs and next-generation satellite terminals to correct deficiencies. The architectures are updated periodically to address specific problem areas.	Planning	MITRE
Mission Effective Information Transmission Systems The Air Force is implementing transfer systems according to the Air Force Information Systems Architecture (AFISA), a set of USAF-approved guidance documents. The AFISA identifies mandatory protocols. The Local Information Transfer Architecture, a volume within AFISA, supplies the guidelines and standards for implementation.	Conceptual	None
SEEK SCORE This radar bomb-scoring system consists of a ground radar that tracks aircraft and a computer that, upon termination of a simulated bomb release tone, computes the bomb impact point. The score is automatically calculated and relayed to the aircraft.	Production	Sierra Research
Software Technology for Adaptable Reliable Systems (STARS) STARS is a multiyear advanced development program with the goal of increasing software productivity a hundredfold in the next five to ten years. Projects include software production environments, software reusability, and expert systems applied to business practices.	Concept Definition	None
Survivable HF/VHF This is a plan for the logical development, acquisition, and fielding of a new-generation HF/VHF radio to meet the emerging requirements of the MAJCOMs. The program will focus on retrofitting new capabilities into current-inventory Air Force radios and designing a new, survivable HF/VHF radio system by implementing networking and spread-spectrum technologies.	Planning	MITRE
Tactical Decision Aids (TDA) A new capability for Air Weather Service to support mission planning and execution. TDA will process target/background information along with associated weather information to provide forecasts of such smart-weapon performance parameters as the lock-on range for infrared, laser, and TV-guided munitions.	Predevelopment	None
UHF Satellite Terminal System (USTS) This component of the MAC C² Upgrade will allow for the efficient use of UHF satellite channels by developing the DoD-standard 5kHz demand-assigned multiple access (DAMA) scheme that will permit several hundred terminals to use the same channel. Also develops portable terminals to be used in aircraft and fixed and mobile ground stations and four network control stations to regulate the worldwide use of the system.	Development	None
Unified Local Area Network Architecture (ULANA) This family of standard networking components will implement data communications networks on Air Force bases and assure interoperability among different hosts and terminals. Commercial off-the-shelf components will be selected to the maximum extent possible and will make use of standard commercial and DoD protocols. Products for baseband and broadband coaxial cable and optical fiber will be procured.	Development	None
Vanguard Vanguard is an Hq. AFSC project to assess existing, planned, and needed warfighting capability for a twenty-year planning horizon. The ESD portion of Vanguard shows the contributions and interrelationships of C³I (command control communications and intelligence) systems.	Planning	MITRE

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Maverick's infrared seeker penetrates haze, light fog, and most battlefield conditions to track a moving target by detecting the heat difference between it and the surrounding terrain. Once the sensor has located a target, the pilot locks on, fires the missile, and leaves. Maverick then uses an onboard computer to track and fly automatically to the intercept.

The Air Force has designated Raytheon as the qualified second source producer of IR Maverick. Our selection followed an extensive competition and a 30-month qualification program that involved environmental, aircraft compatibility, and captive carry tests as well as a series of successful firings.

IR Maverick is the latest in a long list of airborne and surface-launched missiles from Raytheon, a list that includes the Sparrow, Sidewinder, and AMRAAM air-to-air missiles and the Patriot and Hawk ground defense missiles. Each reflects our uncompromising application of the fundamentals required to design, test, and produce a reliable, high-performance system. IR Maverick

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An A-10 aircraft launches a Raytheon-produced IR Maverick missile.

Raytheon

Where quality starts with fundamentals

Electronic combat is a deadly game of measures and countermeasures. Superior equipment is important, but the combatants must use it with cunning and skill.

This hunter/killer team of an F-4E (foreground) and an F-4G Wild Weasel radar suppression platform from the 37th Tactical Fighter Wing at George AFB, Calif., practices its craft. The F-4 is the third generation of aircraft to be outfitted for the Wild Weasel role.

With Waveforms

BY JOHN T. CORRELL
EDITOR IN CHIEF

IN THE world of electronic combat, skill and cunning are frequently as important as superior weapons and systems. The principle is illustrated by the task assigned to Wild Weasel aircrews flying SAM suppression for Operation Linebacker II in December 1972.

The United States, seeking a conclusion to the Vietnam War, sent its heavy bombers and everything else it could lay hands on to pound Hanoi and Haiphong relentlessly for eleven days. Hanoi itself was protected by the most lethal defenses in North Vietnam, including a cordon of SA-2 surface-to-air missiles deployed on all approaches to the city.

Suppressing the radar-controlled SA-2s was the job of the Wild Weasels, organized for that very purpose in the early part of the war. There weren't many of the Wild Weasels, though, and with attacks continuing around the clock, only a few Weasels at a time could be over Hanoi to support the typical Linebacker II bomb run.

"If anybody had told me in pilot training that I'd be going to downtown Hanoi at night with only two bullets [Shrike antiradiation missiles] to cover five SAM sites for twenty minutes, I'd probably have turned in my wings right then," says Tom Floyd, a Weasel pilot who was there. "But we did it."

Sometimes they did it by straightforward assault on the SAM sites, at other times with distraction, intimidation, and maneuvering. The basic idea was to neutralize a part of the SAM defenses long enough for the bombers to get through and deliver their ordnance. Sometimes the SAMs won the engagement, and sometimes the Weasels did.

Vietnam was the war in which electronic combat came of age. It introduced the use of surface mis-

and Wits

sile defenses linked to target-tracking radars to shoot down penetrating aircraft. This war also saw large numbers of US fighters go into battle with ECM (electronic countermeasures) pods slung under their wings to help them avoid engagements. B-66 bombers were given an E prefix and adapted to jam North Vietnamese communications and radars. And in 1965, the Wild Weasels were invented to stalk and fight the SAMs with lethal electronics of their own.

Col. Sam Peacock, a former Weasel now working in the Pentagon, says that merely going into sequence for a Shrike launch was often enough to intimidate SAM batteries, making them shut off their radars. If the battery did fire, the Weasel might duck behind a hill to break the radar's lock or "take it down" in the classic Weasel maneuver—an afterburner dive with a hard turn at the bottom that the missile couldn't follow.

Skill and cunning work both ways, of course. The SAM radar emitted a telltale signal when launch was imminent. The Weasels were alert for it. Consequently, the SAM operators learned to put up phony signals to fake the Weasels. They also surprised them by firing the missile in the general direction of the aircraft, then waiting until the last moment to turn on the tracking radar to correct the trajectory.

This deadly game of measures and countermeasures, feints and deceptions mixed in with an occasional bullet between the eyes, is the standard stuff of electronic combat. The objective is seldom to win a direct duel with the enemy. More often, the electronic warriors are satisfied if they can pull the enemy off balance sufficiently to allow some main battle event, such as attack of an enemy airfield, to suc-

ceed. Each side tries to preserve the electromagnetic spectrum for its own use while degrading, disrupting, or—if the odds are right—destroying the opponent's radar, communications, and other electronic assets.

A probing pulse from a ground radar can be either a threat or an opportunity. If the seeker stays on the air long enough, an antiradiation missile can be sent riding down his beam. A jammer can flood his radar screen with static. Alternatively, the penetrator might manipulate the signal bouncing back to the defender's antenna to feed him false information.

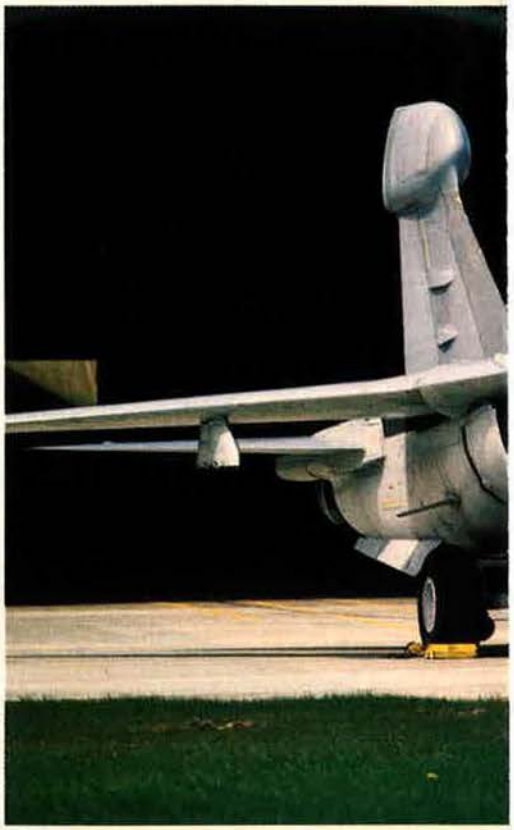
Measures and Countermeasures

In the 1960s, the radar-SAM combination forced penetrators to low altitudes where they could screen themselves behind natural terrain and the curvature of the earth. The fighters began to carry ECM pods routinely for electronic cover, then upgraded to "smart" frequency-hopping pods that adjusted automatically to the jamming requirements of the moment. Defenders soon took the edge off low-level tactics with airborne pulse Doppler technology that could look down and pick out low flyers from the ground clutter on the radarscopes. The tactical electronic environment grew in density as well as in complexity. It is said that combatants in a European war would have to contend with a million pulses of electromagnetic energy per second.

In the fifteen years since Linebacker II, the jammers and the Weasels have improved their weapons and added to their bag of tricks, but so have the Soviet-equipped shooters on the ground. This is especially true along the Warsaw Pact border with Western Europe, where the Soviets have concentrated a thick barrier of their best mobile SAMs *(see accompanying diagram)* and state-of-the-art AAA guns like the ZSU-X, which can shoot on the run.

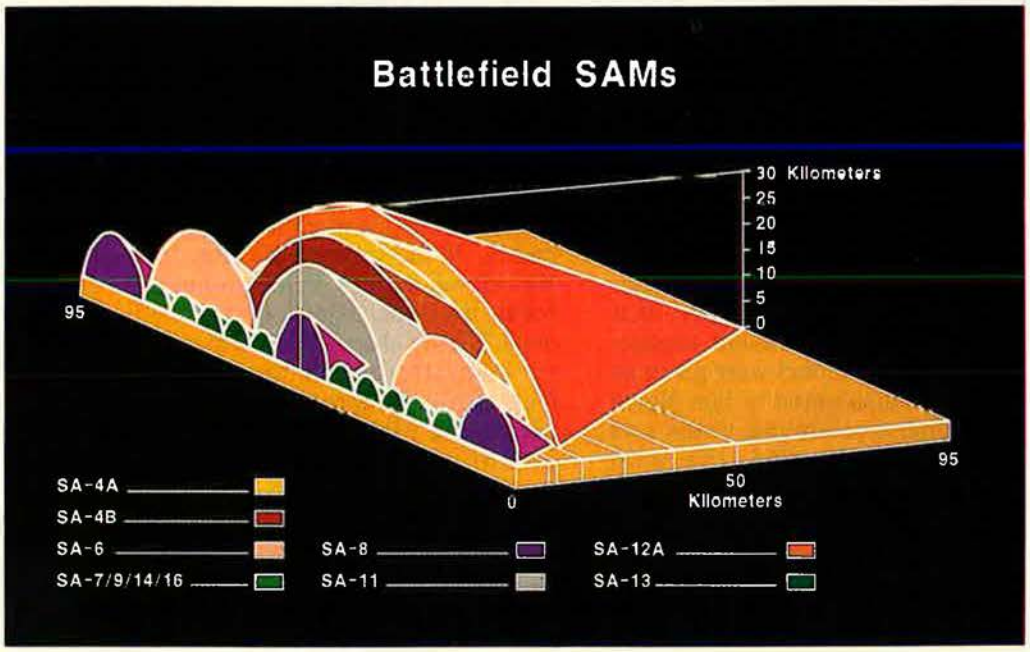
The Soviet Integrated Air Defense System (IADS) has 7,000 radars for early warning and ground-controlled intercept, 13,000 SAM launchers, 12,000 antiaircraft artillery pieces, and 5,300 fighter-interceptor aircraft. Part of this is older equipment. Even the SA-2, upgraded several times since Linebacker II, is still in service at some 350 sites. But some of the newer SAMs are controlled by frequency-hopping monopulse radar, which reads range and direction from the same return and which welcomes a garden-variety jammer strobe as one more bit of useful information. Vietnam-era tactics will not beat this grid.

"There's nothing today that I'd call a Soviet death dot—a weapon that can follow you into the bowels of the earth—but it takes more than maneuvering to survive," says Col. Richard M. Atchison, Director of



Electronic Combat Operations in the Office of the DCS/Plans and Operations at Hq. USAF. "There is no one thing you can put on an airplane that is sufficient by itself to protect you. It takes a mix of equipment, strategy, and tactics."

It's an open question whether the modern Weasels with their F-4G aircraft and High-Speed Antiradiation Missiles (HARMs) would be able to intimidate these SAM operators.



Soviet tactical air defenses incorporate interceptors, antiaircraft guns, and this layered coverage of surface-to-air missiles. These defenses are in depth and pose a threat all the way up from low altitudes and out to a range of thirty kilometers.

Even though it is unarmed, the Grumman EF-111A Raven is one of the most potent aircraft in the Air Force's inventory because of its ability to jam enemy electronic defenses. The Air Force has forty-two EF-111s divided between the 366th TFW at Mountain Home AFB, Idaho, and the unit this Raven belongs to, the 20th TFW at RAF Upper Heyford in the United Kingdom. (Photo © Mi Seitelman/IDI)

Soviet doctrine prescribes emission control, but does not leave the operators much discretion to interpret orders. If they shut down at an unauthorized time, they face a firing squad. But that's the next day or the next week. The threat of the Weasels is immediate. After a few nearby sites are blown away, the discipline of the SAM operators would be tested severely.

To screen its own forces in battle and to degrade the opponent's command and control, the Soviet Union is prepared to conduct large-scale jamming of radars and communications. Its main airborne platforms would be the Il-20 Coot-A and the An-12 Cub-C and D—modified versions of turboprop transports—and the J and K models of the Mi-8 Hip medium helicopter. Ground-based jammers, assigned to radio-electronic combat battalions of the Army, proliferate.

The New "Mainstay" AWACS

The old Soviet airborne warning and control system, the Tu-126 Moss, is limited in effectiveness and has not been a major concern for the West. The new Mainstay AWACS, topped by a "Flat Jack" radome, seems to be another matter. "Now in production, this modified Il-76TD has a true overland look-down capability," says the latest edition of *Soviet Military Power*, published by the US Defense Department in March. "In addition to a new identification, friend or foe [IFF] system, this aircraft may have a comprehensive electronic countermeasures complement."

The Russians have been practicing this game, which they call "radio-electronic combat," since the time of the czars (they jammed a Japanese radio with a spark transmitter in 1904), and they are adept at it. Their better systems rank with the best.

Soviet technology in this field sorts into three time categories, says Brig. Gen. John A. Corder, Director of Electronic Combat for Air Staff R&D. Systems brought out in the 1960s and early 1970s were "poor to fair," but were produced in large numbers.

"Beginning in the mid-1970s, with the advent of monopulse and pulse Doppler processing, the ability [of their airborne radars] to look down and find things in the clutter was improved," General Corder says. The Soviets had not yet mated these radar returns with weapons for a look-down/shoot-down capability, but "no longer could you run around at low altitude and not be found. And with monopulse processing, the ability to hide yourself in angle [azimuth and elevation] was degraded. I'd start calling this pretty good technology, and the numbers were still there." The MiG-23 interceptor represents this category.

In the 1980s, General Corder says, "we begin to see excellent technology in terms of look-down/shoot-down from an airborne threat. The numbers are fairly low right now. They probably won't be significant until the early 1990s, and there won't be as many of them as we've seen before, I don't think, because they cost a lot of money."

Soviet Military Power also reports progress by the USSR on radio-frequency (RF) weapons. Several applications are possible, one of them being the degradation of military electronics. Soviet researchers have generated single pulses of better than a billion watts and have sustained repetitive pulses of greater than 100 million watts.

Punching Holes in IADS

Meanwhile, the US Air Force has been making some progress of its own. It still has some shortcomings, but, all in all, is probably better prepared for electronic combat than at any time in the past. Its major electronic combat aircraft have come into service in the past ten years. Most of its countermeasures equipment has been upgraded or is being upgraded now. Indications are that the United States will be able, in the years ahead, to stretch out the slim lead it now holds over the Soviet Union in this area. Electronic combat has also become a regular part of USAF training and exercises, which contributes both to aircrew preparation and to the mindset it takes to win in the game of measures and countermeasures.

The improvements that meet the eye most readily are those in the area of offensive electronic combat, systems and tactics that prevent the enemy's use of his radars and radios. Individual airplanes in the tactical fleet would go into battle with some countermeasures on board: jammers good enough to set up a local electronic fog, chaff to foil radars, and flares to counter threats from the infrared portion of the electromagnetic spectrum. The

F-15 has its countermeasures equipment tucked neatly inside as part of its Tactical Electronic Warfare System (TEWS), but most aircraft carry their ECM equipment in external pods. These pods, like the radars they work against, are agile frequency hoppers.

Jamming is a matter of how much electronic energy the source can blast into the contested frequency. The jammer can focus his power for intensity or diffuse it for broad coverage, but either way, it takes considerable power to dominate the enemy's large emitters on the ground and control the spectrum over a lot of territory. It isn't practical for fighters to carry jamming sets big enough to do all this. That's a job for escort aircraft that specialize in jamming.

The EF-111A Raven, operational since 1981, can reach out for long distances and disrupt early warning and GCI radars. It is effective against the densest electronic defenses known. Raven can act as a standoff jammer, or it can escort the penetrating force into the battle area. It took part in last year's US action against Libya. The EC-130H Compass Call, introduced in 1983, is a communications jammer that would work from standoff range against the enemy's command and control net. These two jamming platforms perform extremely well, but there aren't many of them. Only forty-two of the EF-111As were ever assembled. The Air Force has just ten Compass Calls, with six more coming.

"First in, last out," according to their motto, will be the Wild Weasels. They have been flying the F-4G variant of the Phantom since 1978. Weasels still carry the Shrike and can employ several other missiles, but preferred ordnance is the AGM-88A HARM, on which the Air Force is currently taking deliveries. HARM has three times the range of the Shrike, plus supersonic speed. To augment the Weasels, the Air Force is outfitting some F-16s to launch Shrikes and HARMs.

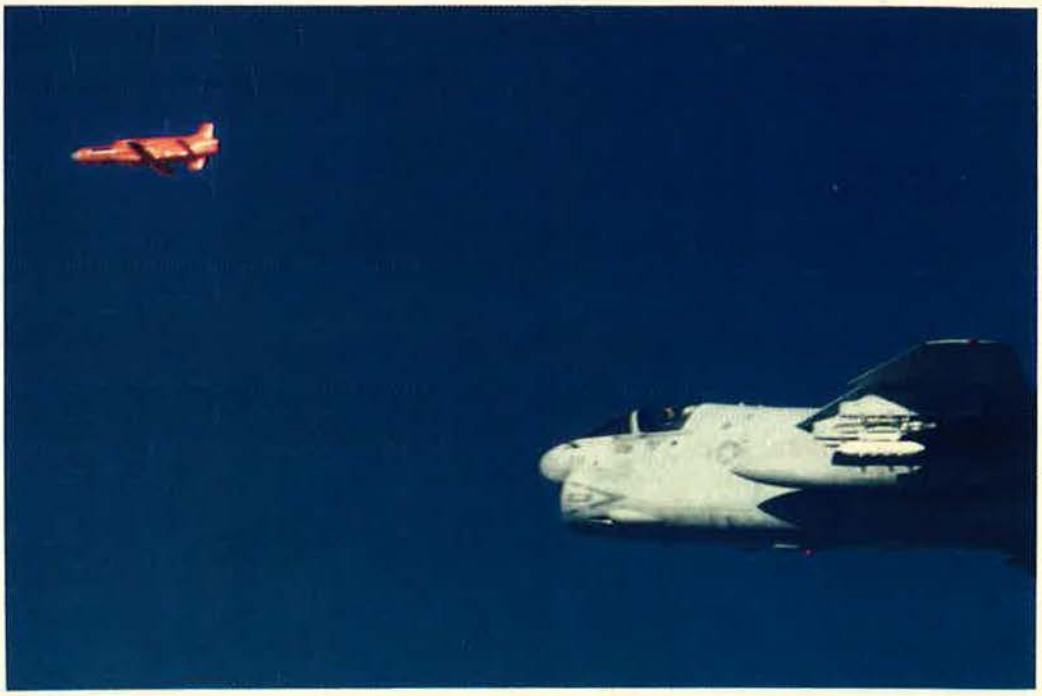
The Less-Noticed Side

Defensive electronic combat is the less-noticed side of the business, but vital to the combat pilot who looks to his radar warning set to tell him when he's being "painted" by the bad guys. Current RHAW (radar homing and warning) gear does a pretty good job of alerting the aircrews to danger and reporting the nature and bearing of the threat. These sets identify enemy equipment by scanning their stored memories for an emissions signature that matches what the receivers are picking up. Reprogramming these systems consumes time, which could be critical. Consequently, a program to provide Area Reprogramming Capability (ARC) in the field is being followed with considerable interest.

Several systems normally regarded as belonging to the domain of C^3 are quite relevant to electronic combat as well. These include the Have Quick tactical radio, whose transmitters jump to a new frequency every tenth of a second to stay ahead of enemy jammers. The Mark XV IFF (identification, friend or foe) system has finally cleared a multinational tangle of delays, and its installation in thousands of platforms will begin around 1993. It will meet a long-standing need for a better way to sort out, electronically, who's who. One of the most important aircraft in any combat theater will be the E-3 AWACS. With its antijam radar, massive tracking and data-processing power, and deep look at the air battle, the E-3 would have a profound influence on the various jammers, jammees, penetrators, interceptors, and ground-based defenders.

Good as these forces and systems are, they cannot defeat the entire electronic order of battle arrayed against them. The emitters and radar-controlled weapons are too numerous for that. The Air Force

Like the EF-111, which serves a unique purpose on deep-strike missions, the Lockheed EC-130H Compass Call aircraft serves a singular role as an enemy communications-jamming aircraft. The EC-130Hs are operated by the 41st Electronic Combat Squadron of the 552d Airborne Warning and Control Wing from Davis-Monthan AFB, Ariz.



The Northrop AGM-136A Tacit Rainbow autonomous loitering missile system is the latest tool to combat the electronic threat. Tacit Rainbow will be used as a complement to the Texas Instruments AGM-88A HARM to knock out enemy radar sites. The AGM-136A will be carried by Air Force B-52s and Navy A-6E Intruders. This picture shows the missile during initial flight testing while a Navy A-7 Corsair (right) flies chase.

would not be able to attack all of them at once, even if that were the strategy, which it isn't. The function of the electronic warriors in a European war would be to punch holes in the Soviet IADS.

The concept of taking on enemy emitters incrementally is seen, for example, in the Air Staff's current thinking about how to deal with the problem of Soviet monopulse radars. Technological responses are possible, and some countermeasures are nearing full-scale development. A pure "systems" solution, however, would be too expensive to provide for the large tactical force. New countermeasures will be employed, as feasible, along with existing countermeasures, tactics, the inherent capabilities of modern fighters, skill, and cunning. This strategy looks at the problem in a total context.

Works in Progress

- **EF-111A Upgrade.** Updates the processing and jamming subsystem of the EF-111A Raven radar-jamming aircraft. Contractor is Eaton AIL. Flight tests begin in January 1988.
- **F-4G Wild Weasel.** Only certain E-model Phantoms can be converted to F-4Gs, and available airframes are getting scarcer. USAF will buy eighteen more in 1988. A Performance Upgrade Program (PUP) is developing a new signal processor for additional memory and speed, and a new direction receiver group will add to the F-4G's capability to process and handle threats of the 1990s. Prime PUP contractor is McDonnell Douglas, with Sperry and E-Systems subcontracting.
- **ASPJ.** The Airborne Self-Protection Jammer will provide internal countermeasures for USAF's F-16 and several types of Navy aircraft. The Pentagon says the program is now on track and that test results look good. Deliveries begin in 1990. Contractors are ITT and Westinghouse.
- **INEWS.** Supposedly the wave of the future, the Integrated Electronic Warfare System will equip USAF's ATF and the Navy's ATA. A fully integrated and versatile electronics suite that pulls everything together. Two joint-venture teams: Sanders/GE and TRW/Westinghouse.
- **ECM Pods.** The older of USAF's two main ECM pods, the ALQ-119, is getting a kit upgrade, after which it will be redesignated the ALQ-184. Contractor is Raytheon. Production of the newer ALQ-131 ECM pod continues by Westinghouse.
- **EC-130H Compass Call.** The Air Force has ten of these aircraft for communications jamming and will acquire six more in 1987. Contractor is Lockheed.
- **AGM-136A Tacit Rainbow.** Joint-service ECM drone in development by Northrop. The Air Force has the lead on the air-launched version, and the Army is working on a ground-launched one.
- **Area Reprogramming Capability (ARC).** Will give theater commands the much-needed capability to reprogram electronic software locally as the threat changes. Reprogramming must currently be done Stateside.

IADS must first pick up the penetrators, then feed the information through the command and control network to the interceptors, SAMs, and guns. The interceptors and the firing batteries have to choose their targets, acquire, track, lock onto, and hit them—all while the fast-moving aircraft are within range of the weapons. This chain of events is a critical path; each function must succeed for the intercept to succeed.

"If we can break the chain at any point, we will defeat the air defenses," says a recently cleared Pentagon briefing. "However, monopulse angle tracking is employed only during radar tracking and missile guidance, and countering it is, therefore, only part of the problem we must solve. We are certainly not always compelled to attack whatever might be the strongest element of the process at a given point in time. Nor must we necessarily attack all of the segments at once. . . . This broad approach is expected not to defeat any segment of the air defense process completely, but rather to reduce its effectiveness to the point where our mission success is maximized."

Inside and Integrated

The Air Force's top procurement priority for electronic combat is self-protection equipment. Over the years, the Air Force has bought numerous specialized systems to meet

The ABCs of Electronic Combat

- **EW. Electronic Warfare.** The use of electromagnetic energy to determine, exploit, reduce, or prevent hostile use of the electromagnetic spectrum. Subsets include ECM, ECCM, and ESM.
- **ECM. Electronic Countermeasures.** Jamming and deception of enemy electronics. ECM systems include EF-111 jamming aircraft and jammers, flares, and chaff carried by individual fighters.
- **ECCM. Electronic Counter-Countermeasures.** The response to ECM. Seeks to protect one's own use of the electromagnetic spectrum and avoid radar-controlled attack by the enemy. Examples include Have Quick antijam radios.
- **ESM. Electronic Support Measures.** Use of a system's electronic signature to learn the enemy's electronic order of battle, including location and capability of his emitters. ESM systems include RF-4C TEREC aircraft.
- **SEAD. Suppression of Enemy Air Defenses.** Physical and electronic measures to neutralize, degrade, or destroy enemy radar emitters, SAM sites, and gun-laying assets. SEAD systems include F-4G Wild Weasels with AGM-88A High-Speed Antiradiation Missiles (HARMs). Also AGM-136A Tacit Rainbow drone, now in development.
- **C^3CM. Command Control and Communications Countermeasures.** Actions to deny the enemy information and to destroy or degrade his C^3 network. Includes Operations Security (OPSEC) measures and EC-130H Compass Call communications-jamming aircraft.

specific threats and now owns an extensive assortment of warning, jamming, and dispensing gear. Most of the fleet carries this equipment in external pods, which ties up weapon stations and creates drag. Nevertheless, pod mods will continue for awhile because the cost of retrofitting all of the airplanes with internal ECM is prohibitive. Aircraft of the future, however, will have internal, fully integrated countermeasures suites.

The F-15 already has internal ECM with its Tactical Electronic Warfare System (TEWS), and the Advanced Self-Protection Jammer (ASPJ) will provide it for some F-16s and several types of Navy airplanes. But the real vision of the future is the Integrated Electronic Warfare System (INEWS), which the Air Force and the Navy are developing jointly for their next generation of tactical fighters.

Whereas countermeasures have traditionally been add-ons or retrofits, INEWS will see everything built together to work together, with the electronics almost as organic to the aircraft as the engines and the airfoils. "INEWS emphasizes jointness and commonality so that parts of the system will be usable in the Army's LHX [new light helicopter family] and other Air Force systems besides ATF," says Col. George R. Winters II of the Deputate for Reconnaissance, Strike, and Electronic Warfare at USAF's Aeronautical Systems Division.

The technologies, especially VHSIC (very-high-speed integrated circuitry), that underlie INEWS may enable the United States to stretch out its lead again in the measures-countermeasures game. General Corder says that Soviet technology in electronic combat now trails the US by a year or two, with the biggest lag seen in packaging. When designers are limited in their ability to combine components in tight spaces, they are forced to make their airframes larger or resort to other ways of compensating.

Even for US designers, who lead the league in that regard, it is not easy to get countermeasures suites down to pocket size. The ASPJ program, for example, gives fighters about the same ECM capability as that in B-52 bombers. In the BUFF, this equipment weighs 700 pounds and occupies fourteen cubic feet. ASPJ does it with 300 pounds in three cubic feet. At 100 pounds per cubic foot, it's a snug fit. (By comparison, a cubic foot of solid aluminum weighs around 112 pounds.)

The Game Goes On

Between wars, the measures-countermeasures struggle continues in less violent form, with each side seeking new advantages and probing for revelations about the electronic progress of the opposition. "You don't wait to learn his capabilities and vulnerabilities in the field," Colonel Atchison says. One subset of the game, Electronic Support Measures, consists of ferreting out such information.

The Soviet Union took note in 1986 when HARM missiles fired by US airmen scored direct hits on Libyan air defenses. And Soviet use of radio-electronic combat in Afghanistan has been of tremendous interest to US intelligence. This part of the game does not stop with observation. Some of the Soviet systems of most concern to the West are based on technology stolen from the United States.

On the technology front in the cold war of measures and countermeasures, the warriors also win some and lose some. An apparent casualty—although not yet certified as a fatality—is the Precision Location Strike System (PLSS). Its role was to be deep-look detection and targeting of enemy radars. "Unfortunately, the complex task of processing and analyzing the vast number of signals picked up during fast-paced combat operations has proven to be more difficult than anticipated," the Defense Department reported to Congress earlier this year.

Most known developments are going well, though, and it's generally assumed that still more are in progress behind the cover of secrecy. Countermeasures tend to be perishable once the enemy has seen them used, so electronic warriors often keep their best tricks hidden until they can spring them with surprise at a telling moment.

Sometimes the most effective countermeasures are the simple ones, perhaps not from the world of advanced technology at all. Colonel Atchison describes such an instance where ingenuity was the answer. When the heat-seeking SA-7 missile was introduced, it gave North Vietnamese ground troops a potent weapon against aircraft.

An AC-130 gunship crew over Fire Base English in 1972 knew about the SA-7 and was ready for it. As the SA-7 rose up from the trees and homed on the airplane, one of the crewmen fired a round from a Very pistol out the rear door. Sure enough, the missile swung toward the hot-burning flare and away from the gunship, which proceeded about its business. Score one for skill and cunning, and stand by for the next move. ■

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There's a lot of the UK in US military electronic systems.

The British Are Coming

BY F. CLIFTON BERRY, JR.

WHEN Paul Revere alerted the neighborhood in April 1775, he shouted, "The British are coming!" In 1987, they are still coming. This time the approach and the reaction are different. Instead of redcoats with muskets, they come with technology, components, and joint business ventures. And instead of fighting, they are welcomed by the US armed services. For US military aerospace, the British participation in current and future projects continues a long-standing trend.

In World War I, the aero squadrons of the American Expeditionary Force (AEF) did not fly airplanes that were designed at home. Instead, they flew such allied aircraft as the French SPAD and the British Sopwith Camel and SE-5A. The next time the country went to war, in 1941, its aerial forces used British-invented radar. The Rolls-Royce Merlin engine in the P-51 Mustang gave that classic fighter the fuel efficiency and power needed for long-range escort of the USAAF's heavy bomber forces.

Before the US entered World War II, Gen. H. H. "Hap" Arnold negotiated for a Whittle W1X jet engine for study in the USA. Frank Whittle, a Royal Air Force officer, invented the jet engine. He ran it for the first time on April 12, 1937. The supersecret Whittle engine was flown to the US in October 1941. General Electric Co. used it to design the first US jet engine, and that engine flew for the first time in the Bell XP-59 on October 2, 1942.

Later, in 1951, the B-57 Canberra bomber from English Electric began to arrive at Tactical Air Command bases. It was USAF's first foreign-designed bomber. The B-57 (which was built by Martin) served through the post-Korean and Vietnam eras.

Now the US Air Force is using a cargo aircraft designed and built in the UK. The C-23 Sherpa from Short Brothers flies on USAFE's European Distribution System, serving a score of air bases. Also, USAF has bought British Aerospace Rapier surface-to-air missile systems to protect its air bases in the UK and Turkey. The US Navy has chosen a British design for its next undergraduate jet pilot trainer, the T-45 Goshawk, a carrier-capable version of the British Aerospace Hawk.

Variations on a Theme

For now and the future, cooperation between the UK and the USA on aerospace programs will become firmer and more extensive. This is especially so in the case of US Air Force requirements. The cooperation ranges from simple purchase of parts and services from UK suppliers through research and development of technologies and systems to complex business arrangements.

Several powerful forces are at work to make this happen.

The basic underpinning of US-UK cooperation in this field is the December 1985 Memorandum of Understanding (MOU). It is intended to "facilitate the mutual flow of defense procurement." When he signed the directive putting the MOU into effect, Secretary of Defense Caspar Weinberger said that its purpose is to promote greater cooperation in research, development, procurement, and logistic support of defense equipment.

As a practical matter, the MOU waives the Buy American and Balance of Payments provisions of the US Code. Bids or proposals from the UK compete on even terms with those from US bidders. (Likewise, bids from US suppliers compete for UK defense business.)

A second force stimulating cooperation with UK suppliers is USAF's drive to increase widespread competition for its business. Money is tight, and intense competition is required. USAF commands can seek bids from UK suppliers who—if their capabilities are sound and their pencils sharp—can compete and win business.

Also, the competition for military aerospace markets is becoming global. For UK companies, it means that the domestic market is not large enough. The European market is larger, but still limited in size. The US military market is even larger. An astute British firm will try to gain shares in all those places, plus the still larger but fragmented global marketplace. For example, GEC Avionics sells to customers in seventy countries. Export means survival.

Officials at the Electronic Engineering Association (EEA) in London point out the significance of exports to their member companies, which are major subcontractors to the platform makers worldwide. For those companies—Dowty, GEC, Plessey, Racal, Smiths Industries, and others—exports constitute up to seventy percent of their revenues. Executives at Lucas Aerospace say that exports make up seventy-five percent of their UK business. At Plessey, they are proud to note that they supply seventy percent of the US bubble-memory market. Mr. A. N. Thatcher, Dowty Chief Executive and President of the EEA, considers international collaboration a top priority, both for his company and EEA.

The relatively recent phenomenon called offsets helps UK companies compete for business in the US. A case in point is the UK government's decision at the end of 1986 to buy the Boeing E-3 AWACS warning and control aircraft. Boeing's AWACS was judged better for the RAF than the competition, the British Nimrod. But to ensure that the decision retained and created jobs in the UK, the government required Boeing to guarantee offset business equal to 130 percent of the AWACS purchase price.

The 130 percent offset means that Boeing and its subcontractors on AWACS are actively seeking UK companies to bid for their business. Under the agreement, the business generated in the UK that is applied to the offset account can be either direct or indirect. Direct offset business is on the UK E-3 program. Indirect business is on other programs. The UK Ministry of Defence has established a special office to keep track of AWACS offset business, both direct and indirect. It is the focal point for identifying and compiling the business that counts against the 130 percent total.

As an example, Boeing entered into a cooperation agreement with Plessey on the E-3A offset. It provides Plessey with bid opportunities on both direct and indirect offset work with Boeing, its sister companies in the Boeing group, and its E-3 subcontractors. Boeing has qualified nineteen of Plessey's companies as approved suppliers.

Plessey concluded a more specific agreement with Westinghouse, a major AWACS subcontractor. That includes more than offsets. Under the agreement, direct UK E-3 offsets have been identified. For Plessey, they include providing E-3

—USAF photo by MSgt. Patrick Nugent

One of the major cooperative efforts between the US and the UK is the Shorts C-23A Sherpa intratheater airlifter. Used to haul spare parts and engines on the European Distribution System (EDS), the eighteen aircraft the US bought perform a valuable service for USAFE. The EDS is centered at Zweibrücken AB, West Germany.

radar test equipment, managing the radar program, furnishing engineering support during tests, and more.

Indirect offset business with Westinghouse uses Plessey expertise to collaborate on such specialized technologies as radar software developments, advanced signal processing, and integration of sensors, among others. Plessey and Westinghouse have also agreed to develop and promote joint ventures in a broad range of technology development and systems production. To further this program, the two companies have set up a joint business organization and have begun exchanging people between Westinghouse in Baltimore, Md., and Plessey at West Leigh, Hampshire.

UK in US Programs

Finding and listing all US programs with UK content is beyond the scope of this article. However, a representative range has been identified, and it encompasses a broad group of mission areas.

- *Unmanned Aircraft*. For the moment, USAF's main unmanned aircraft are cruise missiles and target drones. However, it may be returning soon to the development of remotely piloted vehicles (RPVs) for such other purposes as reconnaissance and strike. British Aerospace is ready for that time, developing an expendable RPV with a price tag of $17,000!
- *Navigation*. For USAF requirements, British Aerospace is preparing to offer TERPROM. The acronym stands for TERrain PROfile Matching. TERPROM stores a digital map of the terrain in its computer memory. This map and the aircraft navigation system predict the aircraft altitude. It then compares the predicted height with the actual height (measured by radar altimeter on board) to correct the navigation readouts.

TERPROM also "thinks ahead," using the stored digital map. It permits terrain following at very low level and high speed, plus "intelligent" ground proximity warnings without using forward-looking radar. It has been tested on a Panavia Tornado and a BAe Jetstream in the UK and on a General Dynamics F-16 in the US.

TERPROM test results were so promising that Collins Government Avionics Division (of Rockwell International) signed an agreement with BAe to market TERPROM in the US for military fixed- and rotary-wing aircraft. Later, the two companies intend a more comprehensive agreement that will allow Collins to manufacture TERPROM units for the US market. Meanwhile, GEC Avionics is demonstrating a full stealth navigation system based on "total terrain avionics" (T^2A), which is being flight-tested in the US.

British Aerospace's ring-laser gyros are competing for USAF's standard navigation system business. With Boeing, their ring-laser gyros could be fitted into Chinese MiG fighter aircraft.

Displays for air traffic control and airspace management systems are heading toward multiple capabilities. Plessey executives note the trend to produce military air traffic control systems that can take over for the civil sector promptly in emergencies. Also, they are developing military air traffic control systems with air defense capabilities. Plessey is working with Texas Instruments on Ground-Air Interface Terminals and with Electro Space Inc., the system integrator for USAF's E-4B National Emergency Command Post plane.

Transatlantic cooperation extends across a broad group of mission areas. One of those fields is in electro-optics, an example of which is this GEC Avionics's Atlantic FLIR (Forward-Looking Infrared) pod fitted to a USAF F-16B for compatibility trials. In addition to being mounted near the intake, the pod can also be fitted underwing.

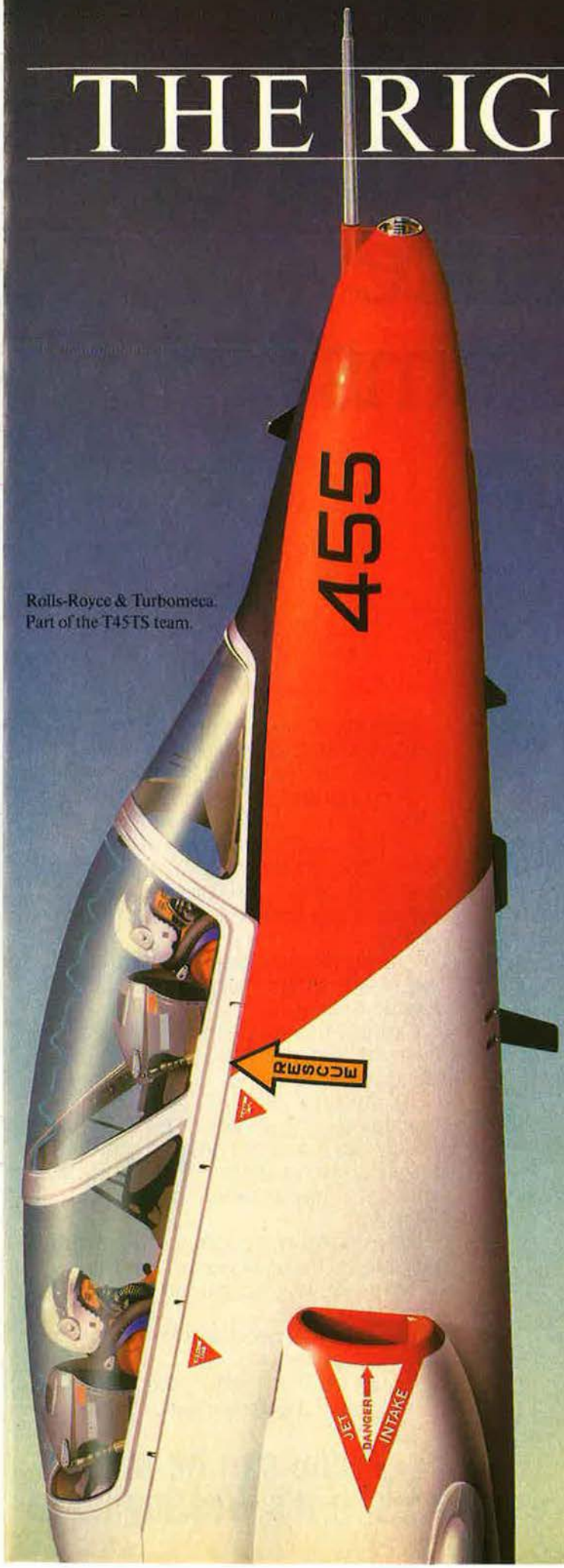
Plessey is integrating aircraft navigational inertial navigation systems with the Navstar Global Positioning System. The result is continuous cross-check and greater reliability.

- *Displays*. GEC, the world's largest producer of HUDs, builds the head-up display for the F-16. It established a US company in Atlanta in the early 1960s. GEC built the first digital HUD for the A-7D/E in the early 1970s, supporting the war effort in Vietnam. Other systems with GEC HUDs include the A-4M, the A-7E with night-vision HUD, the F-16A/B, USAF's LANTIRN with holographic HUD, and the C-17.

The HUD in the US Marine Corps AV-8B Harriers is produced by Smiths Industries, which also provides the HUD for the multinational Tornado aircraft.

- *Electromagnetic Warfare*. Both BAe and Racal are developing jammers in different segments of the electromagnetic spectrum. BAe's IR jammer can interfere with devices using the infrared band. Racal's communication jammer fits into a small, expendable RPV, jamming the tactical communications band from 20 MHz to 90 MHz. The range of both these jammers is short, one kilometer or so. But they require low power and are inexpensive and small enough to ride on a throwaway RPV. Swarms of them can be operating continuously over the battle area, jamming the enemy's IR sensors and tactical communications.

THE RIGHT STUFF



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• *Laser Warning and Countermeasures Devices.* This is an area receiving strong attention from British electronics companies. With the proliferation of laser seekers and designators on and above the battlefield, warning and countermeasures are necessary. This is a growth area for UK-US cooperation.

Laser researchers also warn that the widespread use of lasers could lead to the demise of the HUD. They point out that intense laser light shot through a HUD will almost certainly blind the pilot. This argues for an opaque cockpit, where the outside scene and information are created internally and projected for the pilot. Skeptics pooh-pooh the laser hazard, saying the beams are too narrow and the odds astronomical against blinding.

• *Chips.* This is an area where high-technology companies are moving away from reliance on outside chip suppliers. Racal produces its own version of a very-high-speed integrated circuit, using its own chips. Called the Very Powerful Integrated Circuit, Racal's silicon chip is at present capable of 100,000 instructions per second. Plessey also produces its own custom chips, as do others.

• *Data Monitoring and Management.* A big chunk of USAF and US Navy airborne computer business has been captured by GEC Avionics. In two successive orders, GEC Avionics has won business worth about $100 million for nearly 3,000 of the USAF/USN Standard Central Air Data Computers (SCADC). Computers equip some thirty types and variants of aircraft ranging from the A-4 Skyhawk to the C-5 Galaxy. GEC is also supplying the yaw damper computer for the Navy's T-45A Goshawk trainer.

Business Integration

The spread of business possibilities ranges from license production of foreign products to teaming for specific projects to taking equity positions in foreign companies. Take Lucas Aerospace as an illustration. It has teaming or work-sharing arrangements on projects with Bendix, Hamilton Standard, and Rohr. It is licensed by Bendix and Sundstrand to make certain products for certain markets. Finally, in less than a year, Lucas has bought three US companies: Weinschel Engineering and AUL Instruments in late 1986 and Western Gear in early 1987.

These actions reflect Lucas's long-term strategy for penetrating the US market. Elements in the penetration strategy include direct sales of Lucas products, licensing (as cited above), development of products by its US holdings, collaborative agreements for teaming, and, finally, acquisition of existing companies. In the acquisitions, Lucas will invest in technology and manpower resources and expects to gain in return experience, technology, and new business.

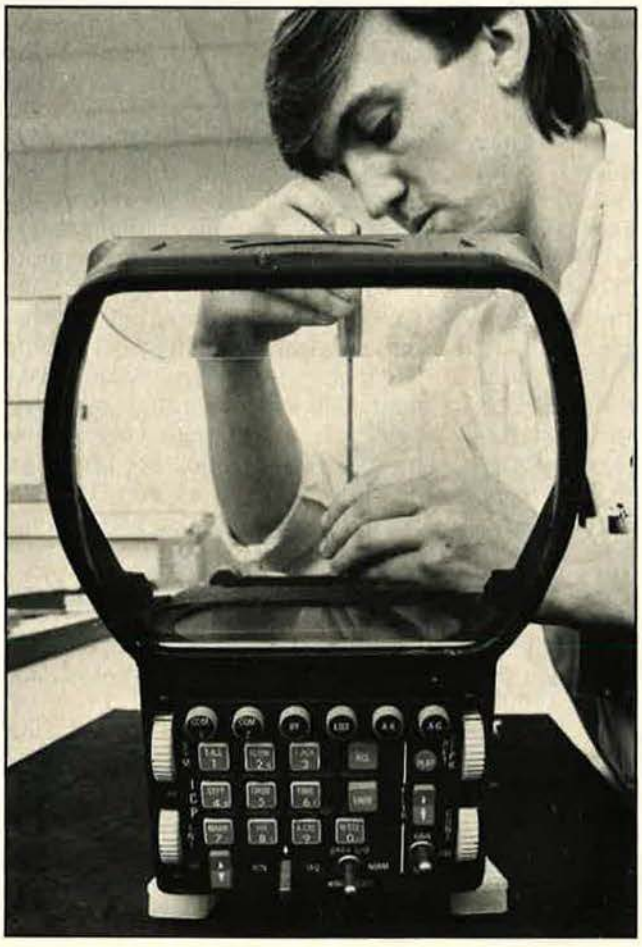
In the other direction, Raytheon, the $5.5 billion US giant, bought Cossor Electronics. Cossor is a leader in air traffic control, precision radar, and other electronic systems.

Ferranti, with headquarters in Edinburgh, has a long and strong US presence, with ten subsidiary companies. Its US subsidiaries team with others and offer Ferranti products directly for USAF and other US military programs. On the B-1B, for instance, it provides the high- and low-voltage power supplies for the Westinghouse Offensive Radar System. Its high-energy lasers are in Ford Aerospace's FLIR pod for the F/A-18 Hornet.

Another example of teaming for transatlantic projects is the EURO-ART COBRA. That is a weapon and counterbattery radar for dealing with the threat of enemy artillery. COBRA will be developed and procured by Britain, France, and West Germany. The EURO-ART consortium comprises Thorn-EMI, General Electric (US), Thomson-CSF (France), and Siemens (West Germany). Competing against EURO-ART are two other consortia. One includes Hughes Aircraft (US), plus AEG (Germany), Marconi (UK), and Thomson-CSF (France). The third is all-European, composed of Marconi Radar and Ferranti (UK), Standard Electric Lorenz (SEL) and BSG (Germany), and LMT-RP (France).

Negative Factors

Cooperation works, as we have



GEC, the world's largest producer of head-up displays, makes the HUD for the Air Force's F-16s. This particular holographic HUD uses diffractive optics to provide the pilot with a wide field of view suitable for both night and day operations in F-16C aircraft. It is the first holographic HUD to be put into volume production.

seen. But just how many parties can collaborate on a project successfully? Pat McDonald, an executive at Thorn-EMI, believes that experience shows that three or four parties can work together successfully. However, when the number grows to seven, eight, or nine participants, progress is impossible. Why? Because that many governments will bog down on such key issues as specifications, work share, technologies, and export-market share.

Coping with the procedures of a foreign market can be formidable. Executives at British companies interviewed for this article unanimously expressed frustration in dealing with US red tape. Their ire focuses on such simple things as visit requests. They experience delays of six to eight weeks in receiving approval to visit US defense contractors or US air bases to discuss bidding for business. Delays like that can prevent timely participation in the competition. However, US aerospace executives say they face similar problems competing for British business. The average processing time for visit approval in the UK is faster, around twenty-one days.

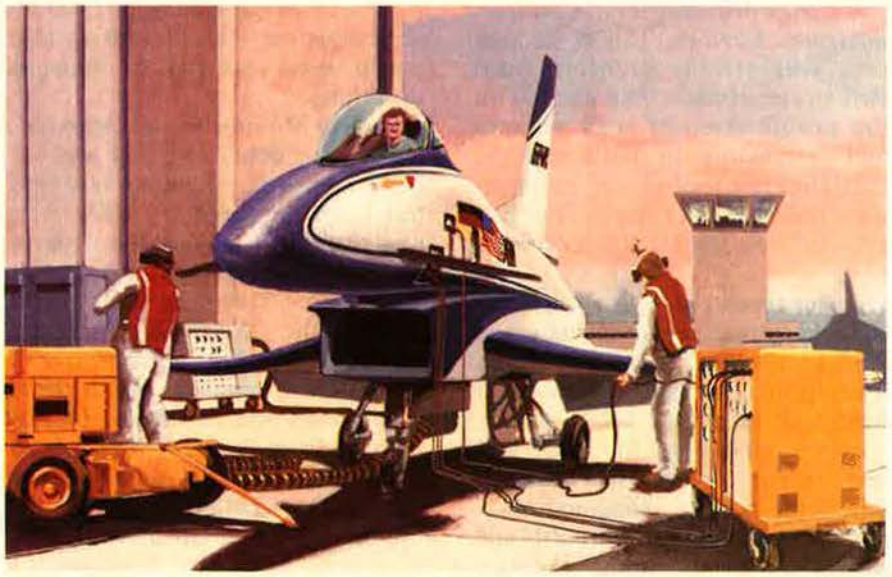
To help British companies compete for foreign defense business, the Ministry of Defence set up the Defence Export Services Organization in London. The US is under DESO's Regional Marketing Directorate 4. British companies can work with the US/Canada office in RMD 4 to find opportunities and suggestions for proceeding in North America.

On this side of the Atlantic, at the British Embassy, is the Defence Supply Office Washington. Roger Harding, an experienced senior official at the ministerial level, heads the office. His office (and another organized to help with visit approvals) assists British companies in navigating the maze that confronts them when they try to do defense business in the US.

Imagine the positive effect on the trade balance if the Defense Department provided US companies the same services with the vigor of the MoD!

EFA and ATF—Test Cases

For examples of major multibillion-dollar projects that are testing the limits of collaboration, look at the European Fighter Aircraft (EFA) and USAF's Advanced Tactical Fighter (ATF).



Yet another example of Euro-US cooperation is the Rockwell X-31A Enhanced Fighter Maneuverability (EFM) demonstrator. This project will bring together the collective talents of several US government agencies, Rockwell, GE, the West German Federal Ministry of Defense, and the German company Messerschmitt-Bölkow-Blohm.

The four-nation consortium developing the EFA wants guarantees from suppliers that the aircraft can be exported to any buyer. This portends immediate adverse effect on Hughes Aircraft. Hughes is teamed with GEC of the UK and AEG of Germany to supply an upgraded version of the Hughes APG-65 radar for the EFA. (The APG-65 is already in Spain's EF-18s and is going into Germany's improved F-4s.) The other team in the EFA radar competition is led by Ferranti of the UK, teamed with Spain's Inisel and Italy's Fiar. It is offering a new development radar called the ECR-90.

But US government export controls prohibit Hughes from guaranteeing that its radar can be exported to any buyer. If the US government relaxes the restrictions, the Hughes team has a chance on the merits of its radar. Also, if the EFA consortium shows flexibility on the export assurance, the Hughes team has a chance. But if both the US government and the EFA team remain stubborn, then the likelihood of Hughes (and other US suppliers) participating in the EFA business is near nil. That could sour the willingness of US companies to collaborate with European companies on other projects.

In the Advanced Tactical Fighter (ATF) case, British electronics executives say they are beginning to sense that the program has a "no foreign" tilt. Because the ATF will be so advanced, they believe the Air Force will limit foreign participation in the competition. That remains to be seen, but the perception is there.

Although international cooperation in USAF projects is increasing, particularly with British companies, the way is not entirely smooth. Companies on both sides of the Atlantic that hope to survive and prosper in this increasingly competitive business have to increase the range of their capabilities and ways of doing business. Those who do not do so will lose market share and eventually go the way of the dodo and the buggy whip. But USAF will be the winner, because the survivors will have withstood the rigors of competition. ■

F. Clifton Berry, Jr., is a former Editor in Chief of AIR FORCE *Magazine. He has written on international security topics for nearly twenty years. He saw USAF service in the Berlin Airlift, 1948–49. Later, he was a paratrooper and officer in the 82d Airborne Division. He commanded airborne and infantry units in the US and Korea and saw Vietnam combat as operations officer of a light infantry brigade. He is a principal in FCB Associates, an information service on international aerospace topics.*

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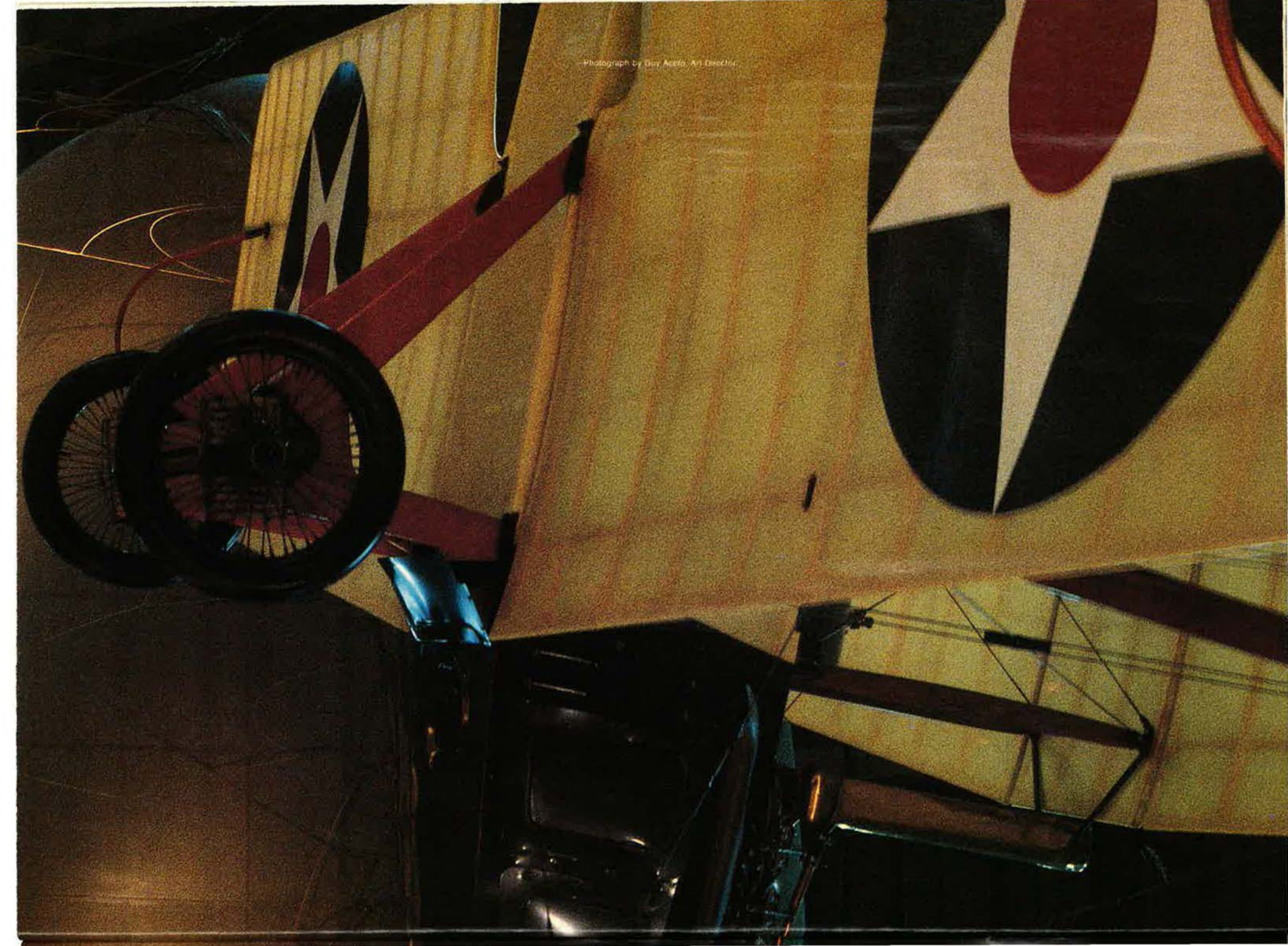
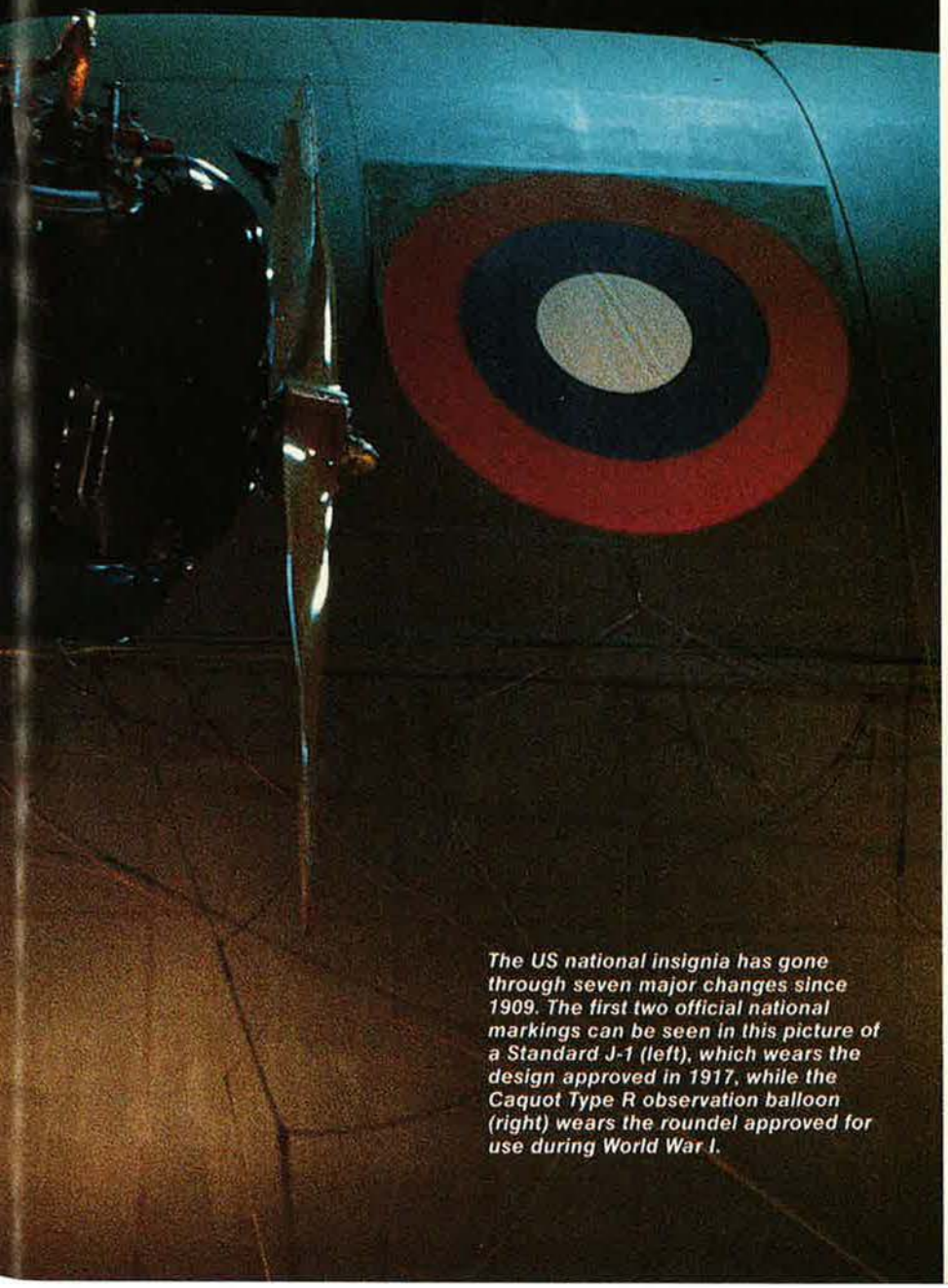

Photograph by Guy Aceto, Art Director

"The National Star insignia shall be applied to the top of the left wing, the bottom of the right wing, and both sides of the fuselage . . ."

—Air Force Technical Order 1-1-4

STARS ON THE WING

BY JEFFREY P. RHODES, AERONAUTICS EDITOR



The US national insignia has gone through seven major changes since 1909. The first two official national markings can be seen in this picture of a Standard J-1 (left), which wears the design approved in 1917, while the Caquot Type R observation balloon (right) wears the roundel approved for use during World War I.

US MILITARY aircraft have nea always borne distinctive mar ings, usually some combination o stars and circles. And in one respect, the past few years have seen the evolution of insignia on American aircraft come full circle. The Wright Military Flyer of 1909 had nothing to distinguish it except the small crossed flags of the Army Signal Corps. The B-1B bomber of today has only a small, very muted national star device.

In the intervening seventy-eight years, the national insignia has gone through seven significant changes and several variations. From the highly unofficial red star of 1916 to the red-bordered design of 1943 to the black-outline versions of 1987, the national insignia has varied between big and small, drab and colorful. The reasons for change have often been interesting. The lineage of the national insignia can still be seen on aircraft on display at the US Air Force Museum at Wright-Patterson AFB, Ohio.

Early Signal Corps airplanes carried no national insignia. The first American marking, although unauthorized, appeared in 1916. The insignia—a red star either alone or in a white circle painted on the rudders—was seen on Curtiss JN-3s and R-4s during the Mexican Punitive Expedition and at the training field at North Island, Calif. This led the Army's Chief Signal Officer to pitch a fit and order that such "mutilation" of government property be stopped immediately.

The first official national emblem was adopted May 17, 1917. Creative airmen used wrapping paper, children's watercolors, and colored pencils to design a white five-pointed star in a blue circle, with a red disc in the center of the star. This insignia was to be applied in four positions on the biplanes then in use—atop each upper wing near the wingtips and in corresponding positions on the underside of the lower wings. While there was no marking on the fuselage, the rudder was painted with single vertical red, white, and blue stripes up to the rudder post.

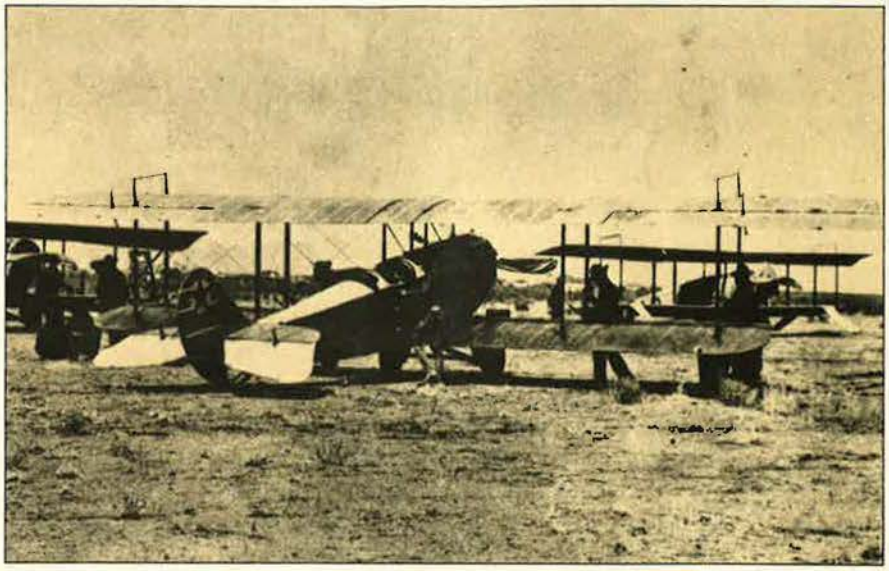
In January 1918, Billy Mitchell, commander of American front-line aerial units in France, had the national insignia changed to a roundel for commonality with British and

French markings. The new insignia was three concentric circles with a white center inside of blue and red rings placed in the four wing positions. The rudder stripes were retained.

The 1917 star-and-red-disc design was brought back in May 1919. Changeover was slow, and it was several years before the roundel disappeared completely. In 1927, the rudder stripes were changed to a vertical blue stripe at the rudder post with thirteen alternating horizontal red and white stripes.

With war clouds on the horizon in 1940, the insignia was removed from the upper and lower left sides of the wings to eliminate the advantage of a balanced aiming point for enemy gunners. The size of the remaining insignia was reduced, but for the first time the national insignia was placed on the fuselage sides. The rudder stripes were also discontinued on camouflaged aircraft in 1940 and two years later were taken off other aircraft as well. A minor but important change was made to the design some five months after the attack on Pearl Harbor. To eliminate any possible confusion with the Japanese *Hinomaru* marking, the red disc on the US symbol was deleted.

The first really major change in the insignia came in June 1943. Shapes are more recognizable than colors at great distances, so two white rectangles were added to the sides of the blue circular field. The new insignia was enlarged by adding



—Photograph courtesy of the US Air Force Museum

These Curtiss JN-3s (above) show the first national insignia, which appeared during the Mexican Punitive Expedition in 1916 and that same year at the training field at North Island, Calif. The red star (left) or the star in a white circle (center aircraft above) was painted on the rudder of some of the few aircraft the Signal Corps had at the time. The star-and-red-disc design (upper corner of the page), shown on this Eberhart SE-5E, was brought back into use in 1919.

In 1942, aircraft involved with Operation Torch, the Allied invasion of North Africa, as well as a number of aircraft that later served in the Mediterranean Theater of Operations and England carried the national insignia with a hand-painted yellow border. This variation was never officially approved.

—Photographs by Guy Aceto, Art Director

In the spring of 1942, the red disc was removed from the star in the national insignia to avoid the possibility of confusion with the Japanese Hinomaru, *or Rising Sun emblem. This Bell P-39 Airacobra (larger photo) is in the markings of the 57th Fighter Squadron in Alaska in 1942. In August 1943, the "winged" design of the insignia with the blue border was adopted, and this insignia was put on more aircraft than any other previous version of the national marking. This insignia, shown here on the right boom of a Lockheed P-38 Lightning, was used for more than a year after World War II ended.*

—Photographs by Guy Aceto, Art Director

The insignia that holds the record for being used for the shortest time is the red-bordered "winged" design, in use for only two months during 1943. The red-edge marking is shown on the upper wing of a Beech UC-43 Traveller (military version of the civilian Staggerwing) that is painted as a plane assigned to Eighth Air Force in England as a liaison aircraft. The inset photo shows the insignia adopted in January 1947. It appears here on a North American F-86A Sabre in a view few MiG-15 pilots got to see—from behind. The F-86 racked up a 14:1 victory margin over the MiG in the Korean War.

This solid black version of the current subdued style of the national insignia is on the fuselage side of the second prototype of the Fairchild A-10A Thunderbolt II close air support aircraft (below). The stencil design (illustrated above) is used mainly on tactical and strategic airlifters today.

"The insignia-blue border and insignia-blue circle may be omitted when the National Star insignia is applied on blue or black finishes." And the tech order is being followed in this view of the North American X-15A-2 (above). On the right, insignia on a Republic F-84F Thunderstreak, a Convair B-36, and a Cessna YA-37A illustrate another part of the tech order, which states, "The National Star insignia shall normally be applied to each side of the aircraft fuselage, midway between the wing trailing edge and the leading edge of the stabilizer."

a red border around the entire design. Tests at Eglin Field, Fla., on P-47s marked with the new "winged" design, the German cross, the Japanese *Hinomaru,* and the old star-in-circle design proved that the red-bordered insignia was sixty percent more recognizable than the others.

The new design would last only two months, though, as fears again rose that the red border might be confused with the Japanese marking, especially in close-in air-to-air combat. The "winged" shape was retained, but the red border was replaced with a blue edge on August 14. This was the design until after the end of the war.

The final major change to the design of the national insignia occurred on January 14, 1947, as a red stripe was added to each of the white rectangles so all of the colors of the US flag would be represented. This latest insignia was prominently displayed until the Vietnam War again brought camouflage into vogue for combat aircraft.

During action in Southeast Asia, the size of the national insignia on combat aircraft was greatly reduced (to a marking that was only fifteen inches high), and late in the war, the blue outline around the "wings" of the insignia on some aircraft was removed. This decreased the demarcation between the insignia and the camouflage and thus further reduced the chance of being spotted. When the first operational F-15s debuted in 1974, they carried the small national marking without the blue border.

Colors of any type became even more of a detriment as sophisticated seekers on enemy missiles were developed. A need to reduce aircraft visibility further led to the subdued insignia, simple gray or black outlines, in the mid-1970s. Since 1979, when the first operational F-16s entered the inventory, all Fighting Falcons have carried these low-visibility markings.

Today, a vast majority of front-line combat aircraft and all tactical and strategic airlifters wear the subdued markings. With just a few marking embellishments, today's aircraft share a common bond with their plain-painted forerunners of the Signal Corps days. ■

The Soviets may talk a good peace offensive, but their military spending climbs even faster than before.

THE GUNS

BY EDGAR ULSAMER
SENIOR EDITOR (POLICY & TECHNOLOGY)

THE CENTRAL conclusion of the just-released 1987 edition of *Soviet Military Power*—the US government's comprehensive annual assessment of the USSR's defense activities—is that Soviet leader Mikhail Gorbachev's "peace offensive" over the past two years is controverted by the USSR's accelerating one-sided arms race. *Glasnost* notwithstanding, Soviet arms spending in 1986 grew more rapidly than in prior years and, in the aggregate, accelerated at an annual rate of three percent over the past few years, even though US defense spending declined by about seven percent over the past two years. Possibly the single most telling statistic unearthed by the new US assessment is that the USSR devotes between fifteen and seventeen percent of its GNP (gross national product) to defense compared to about six percent for the US.

Soviet Military Power 1987 enumerates a host of facts about the Soviet arms buildup, including evidence of operational laser devices that have been used to temporarily blind aircrews from countries that the Pentagon declined to identify as well as of new hard-target-kill-capable SLBMs and new generations of advanced ICBMs. Defense Secretary Caspar W. Weinberger, in the document's preface, provides a quick numerical overview to make the point that in the arms sector the Soviet Union continues to live up to the Leninist dictum that quantity has a quality all its own: "For the decade 1977–86, the USSR built 3,000 ICBMs and SLBMs, the US 850; the USSR 140,000 surface-to-air missiles, the US 16,200; the USSR 24,400 tanks, the US 7,100; the USSR ninety submarines, the US forty-three; the USSR 28,200 artillery pieces, the US 2,750."

In the past, the West has been able to rely on superior technology to counteract the Soviet advantage in numbers of troops and weapons, but of late "our technological lead is being increasingly challenged." Secretary Weinberger explained that each year, "we confront a more technologically advanced Soviet Union," partly as a result of purloined Western technology but due also to that country's steadily growing and maturing technological and scientific base.

No Systemic Changes in Soviet System

Neither the new US document nor the series of briefings involving Secretary Weinberger and other senior experts associated with its issuance recorded evidence of fundamental change in Soviet military policy or geopolitical objectives. While the "winds of change" are indeed blowing in the USSR, they involve changes in form, not substance, as one senior official pointed out. Furthermore, these changes implemented by Gorbachev clearly carry with them the cachet of the Soviet military, for they enhance the productivity of the Soviet Union and thereby the industrial and technological infrastructure of the defense sector. Gorbachev's commitment to revitalizing the country's economic base—the locomotive of future military modernization—has been evident ever since he became General Secretary.

Over the past two years, he has scored impressive gains: The Soviet GNP last year grew by more than four percent, with industry—the focus of Gorbachev's modernization efforts—recording its best growth in a decade. But as a joint CIA-DIA assessment pointed out, whether that growth rate can be maintained for long is problematic for, massive rhetoric notwithstanding, none of Gorbachev's reform measures will "greatly change the system of economic incentives that has discouraged management innovation and technological change." At any rate, the winds of change affect not only the work ethic and discipline of Soviet labor but tangibly provide for enhanced quality control.

Possibly most significant is the relatively rapid replacement of aging machinery and facilities with equipment embodying a higher level of technology to meet what Soviet planners refer to as "world standards." In combination, these reforms are meant to upgrade the country's technological base to put the Soviet Union on a higher, self-sustaining growth level. Gorbachev's goal is to sustain an annual GNP growth rate of four percent for the remainder of the current Five-Year Plan—which ends in 1990—and to seek a five percent average annual growth rate during the 1991–2000 period.

But the economic reforms launched by the new Soviet regime stand in stark contrast with its rigid adherence to the global power politics decreed by Marxist-Leninist ideology. As Secretary Weinberger put it in summarizing the conclusions of the new document, "The Soviets do not change military policy. They can have different kinds of General Secretaries, younger ones, healthier ones, better dressed ones, but the policy remains the same. . . . If a General Secretary came in and tried to

A Soviet Bear-F aircraft on reconnaissance patrol off North America is shadowed by US air defense F-4 interceptors. New Soviet Bear-H bombers capable of carrying the 3,000-kilometer-range, nuclear-armed AS-15 cruise missile sometimes come within fifty miles of US airspace while on routine training missions against North America. At least fifty-five Bear-H bombers are operational. Soviet Blackjack jet bombers now being tested will also carry AS-15 cruise missiles.

OF GLASNOST

change that policy, I don't believe he would be General Secretary very long."

The Afghan Scam

While Soviet ideology and the resultant military policy are treated as sacrosanct dogma by the Kremlin, the portrayal of these commandments to the outside world can shift freely and cynically, the US document points out. The charade of a gradual withdrawal of Soviet forces from Afghanistan is a case in point cited by *Soviet Military Power.* Following General Secretary Gorbachev's televised announcement in Vladivostok last summer that he intended to withdraw a "limited number" of Soviet forces from Afghanistan, beginning with the pullout of six regiments by the end of 1986, the Soviets employed massive and ingenious deception to "document" realization of this hollow pledge. For one, "the Soviets brought in two infantry units from Central Asia expressly for the purpose of being able to remove them."

The Soviets also beefed up understrength units already earmarked for rotation with reinforcements and new equipment from the USSR or from other units stationed in Afghanistan to showcase their withdrawal. After the PR hype, the US document pointed out, most of the equipment and reinforcements were reassigned to units that remain in Afghanistan. Lastly, about half of the units withdrawn as part of this media circus involved air defense forces. Since the *mujahedeen* (the Afghan resistance fighters) have no air force, the US report points out, "the three antiair regiments scheduled to be pulled out were of marginal value to the Soviet military effort."

Broad Array of New Weapons

In hardware terms, the new US intelligence document stresses that the USSR is building new generations of offensive strategic and theater nuclear forces as well as modern conventional land, sea, and air forces and strategic defense forces, going "far beyond legitimate requirements for defense." Among the most noteworthy developments last year cited by *Soviet Military Power* were the following:

- The USSR's newest class of strategic ballistic missile submarine (SSBN), the Delta IV, is entering operational service carrying sixteen SS-N-23 SLBMs. This SLBM, the newest weapon of its type, carries ten warheads. This extremely accurate weapon, US intelligence experts find, will have hard-target kill capability when operated in concert with Glonass, the Soviet equivalent to the US Navstar global positioning system (GPS).
- The USSR's first fifth-generation ICBM, the road-mobile SS-25, now numbers more than 100 launchers, with additional deployments of this Minuteman-size

weapon pending. At the same time, an extensive network of rail support facilities continues to take shape in preparation for the deployment of the rail-mobile MX-size SS-X-24 later this year. Some of these new missiles that carry ten warheads will also be deployed in silos.

The hardness levels of Soviet ICBM silos have been increased to about four times that of the best operational US designs, or about 12,000 psi (pounds of overpressure per square inch). The SS-25 and SS-X-24 are members of the so-called "fifth generation" of Soviet ICBMs. The bulk of all currently deployed Soviet ICBMs represents the fourth generation, consisting of the SS-17s, SS-18s, and SS-19s that were first fielded eight years ago.

By way of a benchmark, the US intelligence assessment points out that the 308 SS-18 Mod 4 ICBMs, by themselves, are capable of destroying between sixty-five percent and eighty percent of all US ICBM silos, while retaining more than 1,000 SS-18 warheads for restrike. In the same vein, the lead in deployed MIRVs that results from the relentless modernization of the Soviet ICBM forces is widening dramatically. Over the past ten years, the number of MIRVs carried by the Soviet ICBM force shot up from about 1,200 warheads to about 6,500 while the US MIRV level remained constant at about 2,200 ICBM warheads. Overall, the operational Soviet ICBM force consists of more than 1,400 silo-based and mobile launchers, which, of and by itself, constitutes a breach of the SALT II agreement that the Soviets—unlike the US—claim to consider binding.

- In addition to the fourth- and fifth-generation ICBMs, the Soviets have started flight-testing a follow-on to the SS-18 Mod 4, bearing the NATO code name Satan. This ICBM will probably have more throw-weight, carry at least ten warheads, and have better accuracy than its predecessor. These attributes suggest unsurpassed effectiveness as a prompt hard-target killer. There is evidence also, according to the latest edition of *Soviet Military Power,* of plans for follow-on systems to both the SS-25 and SS-X-24.
- Not satisfied with an already burgeoning arsenal of SS-20 long-range theater weapons—at least 441 of which are known to have been fielded—the USSR is "vigorously pursuing test-firings" of a still more accurate intermediate-range ballistic missile that is likely to become operational this year. At the same time, deployment of a new generation of shorter-range theater ballistic missiles, the SS-21 and SS-23, continues.
- In terms of air-breathing strategic weapons, strategic aviation is "making a strong comeback in the Soviet Union," according to the new US threat assessment. At least seven Blackjacks, a larger and faster Soviet counterpart to the B-1B, are in advanced flight test. At least fifty-five new Bear-H bombers are operational and can carry the 3,000-kilometer-range, nuclear-armed AS-15 air-launched cruise missiles. Some of these Bears, *Soviet Military Power* points out, routinely fly training missions against North America, at times coming within fifty miles of US airspace. The combination of Bear-H and Blackjack bombers will eventually enable the Soviets to launch hundreds of difficult-to-detect, hard-target-kill-capable AS-15 cruise missiles.
- Along with the operational deployment of air-launched cruise missiles, the USSR is flight-testing SSC-X-4 nuclear-capable, ground-launched cruise missiles as well as nuclear-capable SS-NX-21 sea-launched cruise missiles from submarines.
- Operational deployment of a sophisticated new generation of mobile surface-to-air missiles, the SA-12, has started. One variant, the "Gladiator," or "A" model, is being fielded, while the SA-X-12B/Giant is still under development. The latter type, the US intelligence assessment reports, is deemed broadly effective not only against aircraft and cruise missiles at any altitude but also against tactical ballistic missiles as well as some categories of strategic ballistic missiles. The advent of the SS-12—and its possible deployment by Soviet surrogate forces—could drastically affect the utility of the US SR-71, which heretofore has been largely beyond the reach of hostile surface-to-air weapons.

Upgraded Strategic Defenses

During the past decade, the Soviets allocated resources equivalent to approximately $400 billion to strategic programs, of which about half went to defensive weapons. As a result, the Soviets continue to lead the US in deployed strategic defensive systems by a wide margin, *Soviet Military Power* reports. Key here is the fully operational ABM system ringing Moscow. This system is being expanded to a two-layer network composed of silo-based, long-range, modified and reloadable Galosh interceptors; silo-based, probably nuclear-armed Gazelle high-acceleration interceptors that engage reentry vehicles within the atmosphere; and associated engagement radar systems, including the new Pill Box large, phased-array radar at Pushkino north of Moscow. This modernized two-tiered system is expected to reach operational status within two or three years.

Pacing the ABM defenses is a space-based early warning system resembling the US DSP (Defense Support Program) system, but consisting of ten (rather than three) satellites. The Soviet early warning system provides thirty minutes' tactical warning and can determine the general origin of a given missile. Additionally, two over-the-horizon radars that are directed at US ICBM fields also can give about thirty minutes' warning. The next layer of the Soviet detection and tracking network consists of eleven large Hen House ballistic missile early warning radars situated on the periphery of the USSR. These sensors corroborate the warning information from the satellite and OTH radar systems, determine the size of the attack, and provide target-tracking data in support of antiballistic missile forces.

Backing up these capabilities by providing ballistic warning and tracking are nine LPARs (large phased-array radars), including one at Krasnoyarsk—which, because of its inland location, violates the ABM treaty—and three that were completed last year. These systems and the demonstrated capability of the SA-10 and SA-X-12B/Giant air defense systems to perform ABM functions, the US report charges, create an infrastructure that permits the relatively rapid deployment of a nationwide ABM system.

The Soviet Union also maintains a multifaceted operational strategic air defense system that dwarfs that of the US as well as a wide-ranging research and development program in both traditional and advanced defenses. The operational Soviet ASAT system, which plays a significant strategic role, consists of fifteen inter-

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Together, LTV and Rockwell bring a unique advantage to the RIMS project: a wealth of knowledge and experience that can ensure a successful program.

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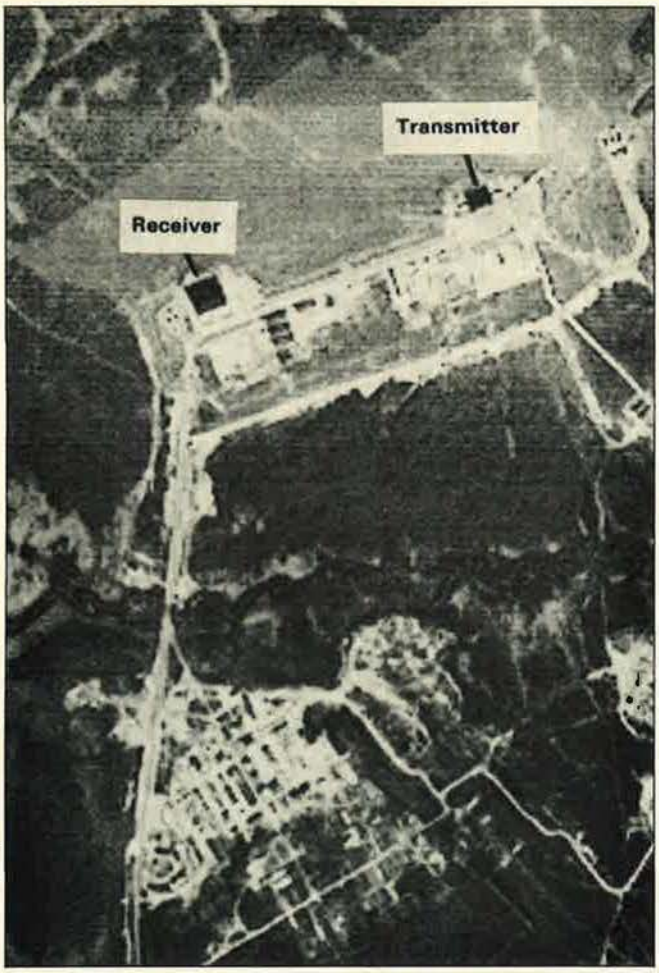

This large phased-array radar at Pechora is one of nine such LPARs under construction or in operation in the Soviet Union for ballistic missile detection and target tracking. One of them—the LPAR at Krasnoyarsk—is suspected of being in violation of the 1972 ABM Treaty by virtue of its design and orientation.

ceptors that can be launched at a rate of five a day. Moreover, the Soviets' passive defense program includes deeply buried shelters—some 800 feet below the surface and protected by solid rock—to protect key elements of the Soviet leadership.

The strategic defensive forces are designed to complement the effectiveness and credibility of the strategic offensive forces in two ways. One is to intercept and destroy whatever hostile strategic weapons—be they missiles or aircraft—that might survive the preemptive strikes of the Soviet offensive forces *before* they can reach their targets on Soviet soil. The other key function assigned to the defensive forces is protection of the Party, state, military, and industrial infrastructures along with key components of the labor force to permit the eventual recovery of the USSR from a nuclear war ahead of any adversary.

Conversely, the job of Soviet offensive strategic forces in the case of nuclear attack is to destroy or neutralize as much of the enemy's strategic forces—regardless of basing mode—before they can be launched. Another mission of the offensive forces is to destroy or disrupt the enemy's command control and communications apparatus. The tools for achieving these tasks are more than 10,000 deployed missile warheads and bombs carried by ICBMs, SLBMs, and bombers with intercontinental range. The most troublesome recent development in the strategic offensive sector, a senior defense official pointed out, is the Soviet commitment to mobile ICBMs, because it is "very, very difficult to . . . find those mobile targets [that] operate as far as 100 miles out of garrison."

Soviet Gains in Space

Support of terrestrial military operations continues to be a top Soviet priority, especially in terms of C^3I, according to *Soviet Military Power.* The USSR operates the world's only military radar and electronic-intelligence ocean reconnaissance satellites. These sensors are eminently capable of detecting and tracking hostile naval forces. The Soviets launch satellites of this type routinely for tests during Soviet and NATO naval exercises.

Robust and versatile launch capabilities are a driving force behind the steady growth in Soviet military space operations. About every third day, the Soviets orbit a military payload, using one of eight types of operational spacelaunch vehicles. The pending deployment of the medium-lift Titan IIIC-class SL-X-16 and of a heavy-lift launcher—comparable to the Apollo program's Saturn V and designated as SL-W—will increase Soviet spacelaunch capabilities even further. The SL-W booster, *Soviet Military Power* points out, will do double duty by serving as the launcher of the Soviet space shuttle orbiter as well as of other heavy payloads weighing around 100,000 kilograms.

The SL-X-16, capable of placing a payload of more than 15,000 kilograms into low earth orbit, will probably serve as the primary launch vehicle for the Soviet space plane, which has been flight-tested by means of a subscale version. This small, manned spacecraft could be used for quick-reaction, real-time reconnaissance missions, satellite repair and maintenance, crew transport, space station defense, satellite inspection, and, if necessary, space combat, according to the new US analysis.

With the SL-X-16 and SL-W, the Soviets will have ten types of expendable launch vehicles, four of which support manned spaceflight, and three different manned space vehicles: Soyuz-TM (an improved crew-ferry vehicle), the Shuttle (whose first launch could come this year or in 1988), and the space plane. The combination of these systems will give the Soviets even greater versatility and redundancy to conduct and augment military operations in space.

Soviet interest in manned military space operations, the US intelligence community believes, impels the USSR's large space-complex program. This large, modular facility—whose construction is expected to get under way within a few years—is to accommodate as many as 100 cosmonauts. Experiments carried out aboard the much smaller Salyut space stations suggest that the Soviets are evaluating the ability of military cosmonauts to locate, identify, and track targets from space as the first step toward "designing a space weapons platform for use against targets in space and on earth." Such a platform, *Soviet Military Power* contends, could be used for ASAT and ballistic missile defense operations as well as space station defense.

Conventional Forces Keep Growing

Concurrent with the expansion of its strategic nuclear forces, Moscow is stepping up modernization and expansion of its conventional warfare forces and capabilities. The Soviet ground forces, the new US report points out, have been boosted to 211 active and five inactive mobilization-base divisions. One of the most significant developments in ground-forces technology brought out by the new US report is Soviet emphasis on reactive armor technology that helps neutralize antiarmor weapons, a concept pioneered by the Israelis. The widespread application of this technology to new Soviet tanks as well as retrofitting it to existing equipment "threatens to shift fundamentally the conventional force balance," according to *Soviet Military Balance*. The basic idea of reactive armor is to dissipate the force of incoming antiarmor rounds by exploding reactive charges.

In the air warfare arena, the new US assessment points out that the Soviet military aircraft industry is "in the midst of a technological revolution." Most of the new military aircraft incorporate much more complex and sophisticated electronic subsystems than did their predecessors. There is evidence that the Soviets have made progress in developing aircraft with low-observable radar signatures. At least one completely new fighter is in development, and several variants of existing, relatively new fighters can be expected to enter production over the next several years.

At the same time, a new airborne warning and control system (AWACS), the Mainstay, is entering the operational inventory in quantity. Primarily meant to handle early warning and air combat command and control, the modified Il-76TD has a true overland look-down capability. There are indications also that in addition to incorporating a new identification, friend or foe (IFF) system, this aircraft may have a comprehensive electronic countermeasures complement.

Two new Soviet attack helicopters, the Havoc and the Hokum, are undergoing prototype testing. Armed with

Soviet Biological Warfare Threat Mounting

A recent Defense Intelligence Agency (DIA) report charges the Soviets with violating the Biological and Toxin Weapons Convention of 1972 by "rapidly incorporating biotechnological developments into their offensive BW program to improve agent utility on the tactical battlefield." Further, the DIA analysis points out that the Soviets "continue to evaluate the military utility of biological and toxin weapons [and] that the size and scope of their efforts are not consistent with any reasonable standard of what could be justified on the basis of prophylactic, protective, or peaceful purposes."

The DIA Director, Lt. Gen. Leonard H. Perroots, acknowledged in the report's foreword that because the lines between military and peaceful biological research are blurred, noncompliance with the 1972 accord is "extremely difficult to identify." Nevertheless, General Perroots pointed out, "The major accident that occurred in the Soviet Union in the city of Sverdlovsk in April 1979 raised concerns that [an] anthrax agent was under investigation at a level beyond what is allowed by the Biological and Toxin Weapons Convention. Indeed, Soviet BW-related activities since World War II lead us to conclude that they have developed and produced biological and toxin agents and the associated hardware for use in BW weapons."

General Perroots went on to explain that US concern is mounting because BW warfare capabilities might be developed also in Third World countries: "We are gravely concerned that we will see BW programs under way in some countries within five years and limited production within a decade."

The DIA report amplified the contention that the USSR continues to develop and produce BW agents as well as to test and evaluate delivery and dissemination systems for these agents by identifying a number of Soviet installations capable of producing disease agents and toxins on a large scale and placing them in munitions and delivery or dissemination systems. At Sverdlovsk, for instance, the DIA believes, the Soviets are developing not only anthrax but tularemia, plague, and cholera for BW purposes as well as botulinum toxin, enterotoxin, and mycotoxins. There is also incontrovertible evidence that the Soviets are working on aerobiology, cloud physics, airborne infections, and disease agent stabilization that have direct application to BW. "Much of the knowledge and technical expertise at these institutions is funded and utilized by the Soviet Ministry of Defense for offensive BW as well as for defensive and protective aspects," according to the DIA report.

BW warfare functions are the responsibility of the Soviet Chemical Troops of the Ministry of Defense, according to the DIA study: "This force has some 45,000 officers and soldiers in the ground forces alone in peacetime. They man special NBC [nuclear, biological, and chemical] reconnaissance and decontamination units [that] are part of ground force formations at all levels from regiment to front. Similar units exist in the other branches of service."

Among the tasks assigned to the NBC forces are RDT&E (research, development, test, and evaluation) of BW and chemical warfare (CW) agents as well as of dissemination systems and the "weaponizing and storage of BW and CW agents," according to the DIA's analysis.

The Soviet Chemical Troops have more than 30,000 vehicles designed specifically for both NBC reconnaissance and decontamination of personnel and equipment. Additionally, almost all newer Soviet vehicles have collective protection systems to permit operation under NBC warfare conditions, according to the DIA.

In order to operate freely in areas contaminated by their own BW weapons, Soviet combat forces are equipped with vaccines and antidotes. In the DIA's view, standard Soviet protective suits and masks, together with sanitary and disease control measures, would be sufficient to protect most Soviet soldiers from the effects of their BW weapons.

Within the intrinsically grisly field of BW warfare, the relatively new discipline of biotechnology is acquiring a singularly ominous prominence. This congeries of diverse spinoffs from medical and agricultural research ranges from genetics and molecular biology to immunology and microbiology. While the long-standing Soviet interest in biotechnology goes back at least to World War II and has its roots in benign industrial objectives, the DIA sees evidence that Moscow—through its Ministry of Defense—is channeling "these same technologies . . . to develop new and more effective BW agents." The DIA analysis warned that with "this biotechnological capability, naturally occurring microorganisms can be made more virulent and manipulated to render current US vaccines ineffective. Such developments would greatly complicate our ability to detect and identify BW agents and to operate in areas contaminated by the Soviets with such biological agents."

Recent advances in biotechnology, the DIA report pointed out, lend themselves readily for BW applications:

"The development of agents having optimal weapons potential is facilitated; basic research [can quickly transition to] mass production; and distinguishing between peaceful research, development, and production and its application for BW purposes becomes more difficult. Finally, we believe smaller nations are going to opt for the BW weapons as they acquire biotechnical capabilities."

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F-16: The Rising Standard in Combat Fighters

F-16 Program Status	Delivered Through April 1987	Total Contracted To Date	Current Acquisition Planning
U.S. Air Force	1,124	1,859	2,729
U.S. Navy		26	52
Belgium	116	160	188
Denmark	58	70	110
The Netherlands	155	214	238
Norway	72	72	98
Israel	97	150	150
Egypt	73	80	120
Pakistan	40	40	46
Venezuela	24	24	36
Korea	15	36	156
Turkey		160	160
Greece		40	60
Thailand		12	20
Singapore		8	20
Indonesia		12	12
Bahrain		12	12
Totals	1,774	2,975	4,207

GENERAL DYNAMICS

either a 23- or 30-mm cannon and as many as sixteen antitank guided missiles, the Havoc's primary quarry will be tanks as well as antitank helicopters. The Hokum, by contrast, is a unique special-purpose helicopter tailored to the air-to-air role. Featuring a coaxial rotor system, retractable landing gear, and a streamlined, jet-aircraft-like fuselage, the Hokum's speed probably ranges around 350 kmh (kilometers per hour). This new helicopter probably will employ air-to-air missiles and a rapid-fire cannon in day, night, and adverse weather conditions in its role as a low-level, tactical counterair system.

A Soviet T-80 tank moves into position for an exercise. The boxlike appendages around its turret are "reactive armor," which explodes to dissipate the force of incoming antitank rounds. Late-model T-80, T-72, and T-64 tanks make up about one-third of the Soviet Ground Forces' 53,000 main battle tanks.

A Cornucopia of New Naval Weapons

The proliferation of new weapon systems, *Soviet Military Power* points out, is evident also in the naval warfare arena. In addition to continuing the production of nine classes of submarines and eight classes of major surface warships during the past year, the USSR also unveiled and began sea trials of a revolutionary new class of amphibious air-cushion vehicles. This landing craft, identified as the Pomornik class, is the largest military air-cushion vehicle ever built. The vehicle is fifty-seven meters long, displaces 350 tons, and is capable of high operating speeds. This craft, which went from building ways to sea trials in less than a year, demonstrates the Soviet Navy's determination to introduce new designs into the fleet.

Another startling new Soviet effort involves WIG (wing-in-ground) amphibious vehicles that cruise efficiently and rapidly at altitudes of less than fifty feet, riding on a cushion of air formed between the wing and the ground during low-altitude flight. Hybrid vehicles of this type can carry heavy loads long distances, especially over water, with great fuel efficiency. One of the Soviet WIG designs under development incorporates six missile launch tubes and is evidently meant to perform antiship missions, according to the US intelligence report.

Organizational Changes and Outlook

While the USSR's military leaders continue to be consulted by the Communist Party's leadership on strategic decisions, *Soviet Military Power* finds that "the standing of the military within the overall Soviet leadership has been somewhat reduced in recent years." This assessment rests, in part, on the fact that Marshal of the Soviet Union Sergei Sokolov, the USSR's Defense Minister, has not yet been made a full member of the Politburo, but remains at the lower status of candidate member. There is evidence that Marshal Sokolov has been passed over for full membership on several occasions, which suggests "a reduction in the status of the armed forces within Soviet decision-making circles," according to the US government assessment.

The ultimate control over all military decisions continues to rest with the Defense Council, which is composed primarily of Party leaders and is chaired by Gorbachev. This body, *Soviet Military Power* asserts, controls "all aspects of national security policy [and] conveys the Party's wishes on all defense, budgetary, organizational, and senior personnel matters." Marshal Sokolov is its only military member.

Linked closely to national security policy is the Soviet Union's foreign policy, which under Gorbachev is taking on a new dynamic dimension: "To energize Soviet foreign policy and to overcome the impression that the influence of the USSR abroad is based solely on its military prowess, Gorbachev has restructured the upper echelons of the country's foreign-affairs apparatus. Eight of eleven first deputy and deputy foreign ministers, in addition to Foreign Minister Eduard Shevardnadze, are Gorbachev appointees."

In addition, more than thirty ambassadors have been replaced, including those in most major Western and Asian capitals. The new appointees, *Soviet Military Power* finds, "are sophisticated men with backgrounds in Party work and international relations as well as knowledge of or experience in dealing with the news media, [well versed in] stressing global interdependence and the flexible, pragmatic nature of Soviet foreign policy."

Central to these changes is the emergence of arms-control policy as the Kremlin's major tool for dealing with the West: "The Soviets are trying to wrest concessions from the US through superficially tempting but one-sided offers [and to] weaken Alliance resolve through protracted negotiations and well-targeted propaganda [aimed at complicating] the funding of US defense programs." Although Moscow's style and rhetoric have changed, the US analysts conclude, the "ultimate goals have not. Expansion of influence and consolidations of gains remain the basic goals of the Soviet Union's activities worldwide." ■

Three million people have had the experience in the past forty years. The duty day still begins early and includes a lot of marching.

IT'S BASIC

BY BRUCE D. CALLANDER

"IF YOU fall into the water, give your name to the instructor and go on. Any questions? Now, I am going to give a lawful order. Failure to obey can result in punishment under the Uniform Code of Military Justice. If you have a medical waiver, wear a medic alert bracelet, or have sustained a recent injury, you are ordered to form a column of twos, females in front, males in the rear. Now! I said twos, not threes. Can't you count? What did you say? I can't HEAR you . . ."

The voice of the military training instructor (MTI) cuts through the chill, damp air with the sound of fingernails being drawn across a blackboard. If you are one of the 3,000,000 men and women who survived "basic" within the last forty years, you can still hear it in your memory.

The column of twos double-times off to a medical examiner for evaluation. The other trainees move, one by one, past a drinking fountain, gulp a few swallows of water, and line up before a muddy pond. Two ropes stretch across it, one about seven feet above the other.

It is the eighteenth day of training (DOT) at the Basic Military Training School, Lackland AFB, Tex. The uniform of the day is fatigues. The scheduled activity is the confidence course. You may have called it the obstacle course—the official name for this human proving ground until some psychologist decided it needed a more positive connotation.

The first trainee steps onto the lower rope, grasping the one above. It looks easy, but as others follow, the flimsy bridge begins to sway.

In one configuration or another, this fiendish theme park has been part of the Lackland landscape since the early 1940s, when the base hosted a preflight school for the aviation cadets of World War II. It has been lengthened and refined a number of times to make it tougher and safer. In whatever form and by whatever name it is remembered, it has remained the most dreaded ordeal in basic.

The trainees make it across the rope bridge and double-time to a pair of chest-high walls. Most hitch themselves up and scramble over easily. Some need a couple of tries. One complains of a pain in his chest and is told to stand aside.

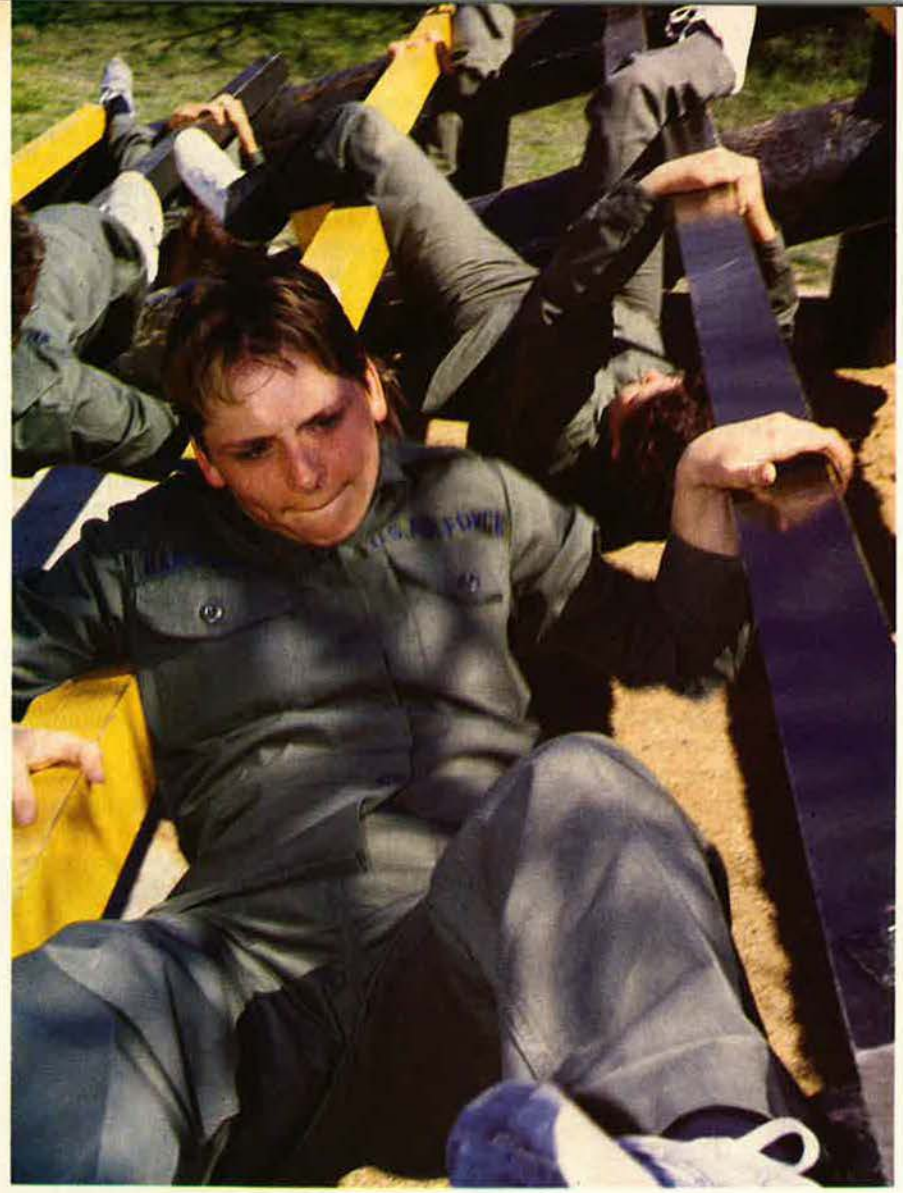
The wall for females is a few inches lower than the other. It is one of the few allowances made for gender differences. Older BMTS alumni will remember other differences. Although women have taken basic training at Lackland since 1948, early classes were strictly segregated. Today's male and female airmen still sleep in separate bays in the dorms, but train together.

More obstacles follow, each a little tougher than the last. A woman murmurs to herself as she double-times between them. The man with the chest pain has caught up but falls out again, this time holding his stomach. An MTI shouts at the other trainees to stop gawking and move on.

It may be called the confidence course these days, but whatever the designation, Air Force recruits still struggle over, around, and under various obstacles. Here, recruits negotiate a water hazard.

You will remember the tone of the MTI's voice, but the pitch might surprise you. These days, the raspy sound coming from beneath the Smokey the Bear hat may not be that of the dog-faced baritone of beloved memory. It could just as well be a soprano voice, filed to give it the edge of a dull razor. Several MTIs are assigned to each flight of forty-five to sixty trainees. The leader may be either male or female.

At the "minefield," the trainees flop to their stomachs on the damp ground. Before them, in parallel rows, is a series of oversized wickets with wires stretched between



Basic training, which has taken place at Lackland AFB, Tex., since the late 1940s, is carefully crafted to challenge the new recruits. Military training instructors (above) are a constant presence.

them to form low tunnels across the field. The trainees crawl slowly forward, walking on their elbows, wiggling their lower bodies like fish. A machine gun spits bursts of flame over their heads. The rounds are blanks, but the sound is real enough. The tunnels, recently lengthened, seem endless, but gradually all inch their way through. Double-timing to the next obstacle, most of the trainees are puffing now, drawing on their reserves.

Carefully Crafted Stress

Remember the feeling? It's not that the obstacles are so physically difficult. It's the carefully crafted stress of the thing. It begins with the lengthy briefing before you are allowed to start, the precise instructions about how to accomplish each obstacle. There is no way you can remember it all. The tension builds with the impatient coaching of the MTIs at each stop, telling you that you're putting the wrong foot here or the wrong hand there. By midcourse you are convinced that your whole future in the service is dangling, literally, at the end of a slippery rope swinging over a dirty ditch.

At the next obstacle, another rope spans another shallow pond. The object is to wrap arms and legs around the rope and travel across upside down, head dangling over the water. At midpoint, a woman shouts that she isn't going to make it. An instructor barks, "Yes, you are! Keep moving!" The woman's legs drop, she holds on for a moment, trying to swing her legs back up to the rope, then lets go and drops into the water. Seconds later, a man falls near her. Both scramble out and run on. An MTI, registering something between disappointment and disgust at their performance, tells the others to keep moving.

The instructor's reaction is more simulated than real. MTIs, themselves the products of an intensive instructor course, are responsible for the well-being of their trainees as well as for their development. They must know when to be tough and when to let up just enough. The trainee is made to feel inadequate, yet at the same time must be convinced that he or she can do better. Physical abuse is taboo, but mental pressure is applied with skill and precision. Trainees are referred to as "males" and "females," rarely as men and women.

The final obstacle has yet another rope, this one dangling over another pool of water. An instructor swings the rope toward the first airman. He jumps, grabs it, and swings across,

letting it swing back for the next person. Missing the rope, grabbing it too low, or letting go too soon will land a trainee waist deep in muddy water. Several take the unwanted bath. Most make it and double-time to their noon meal at another part of the course. For most, it is their first taste of rations in the field.

The course still works, even on a generation said to be the most cynical and most sophisticated in history. The strain shows on the faces of today's airmen as surely as it did on the faces of their parents and grandparents. But so does the triumph of making it. Then come the quiet boasting that it wasn't *that* tough and the dire warnings passed to the trainees yet to face it. Some things never change.

Other things have changed, of course. Married trainees, for example, now make up about twenty percent of the student body. Some couples attend the school together, although they are not assigned to the same flights. Some trainees, both male and female, have spouses waiting off base while they train. Later, the husbands, like the wives, will follow them to their later duty stations.

Testing, Testing . . .

What has not changed is the atmosphere that has pervaded the base since it accepted its first enlisted members for basic training in early 1946, more than a year before there was a separate Air Force. Even the oldest BMTS graduates would find something familiar about this first taste of military life—the arrival in an alien environment, the humiliating clipper cut (limited to a close trim for women), the first night in an open-bay dormitory, the first predawn wake-up, the initial clothing issue, and the first, pathetic attempt at marching.

The faces change, but the routine remains much the same. From 200 to 400 recruits arrive every day. They are assigned to flights of forty-five to fifty-five members each. MTIs hover over them day and night for the first two days and are never far away for the rest of the six-week program. There is a scheduled time for everything—dental processing, aptitude testing, physical conditioning, shots, safety lectures, dormitory inspections, meals—but it seems as though there is never quite enough time for anything.

There is that constant prompting, correcting, and nagging. There's a right way to make a bed, line up footwear beneath it, and lay out a locker. The duffel bag tag must be filled out with name, flight, and squadron and attached to the duffel bag the moment it is issued. Moving a formation through an intersection becomes a complex military maneuver. Arriving late at a formation is made to seem like a capital crime.

During meals, trainees may talk (in a low tone) only with others at the same table. Each must drink two glasses of water with each meal.

Base liberty, the privilege of leaving the squadron area but not the base, is granted after the fifteenth DOT. It is allowed at least one evening a week and on weekends, but is denied to trainees not making satisfactory progress. Those out after dark must carry flashlights and travel in groups of two or more. The one and only town pass, allowing a Saturday or Sunday visit to San Antonio, is permitted after the twenty-fifth DOT. It is preceded by an open-ranks inspection, and—again—the privilege can be denied to trainees making poor progress. Overnight passes are granted only under unusual circumstances.

And, always, there is another lecture, another detail, another briefing, and another form to be filled out completely and in exactly the prescribed manner.

What's the Point?

Critics of the system argue that such slavish attention to routine and detail is unnecessary for today's airmen, most of whom are unlikely ever to do much real "soldiering." They see basic as no more than a dehumanizing process that reduces all recruits to the lowest common denominator. After all, they argue, most of today's recruits are high school graduates with the highest test score averages in history.

Col. Roy D. Sheetz, now in his second year as commander of BMTS, sees it differently. The transition from civilian to military life is an abrupt one, Colonel Sheetz contends, perhaps even more so today than in the past. The Spartan life and demanding schedule of basic quickly mark the dividing line. The program is designed not to crush the spirit of the individual, but to present a challenge and, for those who meet it, a sense of accomplishment. Most important, he believes, it introduces young people, many of them for the first time, to the importance of working as a group.

As for the claim that today's youth are too worldly to respond to the traditional military shape-up-or-ship-out approach, Colonel Sheetz has reservations about that assumption. Admittedly, almost all recruits now have high school diplomas. But, as numerous studies have shown, many of today's high school graduates have been pushed through whether they meet basic requirements or not. For them, BMTS is the first program in which they will succeed or fail on their own merits.

Many recruits arrive deficient in reading and some of the other basic skills. They are expected to read at the eighth-grade level by graduation. Some require intensive remedial instruction to make it.

Colonel Sheetz says that most recruits are also in poor physical condition when they arrive. Except for the relative few who were athletes in high school, they show the effects of too much junk food and too little exercise. The physical requirements for BMTS graduation are only slightly higher than normal Air Force standards, but many trainees have a tough time meeting them. If anything, Colonel Sheetz says, he would like to make the conditioning program harder.

The tight schedule, the demanding curriculum, and the authoritarian stance of the MTIs come as a shock to some recruits, particularly those who are used to getting their own way even when they put out little effort. Many see the program and military life in general as a game they can play on the same terms they always have. Colonel Sheetz says that basic is designed to dispel that notion quickly and remove those who don't get the word.

A sergeant in his third year as a military training instructor agrees. Soft-spoken and a little shy in casual conversation, he admits that he had trouble at first getting into the role of the demanding, never-quite-satisfied MTI. It was against his upbringing to shout at anyone, particu-

larly at a woman. He had the normal human desire to be liked.

He quickly realized, however, that if he didn't take charge, the trainees would soon be running the program. By the time he had guided one class of recruits through their six weeks, he had seen most of the ways trainees try to manipulate their MTIs—the macho-male approach, the helpless-female act, the wheeler-dealer artist, the crocodile tears, the feigned ailment, and all the rest. He now lets his charges know from Day One that none of it works.

In one sense, the program, with its hospital corners on the beds and march-everywhere exaggerations of military life, may be a game. But it is one played with the same deadly seriousness that the Air Staff would give to conducting a simulated war maneuver. To make the point, the sergeant opened a trainee's wall locker. Fatigues were hung on hangers in a precisely prescribed order. Underwear, socks, and personal effects were laid out as though the owner had placed each item according to some divinely drawn blueprint.

"In a few weeks," the sergeant said, "that airman may be working on a $16 million aircraft. I wouldn't want to trust the plane and its pilot to somebody who couldn't follow simple instructions about where to put his or her socks in a locker." The sergeant takes his own role-playing just as seriously. Not too long out of his teens himself, he has learned how to play understanding parent, older brother, father confessor, or strict disciplinarian as the situation demands.

His three-year tour as an instructor nearing an end, the sergeant has extended for another year. He concedes that it is a hard job with long hours and many responsibilities. But he also finds it uniquely rewarding. His previous assignment was with a large organization in which his own contribution seemed to go virtually unnoticed. As an MTI, he has almost complete charge of his recruits and watches them grow day by day. "Where else," he asked, "can you find such a sense of accomplishment in just six weeks?"

Most trainees are housed in modern Recruit Housing and Training facilities (RH&Ts), but the open-bay concept is still used in the school's ten training squadrons (above). All areas of military life, including firing an M-16 machine gun, are part of the BMTS curriculum (above, right).

By the Numbers . . .

That transformation does not come easily, however. The program calls for five twelve-hour training days per week. Weekends and holidays are "free," but trainees are confined to the base for most of these and may be assigned to KP and other details.

The duty day begins at 0500 and ends at 2100 hours. Much of it is spent marching, double-timing, or running. The bulk of the 360-hour formal curriculum is given to what is broadly termed military training. This includes everything from drill and inspections to dormitory maintenance and briefings by MTIs. About forty hours are devoted to physical fitness, including weight checks and the confidence course.

Academic subjects cover slightly more than forty hours and include customs and courtesies of the service, military law, Air Force history, career advancement, personal affairs, and, in recent years, substance abuse and human relations. Processing, which embraces every-

thing from clothing issue to medical exams, aptitude testing, and personal interviews, covers about another seventy-five hours.

Trainees are allowed 336 hours for sleep, 126 hours for meals, twenty-seven hours for study, and about fifty hours of personal time.

The program is outlined step by step in a Daily Operating Guide for MTIs. A Student Study Guide serves as textbook, almanac, and scripture for trainees. There is a fixed time for everything from issuing field jackets on the day of arrival to taking the group photo of the flight on the thirtieth and final DOT. Trainees must sign out and sign in for sick call and other appointments. They march in formation to class and most other activities, posting road guards whenever they cross an intersection. Often they double-time, provided that ninety minutes have elapsed since their last meal. They do their physical conditioning exercises en masse and by the numbers, run a prescribed number of laps, and do another set of exercises.

When it is over, the graduate should know how to wear the uniform, where the color guard stands in a formation, what Billy Mitchell did, and how to behave as a prisoner of war. He or she will not have learned how to fix an airplane, manage an office, or supervise a group of airmen, but should know how to take orders and why it is necessary to do so.

Trainees may not use alcoholic beverages while in basic, not even on the one-day pass allowed after the twenty-fifth day of training. Enforcing the ban off base has become less of a problem since Texas raised the drinking age to twenty-one. Most basics are below that age.

Use or possession of drugs is cause for dismissal. So are theft and committing homosexual acts. There is no voluntary withdrawal provision, and airmen dismissed for cause do not have veteran status or qualify for benefits. Neither do those with physical defects that existed before they enlisted. The washout rate is running about eight percent at present and is roughly the same for both sexes.

Smoking is not banned, but is discouraged. MTIs no longer announce breaks from drill with the traditional, "Smoke if you wish." The idea is to encourage airmen to stop smoking or at least to cut down, but Colonel Sheetz says he would not like to have to enforce a total ban on smoking. It would be too hard to police and, he thinks, too trivial a violation to require dismissal.

Colonel Sheetz says he rarely receives complaints from parents about the program. When he does, it is often because a trainee has given them an exaggerated description of the training. One creative airman wrote his worried family that his training was being cut short and he was on alert for shipment to some Mideast hot spot. More common are the notes Colonel Sheetz receives after graduates have had their first home leave. Typically, parents say they are pleased at the sudden maturity of their sons and daughters. The boys and girls who left home have returned as men and women.

Time for Changes?

Even if it still works that magical metamorphosis, however, does basic prepare airmen for life in today's Air Force and that of the next century? Periodically, the using commands have a chance to debate that question. They are invited to send representatives to review the program and recommend changes. Such a review was scheduled for the spring of 1987, and Colonel Sheetz urged commands to include their top enlisted advisors among their delegates.

Past reviews have considered a number of changes, such as including more chemical warfare (CW) training in the program or introducing a basic course in leadership.

Usually, the delegates abandon such ideas after taking a closer look at the program. They conclude, for example, that CW training is more effective when airmen are assigned overseas, where the need for it is more apparent. NCO leadership training is also premature in basic, Colonel Sheetz believes. Although recruits are given minor responsibilities, such as serving as barracks orderlies, he says they have enough on their hands at this stage just learning to be followers.

In fact, although it has undergone some fine tuning, the program has seen no revolutionary changes since the course was set at six weeks and the curriculum standardized in 1965. Colonel Sheetz himself says there is little he would like to see changed now. He would like to have more computer-based training aids and to substitute simulators and laser scoring for live weapons training. The simulators would be expensive to install, but would save money in the long run by eliminating the need for firing ranges.

If the program has to change in the future, it is more likely to be because of the numbers and types of recruits available. Air Force Secretary Edward C. Aldridge, Jr., has warned that another manpower crunch may be in the offing as the Air Force takes on additional missions and faces stiffer competition for qualified personnel.

If recruiting does become more difficult, the Air Force could be faced, as it has been in the past, with the hard choice between operating shorthanded or lowering enlistment standards. The Air Force has long held that a high school diploma is evidence of an individual's ability to complete a program of study and thus is a better indicator of probable success in the service than are test scores alone. Ideally, the service would like high school graduates

Some days during basic training, it seems like there's always another hurdle to overcome (left), but all the effort is worth it, though, when graduation day arrives at the end of a trainee's stay at Lackland.

who also do well on the tests. But, forced to make a choice, it often has chosen to accept high school graduates with somewhat lower scores over nongraduates with somewhat better scores.

Either choice makes the job at BMTS tougher, however. The school already has to give remedial education to some airmen who enter with both high school diplomas and fairly high test scores. Colonel Sheetz concedes that less qualified airmen could be pushed through basic with added remedial training and measures. With the cost of remedial training already running about $105 per day per trainee, however, the cost of lowering standards could be high.

Even with additional attention, less-qualified trainees probably would have a higher washout rate unless the Air Force also decided to lower the requirements for graduation. That is not a happy prospect for officials who have seen the results of such compromises.

Some still remember a social experiment of the mid-1960s as a practical demonstration of the folly of lowering standards too much. As part of an administration effort to reduce unemployment, the Pentagon had ordered the services to accept 100,000 previously unqualified recruits per year. The Air Force took its share, including many non-high school graduates with low test scores. It provided extensive remedial education, simplified courses, and recycled many of the trainees through basic a second or third time. In the end, the washout rate for "Project 100,000" airmen was far higher than for other basics, and many of those who did graduate later failed in technical training or did poorly in service.

Colonel Sheetz concedes that BMTS could deal with modest changes in academic and physical standards, but he argues that a drastic lowering of quality would be costly not only in dollars but in terms of the Air Force's effectiveness.

Life After Basic

Basic, after all, is not an end in itself, but just the beginning of a training process that will continue for most airmen throughout their careers. Many go on to technical schools. The rest are assigned directly to bases for on-the-job training. Graduation from BMTS does not assure success in service. At best, it is designed to weed out those thought most likely to fail and send on those most likely to succeed.

For many graduates, however, the transition to the "real" Air Force is a letdown. After six weeks of being marched, disciplined, and corrected, they find life on an operating base lax. Suddenly, nobody nags them about their uniforms. Physical conditioning is sporadic. Parades are rare. The customs and courtesies learned so carefully are given little more than lip service. The rest of the Air Force, they find, does not operate as they had been led to expect. Some airmen take the change as a signal that the rules no longer apply. They relax too thoroughly, and their commanders complain that BMTS hasn't done its job.

Like a number of Air Force leaders, Colonel Sheetz thinks this postgraduate syndrome indicates less that basic training is unrealistic than it does that operating units fail to apply the standards they expect BMTS to teach. Like the USAF Academy and Lackland's own Officer Training School, BMTS does not try to duplicate everyday life in the Air Force. No combat organization could spend its time marching or making show-down inspections and still accomplish its mission.

What BMTS tries to do is introduce groups of widely assorted civilians to a way of life most find completely foreign. In fast, heavy doses, it gives them a taste of discipline, a smattering of academic knowledge, a program of physical conditioning, and the rudiments of the profession of arms. If it works, the graduates leave with a sense of accomplishment, a higher level of self-worth, and some notion about what they want to do with their lives or at least with the next several years.

The formula may not be the best that could be devised, but it seems to have gotten the job done for several decades. ■

Bruce D. Callander was a Fifteenth Air Force B-24 bombardier during World War II and was recalled to active duty as an information officer during the Korean War. Between tours of active duty, he earned a B.A. degree in journalism at the University of Michigan. He joined the staff of Air Force Times *in 1952 and became Editor in 1972. Now a free-lance writer, Mr. Callander wrote the article "The Uncertain Art of Career Management" for our April '87 issue.*

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VIEWPOINT

The Swallows and Their Friends

By Gen. T. R. Milton, USAF (Ret.), CONTRIBUTING EDITOR

Standard security programs are not enough to stop the trading of secrets for money or sex. Perhaps the death penalty would be a more effective deterrent.

Mike Royko, the Chicago *Tribune* columnist, once said that hating the New York Yankees was as American as pizza pie, unwed mothers, and cheating on your income tax. Royko, a satirist in the tradition, if not the precise syntax, of Mark Twain, hit several targets with that barbed dart.

There is little question that when it comes to conventional morality, we have slipped a bit. The epidemic drug plague, explicit entertainment that once would have drawn police raids, and a general lowering of the bars have all made their contribution. A result has been the outbreak of treason, from the Walker gang who betrayed for money, to Jonathan Pollard, whose motives were mixed but money was certainly one of them, to the US Marines who succumbed to KGB swallows. Somehow people like these never seemed to surface in the olden days. Our spy scandals centered on ideologues who, however misguided and traitorous, nonetheless believed in another system.

It is hard to guess what damage has been done to national security by this outbreak of treason. The Walkers, according to our government's admission, did severe harm with a sophisticated operation extending over a long period of time. From what we have heard, the Marine guards, at the very least, made Mr. Gorbachev's preparations for Reykjavik an easy chore and caused the execution of some of our Russian agents. Beyond that, there is no telling what expert operators with a free afterhours run in the Moscow American Embassy were able to learn. Sadly, KGB unguided tours may not have been limited to the embassy in Moscow.

All this makes a joke of the ostentatious security that prevails at any of our diplomatic missions between 9:00 and 5:00. During those hours, a visitor waits for an escort to take him past the Marine guards. Thereafter, the visitor is never allowed to venture from one office to another unescorted. Very impressive—but Swallow's Uncle Sasha padded around our Moscow building free as a bird.

Well, the harm, whatever it amounts to, is done, and we can assume the usual steps are being taken to prevent a repetition. Looking back, there does seem to have been an almost incredible laxity. John Walker, despite evidence that he was living well beyond his presumed income, might still be emptying the top-secret vaults had it not been for a scorned wife. And she, in turn, would evidently have kept quiet had she known her son was involved. As for the embassy lapses, it is difficult to believe that in Moscow, of all places, two young Marines, alone, stood between the KGB and a relaxed look around.

Almost twenty years after World War II, we learned that some of the great allied victories had not been solely the result of tactical genius. Our side had been reading the enemy's mail. Field Marshal Montgomery at Alamein, for example, could scarcely have been better informed of Rommel's logistic problems, his plans, and his orders from Hitler had he been at Rommel's staff meetings. And while Montgomery is said to have resented this advantage, others, like the eminently practical General Spaatz, cheerfully welcomed the chance to share in the enemy's message traffic.

It was our great good fortune that the Germans did not have a similar success in code breaking. If they had been privy to allied coded communications, the elaborate charade of phantom preparations for an invasion in the vicinity of Calais, for instance, would surely have been exposed. With the enemy forewarned, Normandy—a near-run thing, to paraphrase Wellington after Waterloo—might have been a military disaster. Yet, even with this edge, victory was a long and bloody time coming. It is a sobering reflection to imagine that war fought with our codes an open book to the other side.

In any case, our codes appear to be broken now, and we have just seen the humiliating spectacle of an American Secretary of State deprived of secure communications in his own Moscow embassy. It will be a while before that link is patched, the embassy debugged, and security over national secrets reestablished. If we were on the verge of hostilities, the advantage to the enemy would be distinct and our nation imperiled because of this treasonous behavior.

Plainly, something must be done to halt this trade in selling out the country. Appeals to patriotism are fine, as is the judicious use of the polygraph, but we have already learned that this is not enough. Security checks, though expensive, are thorough within the limits of that inexact procedure and usually weed out the obvious risks. Walker, Pollard, and Whitworth, on the other hand, had sensitive clearances.

When these latest scandals blow over, as they will in due course, the Soviets will once again plug away at learning our secrets as we will plug away at learning theirs. The difficulty lies in the differing attitudes of the two countries toward traitors. Punishment in the USSR is swift and final for anyone caught dealing in Soviet secrets. The thought of execution is a powerful inhibitor to anyone contemplating treason. In contrast, even a life prison sentence in the US can end after a reasonable number of years.

We are playing the game on uneven ground and according to different rules. Senator Dole is on the right track in sponsoring a bill calling for the death penalty in cases of peacetime treason. ■

Two Days in May

F-4 Squadron Commander Bob Titus had waited a long time for those days. When they came, seventeen years of experience paid off.

BY JOHN L. FRISBEE
CONTRIBUTING EDITOR

ROBERT F. Titus graduated from the Test Pilot School at Edwards AFB in 1954, a young combat veteran with 101 fighter missions in Korea. During the next decade, he did experimental and test flying in most US and several European fighters and made the first jet fighter polar crossing from Germany to Alaska in an F-100F.

In 1965, Titus was selected as project officer for the F-5A "Skoshi Tiger" combat evaluation in South Vietnam. He flew more than 300 missions from Bien Hoa with the unit, then, the next year, did in-theater flight tests to speed up certification of new weapons. When he was named CO of the 389th Tac Fighter Squadron at Danang, Bob Titus brought with him a wealth of fighter experience and a burning desire to tangle with North Vietnam's MiG-21s. That desire wasn't to be completely fulfilled until the air war took a different turn that brought him two momentous days in May 1967.

Until late 1966, the F-4s had a primary strike mission in support of Rolling Thunder, the air campaign against military targets in North Vietnam. The MiGs seldom appeared until September 1966, when the North's fighter force had grown to about 100 planes based near Hanoi. As the MiGs became increasingly aggressive, some F-4s were diverted from their strike mission for air combat against the MiGs. On May 20, 1967, Bob Titus became one of the few USAF pilots up to that time to shoot down a

Robert F. Titus received the Air Force Cross for downing two MiGs in one day.

MiG-21. That was prelude to one of the best days north of the DMZ that any USAF fighter jock could ask for.

On May 22, Titus led eight F-4s, escorting an F-105 strike force to a target near Hanoi. This is how he remembers the action that day:

"I was high and to the right of the Thuds and received word that MiGs were airborne at Hanoi. We got a radar lock-on and jettisoned external tanks. The radar steering dot moved to the right side of the scope, but I couldn't pick them up visually. I had turned away from the strike force about ninety degrees and was concerned about leaving them without cover. The MiGs didn't appear to be an immediate threat, so we turned back and resumed our high position so I could see the entire box of Thuds.

"Shortly after that I saw two MiGs coming in fast at six o'clock. They fired missiles and continued straight past the formation as I pulled up and turned left to meet them, reversed to the right as they overshot, switched to Sidewinders, picked up a strong signal from the Number 2 MiG, and released a missile that drove right up his pipe. He exploded in a huge fireball.

"I immediately concentrated on the other MiG. He broke left in a tight diving turn, and I followed. By now there was too much ground return for the missile to pick up the MiG, so I switched to the externally mounted M61 gun that 'Boots' Blesse [Col. Frederick C. Blesse, then Director of Operations for the 366th Tactical Fighter Wing at Danang] had thoughtfully ordered installed the previous week.

[Earlier, Defense Secretary Robert McNamara's nonflying "Whiz Kids" had decreed that in the air-to-air missile era, guns were excess baggage.]

"I put the pipper in a lead position, and he reversed. I turned, attempted again to get a lead, and again he reversed. We kept this up in a series of rapid, twisting, hard-turning, rolling maneuvers from 25,000 feet or so down to about 2,000 feet. We were in the vicinity of Hoa Lac airfield and were picking up quite a bit of flak and apparently a number of SAMs. My backseater, Capt. Milan Zimer, later told me he counted five.

"Finally the MiG rolled wings level and started a high-G pullout at about 1,500 feet. I got the pipper on him and fired a long burst. He slowed rapidly. I overshot, pulled up, reversed, put the pipper on him again, but my gun had jammed. I called for my wingman to take him, but the MiG by now was in a shallow dive, rocking his wings, and continued down until he hit the ground. It was an exciting, brief episode that culminated seventeen years of fighter flying and training. We joined up and headed home, low on fuel as usual, but satisfied with a good day's work."

Bob Titus, now a retired brigadier general living in Colorado Springs, was awarded the Air Force Cross for that mission—one of the rare occasions when a US pilot shot down two MiGs in a single day. He has only one regret about his combat experience in Vietnam. "There was too little air-to-air work for a thirsty fighter pilot."

Some of Uncle Ho's MiG pilots who are alive today might not agree with that. ■

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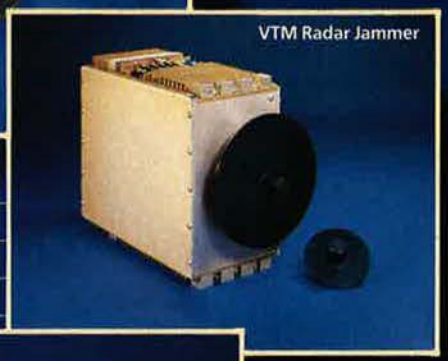
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The prototype McDonnell Douglas F-15E made its first flight at St. Louis on 11 December 1986

MCDONNELL DOUGLAS

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MCDONNELL DOUGLAS F-15E

The F-15E is a two-seat dual role version of the Eagle capable of performing long-range, deep interdiction, high ordnance payload air-to-ground missions by day or night, and in adverse weather, while retaining its proven air-to-air capabilities. The demonstrator, known initially as Strike Eagle, was developed with industry funds as a modification of a two-seat F-15B (71-291). The rear cockpit was upgraded with four multi-purpose CRT displays for radar, weapon selection, and monitoring of enemy tracking systems. Production F-15Es also have front cockpit modifications that include redesigned 'up front' controls, a wide field of view head-up display, and three CRTs providing multi-purpose displays for improved navigation, weapons delivery, and systems operation, including moving map displays, weapons options, precision radar mapping, and terrain following.

For tactical target missions at night and in all-weather conditions, the F-15E has advanced radar and infra-red systems. A new high resolution synthetic aperture Hughes APG-70 radar, wide-field forward looking infra-red (FLIR), and Martin Marietta LANTIRN navigation and targeting pods will ensure target detection/identification, and improve the accuracy of weapons delivery. Successful integration of these systems was demonstrated during 1982 in flight tests at Edwards AFB, Calif., and Eglin AFB, Fla., resulting in accurate 'blind' weapons delivery.

Some sixty per cent of the F-15's structure was redesigned to create the F-15E, and the airframe is expected to have a fatigue life of 16,000 flight hours. To accommodate the new avionics, internal fuel capacity has been reduced slightly, to 7,643 litres (2,019 US gallons), by reducing the capacity of one fuselage tank; but for increased payload/range capability the F-15E can utilise standard F-15 conformal tanks with a full complement of bombs carried on integral, tangential bomb racks. The conformal tanks add 5,678 litres (1,500 US gallons) of fuel for increased range, and can be used in conjunction with up to three 2,309 litre (610 US gallon) external fuel tanks. In addition to carrying a variety of guided and unguided bombs, and other air-to-ground weapons, the F-15E retains its air superiority performance and weapons (AIM-7 Sparrow, AIM-9 Sidewinder, and AIM-120 AMRAAM missiles).

A digital, triple redundant Lear Siegler Astronautics flight control system is installed in the F-15E, permitting coupled automatic terrain following, and a Honeywell ring laser gyro inertial navigation system provides quick reaction alignment and

Artist's impression of F-15E in deep interdiction configuration. Six Mk 82 bombs are attached to the conformal fuel tanks. Under each wing are two AMRAAM missiles and a GBU-10 laser guided bomb. The centreline drop tank is flanked by LANTIRN pods

improved navigational accuracy. A new engine bay developed by McDonnell Douglas enables the F-15E to be powered by either General Electric F110 or Pratt & Whitney F100 engines. The engine bay structure consists of large titanium sections manufactured with superplastic forming and diffusion bonding processes, and will permit future installation of growth versions of these engines, providing a total of up to 266.9 kN (60,000 lb st) in the aircraft's two-engine installation. An F-15 powered by Pratt & Whitney's improved F100-PW-220 engine was delivered to the 33d TFW at Eglin AFB, Fla., in August 1986 for in-service evaluation. The F-15E incorporates digital electronic engine control, engine trimming and monitoring systems.

US Air Force and McDonnell Douglas pilots began flight testing product improvements for the F-15E on four Eagles, including an F-15C, an F-15D, and the Strike Eagle, at Edwards AFB in November 1982. The test programme was completed successfully on schedule on 30 April 1983, after more than 200 flights. During tests, an F-15 took off for the first time at a gross weight of 34,019 kg (75,000 lb), *i.e.*, 3,175 kg (7,000 lb) more than the standard max T-O weight of the F-15C with conformal fuel tanks. On this occasion, the aircraft was equipped with two CFTs, three other external tanks, and eight 500 lb Mk 82 bombs. In the overall programme, 16 different stores configurations were tested, including the carriage of 2,000 lb Mk 84 bombs and BDU-38 and CBU-58 weapons, delivered by both visual and radar means.

After evaluating the potential of the dual role Eagle against that of the General Dynamics F-16XL, USAF announced on 24 February 1984 that it had selected the F-15E for development. Design work began in April 1984 under an initial increment of a $359.4 million fixed-price incentive contract. Construction of the first of three F-15E prototypes began in 1985. This aircraft (86-183) made its first flight on 11 December 1986 and took part in an official roll-out ceremony at McDonnell Douglas's St. Louis, Mo., plant one week later. The first production F-15E is expected to fly in December 1987, for delivery to USAF's 405th Tactical Training Wing at Luke AFB, Ariz., in January 1988. The US Air Force plans to procure 392 dual role Eagles. IOC is expected in late 1988.

The following description refers to the F-15E where it differs from the F-15C:

TYPE: Two-seat dual role attack/air superiority fighter.

FUSELAGE: Upper rear fuselage, rear fuselage keel structure, main landing gear doors, and some rear fuselage fairings incorporate superplastic-formed/diffusion bonded (SPF/DB) titanium structure, providing additional engine bay volume to permit compatibility with alternative engines.

LANDING GEAR: Bendix wheels and Michelin AIR X radial tyres on all units. Nosewheel tyre size 22 × 7.75-9; mainwheel tyres size 36 × 11-18; tyre pressure 21.03 bars (305 lb/sq in) on all units. Bendix five-rotor carbon disc brakes.

ACCOMMODATION: Two crew, pilot and weapons system officer, in tandem on McDonnell Douglas ACES II ejection seats. Single-piece, upward-hinged canopy.

ARMAMENT: One 20mm M61A1 six-barrel gun in starboard wingroot, with 512 rounds. General Electric lead computing gyro. Provision on underwing (one per wing) and centreline pylons for air-to-air and air-to-ground weapons, and external fuel tanks. Wing pylons use standard rail and ejection launchers for AIM-9 Sidewinder and AIM-120 AMRAAM air-to-air missiles; AIM-7 Sparrow and AIM-120 AMRAAM can be carried on launchers on centreline station, or on tangential stores carriers on conformal fuel tanks (maximum total load four each AIM-7 or AIM-9, up to eight AIM-120). Single or triple rail launchers for AGM-65 Maverick air-to-ground missiles can be fitted to wing stations only. Tangential carriage on CFTs provides for up to six bomb racks on each tank, with provision for triple ejector racks on wing and centreline stations. The F-15E can carry a wide variety and quantity of guided and unguided air-to-ground weapons, including Mk 20 Rockeye (26), Mk 82 (26), Mk 83 (15), Mk 84 (seven), BSU-49 (26), BSU-50 (seven), GBU-8 (five), GBU-10 (seven), GBU-12 (15), GBU-15 (two), GBU-22 (15), GBU-24 (five), CBU-52 (25), CBU-58 (25), CBU-71 (25), CBU-87 (25), CBU-89 (25), CBU-90 (25), CBU-92 (25), CBU-93 (25) bombs; LAU-3A rockets (nine), SUU-20 training weapons (five), A/A-37 U-33 tow target (one), B-57 and B-61 series nuclear weapons (five), and AGM-65 Maverick (six). An AXQ-14 data link pod is used in conjunction with the GBU-15; LANTIRN pod illumination is used to designate targets for the GBU-12, -22, and -24 laser guided bombs.

WEIGHTS:

Basic operating weight empty	14,379 kg (31,700 lb)
Max weapon load	10,659 kg (23,500 lb)
Max fuel weight:	
internal	5,952 kg (13,123 lb)
external (two CFTs and three 610 USG drop tanks)	9,818 kg (21,645 lb)
Max T-O weight	36,741 kg (81,000 lb)
Max zero-fuel weight	28,440 kg (62,700 lb)
Max landing weight:	
unrestricted	20,094 kg (44,300 lb)
at reduced sink rates	36,741 kg (81,000 lb)

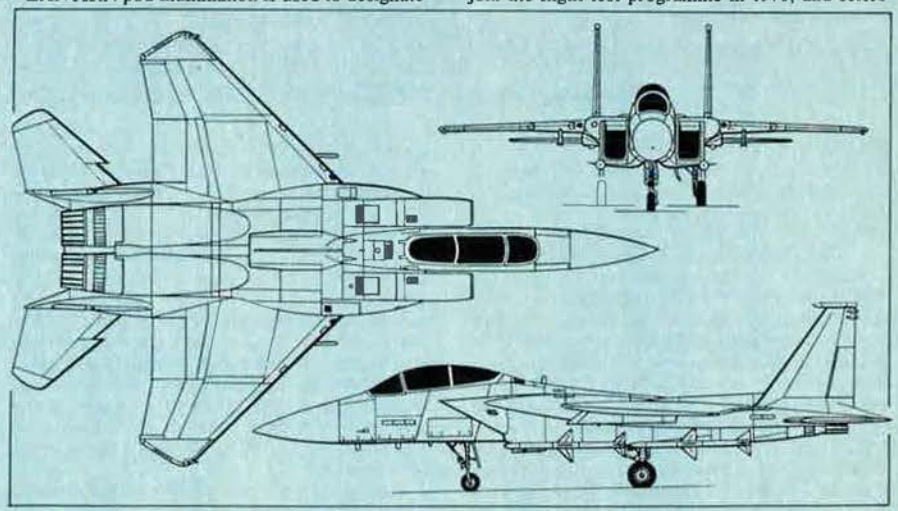
AERO

AERO VODOCHODY NÁRODNÍ PODNIK (Aero Vodochody National Corporation), Vodochody, p. Odelená Voda, near Prague, Czechoslovakia

AERO L-39 ALBATROS

The L-39 basic and advanced jet trainer was developed by a team led by Dipl Ing Jan Vlcek, working in close co-operation with the USSR. Two prototype airframes were built initially, of which the first (X-01) was used for structural testing. The first flight, on 4 November 1968, was made by the X-02 second aircraft (OK-32). By the end of 1970, five flying prototypes (X-02/-03/-05/-06/-07) and one other (X-04) for fatigue testing had been completed. Slightly larger and longer air intake trunks were fitted after preliminary flight tests.

A pre-production batch of ten aircraft began to join the flight test programme in 1971, and series



F-15E dual role Eagle in air defence configuration, with Sparrow air-to-air missiles and no conformal tanks *(Pilot Press)*

production started in late 1972, following official selection of the L-39 to succeed the L-29 Delfin (1974–75 *Jane's*) as the standard jet trainer for the air forces of the Soviet Union, Czechoslovakia, and the German Democratic Republic. Service trials took place in 1973 in Czechoslovakia and the USSR, and by the spring of 1974 the L-39 had begun to enter service with the Czechoslovak Air Force. Other recipients include Afghanistan (18), Cuba (30), Ethiopia (12), Iraq (80), Libya (170), Nigeria (10), Romania (35), Syria (100), and Viet-Nam (25).

By May 1977, when the L-39 made its first appearance in the West, at the Paris Air Show, some 400–500 were in service with several air forces. Production had totalled more than 1,900 by the beginning of 1987, and is expected to continue for at least five more years, at the rate of 200 a year. The Albatros is used in Czechoslovakia for all pilot training, including that of helicopter pilots. On average, pupils solo after approx 14 hours' dual instruction on the L-39 C.

Official Czechoslovak designations for the L-39 are as follows:

L-39 C. Basic version, for basic and advanced flying training, to which the detailed description chiefly applies. Two underwing stations only. In service with the air forces of Afghanistan, Cuba, Czechoslovakia, Germany (Democratic Republic), and USSR. In production.

L-39 V. As basic L-39 C, but modified as single-seater and equipped with winch and 1,700 m (5,575 ft) cable in rear cockpit for towing KT-04 targets for anti-aircraft artillery training. Prototype (X-08) first flown late 1972.

L-39 Z0. Jet trainer with four underwing weapon stations (Z = Zbrojní: armed) and reinforced wings. Prototype (X-09) first flown 25 August 1975. Export customers include the air forces of Iraq, Libya, and Syria. In production.

L-39 ZA. Ground attack and reconnaissance version of L-39 Z0, with underfuselage gun pod and four underwing weapon stations; reinforced wings and landing gear. Prototypes (X-10 and X-11) first flown 1975–76. In service with the air forces of Czechoslovakia and Romania. In production.

L-39 MS. New version with improved airframe, more powerful engine (approx 23.5 kN; 5,300 lb st), and upgraded avionics and equipment, including electronic displays. Prototype was flying in 1985 with standard AI-25 TL engine. New power plant, available during the current year, will be used to enhance performance rather than payload. In particular, rate of climb will be improved by about 20 per cent. No other details received for publication.

The following description applies to the current production L-39 C basic version, except where indicated:

TYPE: Two-seat basic and advanced jet trainer; L-39 ZA also has ground attack and reconnaissance capability.

WINGS: Cantilever low-wing monoplane, with 2° 30′ dihedral from roots. Wing section NACA 64A012 mod. 5. Incidence 2°. Sweepback 6° 26′ on leading-edges, 1° 45′ at quarter-chord. One-piece all-metal stressed skin structure, with main spar and auxiliary spar; four-point attachment to fuselage. All-metal double-slotted trailing-edge flaps, operated by push/pull rods actuated by a single hydraulic jack. Flaps retract automatically when airspeed reaches 167 knots (310 km/h; 193 mph). Small fence above and below each trailing-edge between flap and aileron. Mass balanced ailerons, each with electrically operated servo tab; port tab, used also for trim, is operated by electromechanical actuator. Flaps deflect 25° for take-off, 44° for landing; ailerons deflect 16° up or down; airbrakes deflect 55° downward. Non-jettisonable wingtip fuel tanks, incorporating landing/taxying lights.

FUSELAGE: Metal semi-monocoque structure, built in two portions. Front portion consists of three sections, the first of which is a laminated glass-fibre nosecone housing avionics, antennae, battery, compressed air and oxygen bottles, and the nose landing gear. Next comes the pressurised compartment for the crew. The third section incorporates the fuel tanks, air intakes, and the engine bay. The rear fuselage, carrying the tail unit, is attached by five bolts and can be removed quickly to provide access for engine installation and removal. Two airbrakes side by side under fuselage, just forward of wing leading-edge, actuated by single hydraulic jack; these are lowered automatically as airspeed nears a maximum of Mach 0.8.

TAIL UNIT: Coventional all-metal cantilever structure, with sweepback on vertical surfaces. Variable incidence tailplane. Control surfaces actuated by pushrods. Electrically operated trim tab in each elevator; servo tab in rudder. Elevators deflect 30° up, 20° down; rudder 30° to right and left.

LANDING GEAR: Retractable tricycle type, with single wheel and oleo-pneumatic shock absorber on each unit. Gear is designed for a touchdown sink rate of 3.4 m (11.15 ft)/s at AUW of 4,600 kg (10,141 lb). Retraction/extension is operated hydraulically, with electrical control. All wheel well doors close automatically after wheels are lowered, to prevent ingress of dirt and debris. Mainwheels retract inward into wings (with automatic braking during retraction), nosewheel forward into fuselage. K24 mainwheels, fitted with Barum tubeless tyres size 610 × 215 mm (610 × 185 mm on early production aircraft), pressure 5.88 bars (85.34 lb/sq in). K25 castoring and self-centring nosewheel, fitted with Barum tubeless tyre size 450 × 165 mm (430 × 150 mm on early production aircraft), pressure 3.92 bars (56.89 lb/sq in). Hydraulic disc brakes and anti-skid units on mainwheels; shimmy damper on nosewheel leg. The L-39 is capable of operation from grass strips (with a bearing strength of 6 kg/cm²; 85 lb/sq in) at up to 4,600 kg (10,141 lb) T-O weight, or from unprepared runways. Landing gear of L-39 ZA reinforced to cater for higher operating weights.

POWER PLANT: One 16.87 kN (3,792 lb st) Ivchenko AI-25 TL turbofan mounted in rear fuselage, with semi-circular lateral air intake, fitted with splitter plate, on each side of fuselage above wing centre-section. Fuel in five rubber main bag tanks aft of cockpit, with combined capacity of 1,055 litres (232 Imp gallons; 279 US gallons), and two 100 litre (22 Imp gallon; 26.5 US gallon) non-jettisonable wingtip tanks. Total internal fuel capacity 1,255 litres (276 Imp gallons; 332 US gallons). Gravity refuelling points on top of fuselage and on each tip tank. Provision for two 350 litre (77 Imp gallon; 92.5 US gallon) drop tanks on inboard underwing pylons, increasing total overall fuel capacity to a maximum of 1,955 litres (430 Imp gallons; 517 US gallons). Fuel system permits up to 20 s of inverted flight.

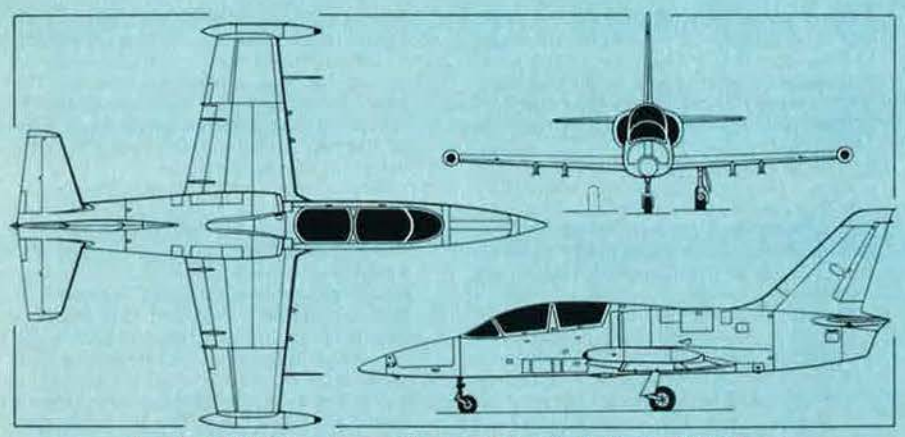
ACCOMMODATION: Crew of two in tandem, on Czechoslovak VS-1-BRI rocket assisted ejection seats, operable at zero height and at speeds down to 81 knots (150 km/h; 94 mph), beneath individual transparent canopies which hinge sideways to starboard and are jettisonable. Rear seat elevated. One-piece windscreen hinges forward to provide access to front instrument panel. Internal transparency between front and rear cockpits. Dual controls standard.

SYSTEMS: Cabin pressurised (standard pressure differential 0.227 bars; 3.29 lb/sq in, max overpressure 0.29 bars; 4.20 lb/sq in) and air-conditioned, using engine bleed air and cooling unit. Air-conditioning system provides automatic temperature control from 10° to 25°C at ambient air temperatures from − 55°C to + 45°C. Main and standby interconnected hydraulic systems, the main system having a variable flow pump with an operating pressure of 147 bars (2,133 lb/sq in) for actuation of landing gear, flaps, airbrakes, ram air turbine, and (at 34.3 bars; 500 lb/sq in pressure) wheel brakes. Emergency system, for all of above except airbrakes, incorporates three accumulators. Pneumatic canopy seals supplied by a 2 litre compressed air bottle in nose (pressure 147 bars; 2,133 lb/sq in). Electrical system (27V DC) is powered by a 7.5kVA engine driven generator. If primary generator fails, a V 910 ram air turbine is extended automatically into the airstream and generates up to 3kVA of emergency power for essential services. 12V 28Ah SAM 28 lead-acid battery for standby power and for APU starting. Two 800VA static inverters (the first for radio equipment, ice warning lights, engine vibration measurement, and air-conditioning, the second for navigation and landing systems, IFF, and air-to-air missiles) provide 115V single-phase AC power at 400Hz. A second circuit incorporates a 500VA rotary inverter and 40VA static inverter to provide 36V three-phase AC power, also at 400Hz. Saphir 5 APU and SV-25 turbine for engine starting. Air intakes and windscreen anti-iced by engine bleed air; normally, anti-icing is sensor-activated automatically, but a manual standby system is also provided. Six-bottle oxygen system for crew, pressure 147 bars (2,133 lb/sq in).

AVIONICS AND EQUIPMENT: Standard avionics include R-832 M two-band com radio (VHF 118–140MHz, UHF 220–389MHz); SPU-9 crew intercom; RKL-41 ADF (150–1,800kHz); RV-5 radar altimeter; MRP-56 P/S marker beacon receiver; SRO-2 IFF; and RSBN-5S navigation and landing system. VOR/ILS system available at customer's option. Landing and taxying light in forward end of each tip tank.

ARMAMENT (L-39 Z0 and ZA): Underfuselage pod on ZA only, below front cockpit, housing a single 23 mm Soviet GSh-23 two-barrelled cannon; am-

Basic L-39 C Albatros trainer in Czechoslovak Air Force service



Aero L-39 Z0 Albatros two-seat basic and advanced jet trainer *(Pilot Press)*

munition for this gun (max 150 rds) is housed in fuselage, above gun pod. Gun/rocket firing and weapon release controls, including electrically controlled ASP-3 NMU-39 Z gyroscopic gunsight and FKP-2-2 gun camera, in front cockpit only (no FKP-2-2 in L-39 V). Z0 and ZA have four underwing hardpoints, the inboard pair each stressed for loads of up to 500 kg (1,102 lb) and the outer pair for loads of up to 250 kg (551 lb) each; max underwing stores load 1,100 kg (2,425 lb). Non-jettisonable pylons, each comprising a D3-57D stores rack. Typical underwing stores can include various combinations of bombs (two 500 kg, four 250 kg, or six 100 kg); four UB-16-57 M pods each containing sixteen S-5 57 mm air-to-surface rockets; infra-red air-to-air missiles (outer pylons only); a five-camera day reconnaissance pod (port inboard pylon only); or (on inboard stations only) two 350 litre (77 Imp gallon; 92.5 US gallon) drop tanks.

DIMENSIONS, EXTERNAL:

Wing span	9.46 m (31 ft 0½ in)
Wing chord (mean)	2.15 m (7 ft 0½ in)
Wing aspect ratio: geometric	4.4
incl tip tanks	5.2
Length overall	12.13 m (39 ft 9½ in)
Height overall	4.77 m (15 ft 7¾ in)
Tailplane span	4.40 m (14 ft 5 in)
Wheel track	2.44 m (8 ft 0 in)
Wheelbase	4.39 m (14 ft 4¾ in)

AREAS:

Wings, gross	18.80 m² (202.36 sq ft)
Ailerons (total)	1.23 m² (13.26 sq ft)
Trailing-edge flaps (total)	2.68 m² (28.89 sq ft)
Airbrakes (total)	0.50 m² (5.38 sq ft)
Vertical tail surfaces (total)	3.51 m² (37.78 sq ft)
Tailplane	3.93 m² (42.30 sq ft)
Elevators, incl tabs	1.14 m² (12.27 sq ft)

WEIGHTS AND LOADINGS:

Weight empty, equipped: C	3,459 kg (7,625 lb)
Z0	3,488 kg (7,690 lb)
ZA	3,656 kg (8,060 lb)
Fuel load: fuselage tanks	824 kg (1,816 lb)
wingtip tanks	156 kg (344 lb)
Max external stores load: C	500 kg (1,102 lb)
Z0 and ZA	1,100 kg (2,425 lb)
T-O weight 'clean': ZA	4,549 kg (10,029 lb)
Max T-O weight: C	4,700 kg (10,362 lb)
Z0 and ZA	5,600 kg (12,346 lb)
Max wing loading: C	250.0 kg/m² (51.23 lb/sq ft)
Z0 and ZA	297.9 kg/m² (61.01 lb/sq ft)
Max power loading: C	278.6 kg/kN (2.73 lb/lb st)
Z0 and ZA	332.0 kg/kN (3.25 lb/lb st)

PERFORMANCE (at max T-O weight except where indicated):

Max limiting Mach number	Mach 0.80
Max level speed at S/L: C	378 knots (700 km/h; 435 mph)
Z0	329 knots (610 km/h; 379 mph)
Max level speed at 5,000 m (16,400 ft): C	405 knots (750 km/h; 466 mph)
Z0	340 knots (630 km/h; 391 mph)
ZA	407 knots (755 km/h; 469 mph)
Stalling speed: C	90 knots (165 km/h; 103 mph)
Z0	98 knots (180 km/h; 112 mph)
Max rate of climb at S/L: C	1,320 m (4,330 ft)/min
Z0	810 m (2,657 ft)/min
ZA	1,260 m (4,130 ft)/min
Time to 5,000 m (16,400 ft): C	5 min
Z0	10 min
Service ceiling: ZA	11,000 m (36,100 ft)
C	11,500 m (37,730 ft)
Z0	7,500 m (24,600 ft)
T-O run (concrete): C, ZA	480 m (1,575 ft)
Z0	970 m (3,182 ft)
Landing run (concrete): C	600 m (1,968 ft)
Z0	800 m (2,625 ft)
Range at 5,000 m (16,400 ft), max internal fuel: C	540 nm (1,000 km; 621 miles)
Z0	680 nm (1,260 km; 783 miles)
Ferry range: C	944 nm (1,750 km; 1,087 miles)
Endurance at 5,000 m (16,400 ft): C	2 h 30 min
Z0	3 h 20 min
g limits: operational, at 4,200 kg (9,259 lb) AUW	+8/−4
ultimate, at 4,200 kg (9,259 lb) AUW	+12
operational, at 5,500 kg (12,125 lb) AUW	+5.2/−2.6

L-39 ZA ground attack and reconnaissance version of the Z0

LEARJET

GATES LEARJET CORPORATION, Tucson International Airport, PO Box 11186, Tucson, Arizona 85734, USA

GATES LEARJET 35A and 36A SPECIAL MISSIONS VERSIONS

The basic Learjet 35A and 36A executive/utility transports are almost identical, differing in fuel capacity and accommodation. Customers include USAF, which acquired 80 Model 35As, under the designation C-21A, to replace CT-39 Sabreliners of Military Airlift Command for high-priority cargo delivery, pilot proficiency training, passenger airlift, and other operational support missions, including medical evacuation.

In addition to these standard versions, Gates Learjet offers special missions aircraft for a wide range of civilian and paramilitary applications, some of which are designated as follows:

EC-35A. Electronic warfare version of Learjet 35A. Provides complete EW training simulation or may be used to provide standoff support during tactical operations as well as for intelligence gathering. Equipment includes underwing turbine powered ECM deception jammer.

PC-35A. Maritime patrol version of Learjet 35A. Available equipment includes Litton AN/APS-504(V)3 sea surveillance radar, with 360° sweep from the underbelly radome and digital CFAR clutter suppression; low light level TV with video tape and scan conversion; forward looking infra-red; Daedalus DS-1210 multi-spectral infra-red and ultra-violet linescanner with tape data storage and hard copy printer; mini-computers for data processing, with tape input/output and graphic display capability; ASW sonobuoy drop and detection equipment; ESM; MAD; a hardpoint under each wing with an Alkan 165B ejector for survival equipment, flares, or up to 453 kg (1,000 lb) of other stores; drop hatch for rescue gear; high intensity searchlight; reconnaissance, mapping or LOROP cameras; HF, VHF, and UHF homers; GNS-1000 VLF Omega navigation system; side looking airborne radar; Bendix RDR 1300B weather radar; and hand held cameras with position information printout.

RC-35A. Reconnaissance version of Learjet 35A. Standard installations include LOROP cameras, side looking synthetic aperture radar, and various pod mounted surveillance camera systems carried as external stores.

UC-35A. Utility version of Learjet 35A for target towing, aerial survey, photography, weather modification, airways calibration, medical evacuation, cargo transport, and mixed cargo/passenger transport missions. Survey version can carry all Zeiss or Wild cameras, in single or dual packs, including the Zeiss RMK A 8.5/23 and Wild RC-10 with SAG or UAG lens cones.

U-36A. Special version of Learjet 36A developed, in association with Shin Meiwa, to meet a Japan Maritime Self-Defence Force requirement for onboard radar training of naval units. Primary uses include target towing, anti-ship sea skimming missile simulation, and ECM jamming. Equipment includes HWQ-1T missile seeker simulator and ALQ-6 jammer in longer wingtip tanks of increased diameter; long-range ocean surveillance radar in an underbelly fairing; an ALE-43 chaff dispenser; an ARS-1-L high speed tow sleeve with scoring; a new two-piece windscreen with electric demisting system for increased speed during low level missions; and expanded underwing stores capacity. Max T-O

and landing weights increased. First two U-36As delivered in November 1985 and January 1987, in 'green' configuration, for further modification and finishing by Shin Meiwa. Additional deliveries will extend into the 1990s.

Special Missions Learjets are operating in some 20 countries worldwide, including Argentina, Australia, Bolivia, Brazil, Chile, China, Colombia, Ecuador, Finland, West Germany, Japan, Mexico, New Zealand, Peru, Saudi Arabia, Sweden, Switzerland, the UK, USA, and Yugoslavia.

The following description applies to the basic transport versions of the Learjet 35A and 36A:

TYPE: Twin-turbofan light executive transport.

WINGS: Cantilever low-wing monoplane. Wing section NACA 64A 109 with modified leading-edge. Dihedral 2° 30'. Incidence 1°. Sweepback 13° at quarter-chord. All-metal eight-spar structure with milled alloy skins. Manually operated, aerodynamically balanced all-metal ailerons. Softflite handling package, comprising two rows of boundary layer energisers forward of each aileron, full-chord fences, and stall strips on the leading-edges to improve stall characteristics. Hydraulically actuated all-metal single-slotted flaps. Hydraulically actuated all-metal spoilers ahead of flaps. Electrically operated trim tab in port aileron. Balance tab in each aileron. Anti-icing by engine bleed air ducted into leading-edges.

FUSELAGE: All-metal flush riveted semi-monocoque fail-safe structure.

TAIL UNIT: Cantilever all-metal sweptback structure, with electrically actuated variable incidence T tailplane and small ventral fin. Conventional manually operated control surfaces. Electrically operated trim tab in rudder. Electrically heated de-icing of tailplane leading-edge.

LANDING GEAR: Retractable tricycle type, with twin wheels on each main unit and single steerable nosewheel. Hydraulic actuation, with back-up pneumatic extension. Oleo-pneumatic shock absorbers. Mainwheels fitted with Goodyear 18 × 5.50 10-ply tyres, pressure 7.93 bars (115 lb/sq in). Nosewheel fitted with Goodyear dual chine tyre size 18 × 4.40 10-ply rating, pressure 7.24 bars (105 lb/sq in). Goodyear multiple-disc hydraulic brakes. Pneumatic emergency braking system. Parking brakes. Fully modulated anti-skid system.

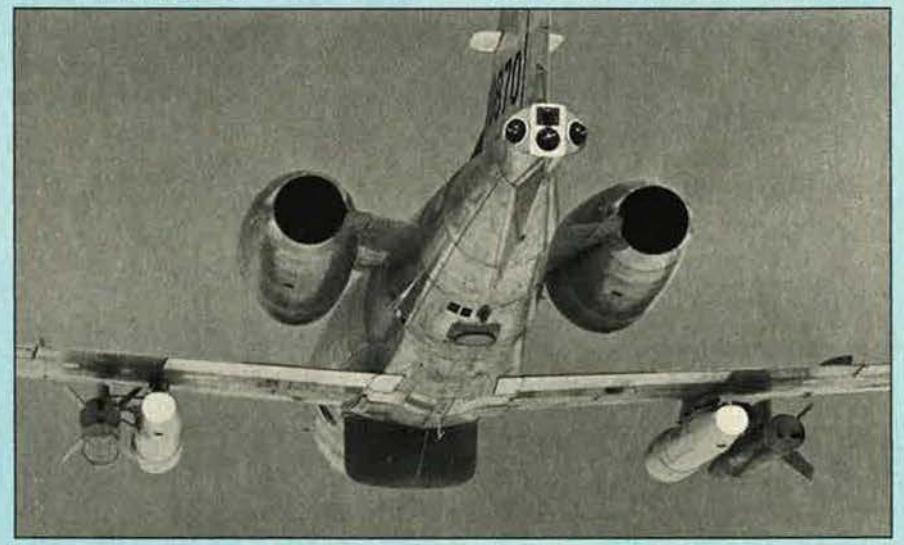
POWER PLANT: Two Garrett TFE731-2-2B turbofan engines, each rated at 15.6 kN (3,500 lb st), pod-mounted on sides of rear fuselage. Fuel in integral wing and wingtip tanks and a fuselage tank, with a combined usable capacity (Learjet 35A) of 3,524 litres (775 Imp gallons; 931 US gallons). Learjet 36A has a larger fuselage tank, giving a combined usable total of 4,201 litres (924 Imp gallons; 1,110 US gallons). Refuelling point on upper surface of each wingtip tank. Fuel jettison system. Engine nacelle leading-edges anti-iced by engine bleed air. T/R-4000 thrust reversers optional.

ACCOMMODATION: Crew of two on flight deck, with dual controls. Up to eight passengers in Learjet 35A; one on inward facing bench seat on starboard side at front, then two pairs of swivel seats which face fore and aft for take-off and landing, with centre aisle, and three on forward facing couch at rear of cabin. Alternative 'mid-cabin' arrangement, available optionally, places a refreshment area in the middle of the cabin, accessible from fore and aft club seating areas, each for four passengers. Learjet 36A accommodates up to six passengers, one pair of swivel seats being removed. Toilet and stowage space under front inward facing seat, which can be screened from remainder of cabin. Refreshment cabinet opposite this seat, aft of passenger door. Provisions for carrying FAA certificated litter and life support systems in place of some seats in medical evacuation configuration. Baggage compartment with capacity of 226 kg (500 lb) aft of cabin. Two-piece clamshell door at forward end of cabin on port side, with integral steps built into lower half. Emergency exit on starboard side of cabin. Bird-proof windscreen.

SYSTEMS: Environmental control system comprises cabin pressurisation, ventilation, heating, and cooling. Heating and pressurisation by engine bleed air, max differential 0.65 bars (9.4 lb/sq in). Freon R12 vapour cycle cooling system supplemented by a ram-air heat exchanger. Flight control system includes dual yaw dampers, dual stick pushers, dual stick shakers, and Mach trim. Anti-icing system includes distribution of engine bleed air for wing, tailplane, and engine nacelle leading-edges and windscreen; electrical heating of pitot heads, stall warning vanes, and static ports; and alcohol spray on windscreen and nose radome. Hydraulic system supplied by two engine driven pumps, each pump capable of maintaining alone the full system pressure of 103.5 bars (1,500 lb/sq in) for operation of landing gear, brakes, flaps, and spoilers. Hydraulic system maximum flow rate 15 litres (3.3 Imp gallons; 4 US gallons)/min. Cylindrical reservoir pressurised to 1.38 bars (20 lb/sq in). Electrically driven hydraulic pump for emergency operation of all hydraulic services. Pneumatic system of 124 to 207 bars (1,800 to 3,000 lb/sq in) pressure for emergency extension of landing gear and operation of brakes. Electrical system powered by two 30V 400A brushless generators, two 1kVA solid state inverters to provide AC power, and two 24V 37Ah lead-acid batteries. Oxygen system for emergency use, with crew demand masks and drop-out mask for each passenger.

AVIONICS AND EQUIPMENT: Standard avionics include Collins FIS-84/EHSI-74 flight director integrated with J.E.T. FC-530 FCS and dual yaw dampers (pilot's side); Collins/J.E.T. PN-101/RAI-302 co-pilot's flight indicator; dual Collins VHF-22A com transceivers; dual VIR-32 nav receivers; ADF-60; dual DME-42 with IND-42C indicators; dual Allen 3137 RMIs; dual Collins TDR-90 transponders; Collins ALT-55B radio altimeter with DRI-55 indicator; Sperry Primus 300SL colour weather radar; dual J.E.T. VG-206D vertical gyros; dual J.E.T. DN-104B directional gyros; J.E.T. PS-835D and AI-804 emergency battery and attitude gyro; IDC electric encoding altimeter with altitude alerter and IDC air data unit (pilot's side); IDC barometric altimeter (co-pilot); dual Teledyne IVSIs; dual marker beacon indicators; dual Avtech audio systems; eight-day wind-up clock (pilot's side); Davtron 877 clock (co-pilot); nacelle heat annunciator; N_1 reminder; avionics master switch; chip detector and flap pre-select. Optional all-digital flight deck in which autopilot and flight data are presented on colour CRTs. This can include, typically, Collins Pro Line II avionics, with dual FIS-84 flight integration systems and EHSI-74 electronic HSIs, WXR-350 weather radar,

Enlarged wingtip tanks identify the customised Learjet U-36A supplied to Japan's Maritime Self-Defence Force. This aircraft can simulate sea skimming missiles in training missions against naval vessels



Special Missions Gates Learjet Model 35A with drop hatch, LOROP camera windows, air turbine target reeling pods, surveillance radar, and ESM system

ADS-82 air data computer, dual AHS-85 AHRS, APS-85 digital autopilot with glareshield controller, and DB audio system. Standard equipment includes dual angle of attack indicators; dual battery temperature gauges; engine synchronisation meter; cabin differential pressure gauge; cabin rate of climb indicator; interstage and turbine temperature gauges; turbine and fan speed gauges; wing temperature indicator; alternate static source; dual battery overheat warning; depressurisation warning; engine fire warning lights; Mach warning system; dual stall warning system; fire axe; cabin fire extinguisher; flotation jackets for crew and passengers; soundproofing; baggage compartment, courtesy, instrument panel, flood, map, and reading lights; dual anti-collision, landing, navigation, recognition, strobe, and taxi lights; dual engine fire extinguishing systems with 'systems armed' and fire warning lights; engine synchronisation system; control lock; external power socket; and lightning protection system.

DIMENSIONS, EXTERNAL:

Wing span over tip tanks	12.04 m (39 ft 6 in)
Wing chord: at root	2.74 m (9 ft 0 in)
at tip	1.55 m (5 ft 1 in)
Wing aspect ratio	5.74
Length overall	14.83 m (48 ft 8 in)
Height overall	3.73 m (12 ft 3 in)
Tailplane span	4.47 m (14 ft 8 in)
Wheel track	2.51 m (8 ft 3 in)
Wheelbase	6.15 m (20 ft 2 in)
Passenger door:	
Standard: Height	1.57 m (5 ft 2 in)
Width	0.61 m (2 ft 0 in)
Optional: Height	1.57 m (5 ft 2 in)
Width	0.91 m (3 ft 0 in)
Emergency exit: Height	0.71 m (2 ft 4 in)
Width	0.48 m (1 ft 7 in)

DIMENSIONS, INTERNAL (A: Learjet 35A; B: Learjet 36A):

Cabin: Length, incl flight deck:	
A	6.63 m (21 ft 9 in)
B	5.77 m (18 ft 11 in)
Max width	1.50 m (4 ft 11 in)
Max height	1.32 m (4 ft 4 in)
Volume, incl flight deck:	
A	9.12 m³ (322 cu ft)
B	7.25m³ (256 cu ft)
Baggage compartment: A	1.13 m³ (40 cu ft)
B	0.76 m³ (27 cu ft)

AREA:

Wings, gross	23.53 m² (253.3 sq ft)

WEIGHTS AND LOADINGS (A: Learjet 35A; B: Learjet 36A):

Weight empty, equipped:	
A	4,342 kg (9,571 lb)
B	4,341 kg (9,570 lb)
Max payload: A, B	1,361 kg (3,000 lb)
Max T-O weight:	
A (basic)	7,711 kg (17,000 lb)
A (optional), B	8,300 kg (18,300 lb)
Max ramp weight:	
A (basic)	7,824 kg (17,250 lb)
B	8,391 kg (18,500 lb)
Max landing weight:	
A, B	6,940 kg (15,300 lb)
Max wing loading:	
A (basic)	327.6 kg/m² (67.1 lb/sq ft)
B	347.1 kg/m² (71.1 lb/sq ft)
Max power loading:	
A (basic)	247.1 kg/kN (2.43 lb/lb st)
B	261.7 kg/kN (2.57 lb/lb st)

PERFORMANCE ('clean' aircraft at max T-O weight, except where indicated; A: Learjet 35A at 7,711 kg, 17,000 lb; B: Learjet 36A):

Never-exceed speed: A, B	Mach 0.83
Max level speed at 7,620 m (25,000 ft):	
A, B	471 knots (872 km/h; 542 mph)
Max cruising speed, mid-cruise weight, at 12,500 m (41,000 ft):	
A, B	460 knots (852 km/h; 529 mph)
Econ cruising speed, mid-cruise weight, at 13,700 m (45,000 ft):	
A, B	418 knots (774 km/h; 481 mph)
Stalling speed, wheels and flaps down, engines idling:	
A, B	96 knots (178 km/h; 111 mph) IAS
Max rate of climb at S/L:	
A	1,451 m (4,760 ft)/min
B	1,322 m (4,339 ft)/min
Rate of climb at S/L, one engine out:	
A	448 m (1,470 ft)/min
B	389 m (1,276 ft)/min
Service ceiling: A, B	13,715 m (45,000 ft)
Service ceiling, one engine out:	
A	7,710 m (25,300 ft)
B	7,165 m (23,500 ft)
T-O balanced field length, FAR Pt 25:	
A at 7,711 kg (17,000 lb)	1,287 m (4,224 ft)
A, B at 8,300 kg (18,300 lb)	1,515 m (4,972 ft)
Landing distance, FAR Pt 25, at max landing weight:	
A, B	937 m (3,075 ft)
Range with 4 passengers, max fuel, and 45 min reserves:	
A	2,289 nm (4,239 km; 2,634 miles)
B	2,708 nm (5,015 km; 3,116 miles)

OPERATIONAL NOISE LEVELS (FAR Pt 36):

T-O: A	83.7 EPNdB
B	83.9 EPNdB
Approach: A	91.4 EPNdB
Sideline: A	86.9 EPNdB
B	87.8 EPNdB

IL

INSTYTUT LOTNICTWA (Aviation Institute), Al. Krakowska 110/114, 02-256 Warszawa-Okecie, Poland

PZL I-22

Pictures of this new jet trainer and light attack aircraft first appeared in a Polish television programme in October 1986, and it was identified by the designation I-22 a few weeks later. When a more detailed description, via the Polish aviation press, became available in early 1987, it revealed that the I-22's existence had been a well-kept secret for nearly two years, for the prototype had made its first flight as long ago as 3 March 1985. Test pilot on that occasion was Eng Ludwik Natkaniec.

The I-22 was designed at the Instytut Lotnictwa in Warsaw, the design team being led by the IL's chief designer, Dr Eng Alfred Baron, assisted by the Ośrodek Badawczo-Rozwojowy Sprzetu Komunikacyjnego (Communications Equipment Research and Development Centre) at Mielec, where the prototypes were built, and various other Polish aviation industry establishments. By early 1987 the aircraft had been flown, and well commended, by a number of industry and air force pilots. The flight test programme was then continuing under the leadership of Eng Wlodzimierz Stepień.

Evidently intended as a successor to the PZL Mielec TS-11 Iskra, the I-22 has been designed to cover the full spectrum of pilot, navigation, air combat, reconnaissance, and ground attack training, with day/night and bad-weather capability. This versatility, coupled with the ability to operate from unprepared airstrips and to carry a useful variety of ordnance, enables the I-22 also to fulfil the role of light close support aircraft.

TYPE: Two-seat jet trainer and light close support aircraft.

WINGS: Cantilever high-wing monoplane, with approx 20° sweepback on leading-edges, non-swept trailing-edges, and approx 5° anhedral from roots. Two-spar all-metal stressed skin structure, built as one piece with centre and inboard portions forming integral fuel tanks. Laminar flow aerofoil section, with multi-stage aerodynamic twist. All-metal mass balanced ailerons, actuated by pushrods with hydraulic boost. All-metal single-slotted trailing-edge flaps deflect hydraulically (20° for take-off, 40° for landing), with auxiliary pneumatic system for emergency deflection in the event of hydraulic failure.

FUSELAGE: Conventional all-metal semi-monocoque structure of frames and longerons, with aluminium alloy skin. Door type airbrake on each side of upper rear fuselage.

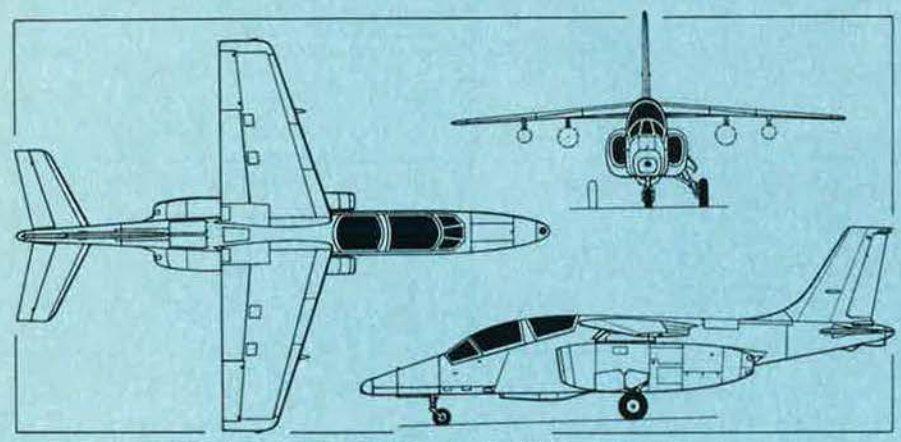
TAIL UNIT: Conventional all-metal structure, with sweepback on all surfaces. Curved fillet at base of fin. Variable incidence tailplane, mid mounted on fuselage tailcone, has approx 7° anhedral and is actuated hydraulically. Mass balanced elevators and rudder, actuated by pushrods. Ground adjustable tab on rudder.

LANDING GEAR: Retractable tricycle type, with single wheel and low pressure tubeless tyre on each unit. Hydraulic extension and retraction: nose unit retracts forward, main units upward into engine nacelles. Auxiliary pneumatic system for lowering gear in an emergency. Oleo-pneumatic shock absorber in each unit. Hydraulic disc brakes on mainwheels; auxiliary mainwheel parking brake serves also as emergency brake. Braking parachute in fuselage tailcone. Small tail bumper under rear of fuselage.

POWER PLANT: Two 10.79 kN (2,425 lb st) PZL Rzeszów SO-3W22 non-afterburning turbojets, pod mounted on lower sides of centre-fuselage. Fuel in two fuselage and three integral wing tanks, total capacity 2,540 litres (559 Imp gallons; 671 US gallons). Provision for one 400 litre (88 Imp gallon; 106 US gallon) auxiliary tank to be carried under each wing. Fuel system permits inverted flight. Single-point pressure refuelling (at front of port engine nacelle), plus gravity filling point for each tank. Air intakes anti-iced by engine bleed air.

ACCOMMODATION: Pressurised, heated, and air-conditioned cockpit, with tandem seating for pupil (in front) and instructor; rear seat elevated 400 mm (15¾ in). For solo flying, pilot occupies front seat. Individual framed canopies, opening pneumatically. Ejection seats are rocket assisted, fitted with canopy breakers, and can be operated at zero altitude and at speeds above 81 knots (150 km/h; 93 mph). Dual controls standard; front

The PZL I-22 jet trainer and light attack aircraft is intended to replace the familiar TS-11 Iskra



PZL I-22 jet trainer (two PZL Rzeszów SO-3W22 turbojets) *(Pilot Press)*

With two years of flight testing completed, the I-22 has received enthusiastic reports from industry and air force test pilots

cockpit equipped for IFR flying. Windscreen anti-iced by electric heating, supplemented by alcohol spray. Remaining transparencies anti-iced and demisted by hot engine bleed air.

SYSTEMS: Cockpits pressurised and air-conditioned by engine bleed air. Main hydraulic system, nominal pressure 210 bars (3,045 lb/sq in), actuates landing gear extension and retraction, wing flaps, airbrakes, tailplane incidence, brake-chute deployment, differential braking of mainwheels, and parking/emergency brake. Auxiliary hydraulic system for aileron control boost. Pneumatic system comprises three separate circuits, each supplied by a nitrogen bottle pressurised at 150 bars (2,175 lb/sq in): one powers emergency extension of wing flaps for landing, one the emergency extension of the landing gear; the third is for canopy opening, closing, and sealing, windscreen fluid de-icing system, and hydraulic reservoir pressurisation. All three bottles charged simultaneously through a common nozzle. Electrical system, powered by two 9kW starter/generators, supplies 115V single-phase AC and three 36V three-phase AC, both at 400Hz; two 24V batteries provide DC power in the event of a double failure. Each AC voltage is supplied by one main converter and one standby, the latter automatically assuming full load if a main converter fails. Engine fire detection and extinguishing system (two Freon bottles in rear fuselage). Electronic control system for gun firing and weapon release.

AVIONICS AND EQUIPMENT: Avionics bays in nose and under floor of rear cockpit. VHF and UHF multi-channel com radio; ADF navigation system using radio compass; radar altimeter for low level flying; marker beacon receiver; and other systems according to mission and customer's requirements. Blind-flying instrumentation. Flight data recorder in dorsal fin fillet.

ARMAMENT: One 23 mm twin-barrel cannon in underfuselage pack, with 200 rounds, plus gyro gunsight and nose mounted gun camera. Four underwing attachments, each stressed for load of up to 500 kg (1,102 lb), for bombs, guided or unguided rockets, or (inboard stations only) auxiliary fuel tanks.

DIMENSIONS, EXTERNAL:

Wing span	9.60 m (31 ft 6 in)
Length overall	13.22 m (43 ft 4½ in)
Height overall	4.30 m (14 ft 1¼ in)
Wheel track	2.71 m (8 ft 10¾ in)
Wheelbase	4.90 m (16 ft 1 in)

AREA:

Wings, gross	19.92 m² (214.4 sq ft)

WEIGHTS:

Operational, weight empty	3,962 kg (8,735 lb)
Max external stores load	1,200 kg (2,645 lb)
Max T-O weight	7,493 kg (16,519 lb)

PERFORMANCE:

Max Mach number	0.85
Max level speed at S/L	494 knots (915 km/h; 568 mph)
Service ceiling	12,600 m (41,340 ft)
g limits ('clean')	+8/−4

VALMET

VALMET AIRCRAFT DIVISION, Kuorevesi Works, SF-35600 Halli, Finland

As described in the 1986–87 *Jane's All the World's Aircraft*, Valmet produced 30 examples during 1980–82 of its piston engined L-70 Miltrainer, delivering them to the Finnish Air Force (by which they are known as the Vinka) for primary training duties. An early turboprop successor (see 1985–86 *Jane's*) was known as the L-80 TP; this has since been superseded by the L-90 TP Redigo, which is intended to fulfil both the basic and primary flying training roles.

VALMET L-90 TP REDIGO

The L-90 TP is developed from, and is slightly larger than, the L-70, from which it differs primarily in having a turboprop power plant, new wings, and retractable landing gear. The first prototype (OH-VTP) made its initial flight in June 1986. Two additional prototypes are under construction, one of which may be used to flight test an alternative all-composites wing (mainly of carbonfibre, but with the same aerofoil section). Valmet has also said that it intends to fly one aircraft, probably in mid-1987, with a 313 kW (420 shp) Turboméca TP319 turboprop instead of the Allison 250.

Suitable for primary and basic flying training, aerobatic training, night and instrument flight training, tactical training, observation, and liaison missions, the Redigo is designed to fit a training system that can produce combat-ready pilots within minimum time and cost levels, students proceeding directly from the L-90 TP to a demanding advanced trainer such as the BAe Hawk used by the Finnish Air Force. Additional roles can include search and rescue, weapons training, photographic reconnaissance, and target towing.

The following description applies to the first prototype:

TYPE: Two/four-seat multi-purpose military primary and basic training aircraft, designed to airworthiness requirements of FAR Pt 23 and BCAR Section K. Minimum fatigue life of 10,000 flight hours (fatigue spectrum MIL-A-8866B).

WINGS: Cantilever low-wing monoplane of tapered planform, with forward-swept inboard leading-edges. Wing section NACA 63-218 (Mod B3) at root, NACA 63-412 (Mod B3) at tip. Dihedral 6° from roots. Incidence 3° at root; −3° washout at tip. Fail-safe structure comprising main spar, auxiliary spar, ribs and stringers, bolted to fuselage. Construction mainly of aluminium alloy, with riveted skin (fluted on flaps and ailerons). Inwing fuel tanks are of Valmet load bearing sandwich construction. Wingroot fairings are of CFRP, wingtips of glassfibre. All-metal single-slotted trailing-edge flaps, actuated electrically by screwjack. Ailerons, also all-metal, are of modified Frise type, mass balanced, and actuated by cables. Geared tab and spring tab in each aileron; starboard geared tab can be operated also as a trim tab.

FUSELAGE: Conventional aluminium alloy semi-monocoque fail-safe structure of frames and longerons, with riveted skin; CFRP and glassfibre used in tailcone and engine cowling panels. First prototype has two ventral strakes on centreline.

TAIL UNIT: Cantilever aluminium alloy structure, with riveted skin (fluted on fin, rudder, and elevators). CFRP dorsal fin. Fin and rudder swept-back; horizontal surfaces non-swept. Elevators and rudder horn balanced and cable operated. Geared tab in rudder and each elevator, all three operable also as trim tabs.

LANDING GEAR: AP Precision Hydraulics electro-hydraulically retractable tricycle type, with single wheel and oleo-pneumatic shock absorber on each unit. Nosewheel, which is steerable 25° to left and right, retracts rearward; main units retract inward into wings. Spring assisted lowering of all units in event of emergency. Mainwheel tyres size 17.5 × 6.3–6.0 in, pressure 3.79 bars (55 lb/sq in); nosewheel tyre size 14.2 × 4.95–5.0 in, pressure 3.45 bars (50 lb/sq in). Differential brakes on mainwheels. Parking brake.

POWER PLANT: One Allison 250-B17D turboprop (max power 313 kW; 420 shp), flat rated at 268 kW (360 shp), driving a Hartzell HC-B3TF-7A/T10173-15 three-blade constant-speed reversible-pitch propeller with spinner. Fuel in four wing tanks and a fuselage collector tank, total usable capacity 360 litres (79 Imp gallons; 95 US gallons). Collector tank (15 litres; 3.3 Imp gallons; 4 US gallons) serves as tank for up to 30 s of inverted flight. Gravity refuelling point in top of each wing tank. Oil capacity 5.7 litres (1.25 Imp gallons; 1.5 US gallons). Anti-icing for engine air intake, spinner, and propeller blades.

ACCOMMODATION: Instructor and pupil, side by side, beneath one-piece rearward sliding jettisonable canopy with steel tube turnover windscreen frame. Canopy can be locked in partially open position if required. Zero/zero rocket as-

First prototype of the Valmet L-90 TP Redigo primary and basic military trainer

sisted escape system optional. Dual controls standard, but instructor's or pupil's control column can be removed if desired. Both front seats are adjustable longitudinally and for rake, and are fitted with five-point seat belts and inertia reel shoulder harnesses. Provision for two more seats at rear, with four-point harnesses, which can be removed to make room for up to 200 kg (440 lb) of baggage. As ambulance, can accommodate one stretcher patient, and a medical attendant or sitting patient, in addition to pilot. Accommodation heated and ventilated by heat exchanger, fresh air intake, and mixer unit. Auxiliary fresh air intake in fin leading-edge.

SYSTEMS: No hydraulic, pneumatic, or air-conditioning systems. Electrical system is 28V DC, powered normally by a 150A engine driven starter/generator, with a 23Ah nickel-cadmium battery for emergency supply and engine starting. Ground power receptacle. Emergency battery for main artificial horizon. Oxygen system for two occupants, capacity 13.3 litres (812 cu in).

AVIONICS AND EQUIPMENT: Dual controls and instrumentation for day and night VFR and IFR operation, including VHF com radios (two), ADF, DME transponder, RMI, HSI, marker beacon receiver, standby compass, airspeed indicator, attitude indicator, altimeter, turn and bank indicator, vertical speed indicator, outside air temperature gauge, and clock. Twin landing lights in starboard wing leading-edge.

ARMAMENT AND OPERATIONAL EQUIPMENT: Six underwing attachments, each inner point stressed for 250 kg (551 lb) and the other four 150 kg (331 lb) each; max external stores load 800 kg (1,764 lb). When flown solo, can carry six 100 kg bombs; two 250 kg bombs plus two 50 kg bombs and two flares; six pods each with eighteen 37 mm or six 68 mm rockets; two rocket pods, two gun pods (each with either two 7.62 mm and 2,000 rds or one 12.7 mm and 300 rds), and two flares; or up to four photographic, TV, radar or reconnaissance pods plus two flares. As two-seater, typical loads can include six to twelve anti-tank missiles; five liferafts or emergency packs and one searchlight pod; and photo and TV pods. Provision for reflector sight, internally mounted cameras (one long-focus or four short-focus), or for target towing with winch and hit counters.

DIMENSIONS, EXTERNAL:

Wing span	10.34 m (33 ft 11 in)
Wing chord: at root	1.83 m (6 ft 0 in)
mean aerodynamic	1.50 m (4 ft 11 in)
at tip	1.098 m (3 ft 7¼ in)
Wing aspect ratio	7.25
Length overall	7.90 m (25 ft 11 in)
Fuselage: Max width	1.22 m (4 ft 0 in)
Height overall	2.85 m (9 ft 4¼ in)
Elevator span	3.68 m (12 ft 1 in)
Wheel track	3.36 m (11 ft 0¼ in)
Wheelbase	2.13 m (7 ft 0 in)
Propeller diameter	2.19 m (7 ft 2¼ in)
Propeller ground clearance	0.29 m (11½ in)

DIMENSIONS, INTERNAL:

Cockpit: Length	1.81 m (5 ft 11¼ in)
Max width	1.14 m (3 ft 9 in)
Height (seat cushion to canopy)	1.02 m (3 ft 4¼ in)

AREAS:

Wings, gross	14.75 m² (158.8 sq ft)
Ailerons (total, incl tabs)	1.98 m² (21.31 sq ft)
Trailing-edge flaps (total)	1.76 m² (18.94 sq ft)
Fin	0.97 m² (10.44 sq ft)
Rudder, incl tab	0.99 m² (10.66 sq ft)
Tailplane	1.56 m² (16.79 sq ft)
Elevators (total, incl tabs)	1.53 m² (16.47 sq ft)

WEIGHTS AND LOADINGS (A: Aerobatic category; U: Utility; N: Normal category):

Weight empty, equipped: A	890 kg (1,962 lb)
Max fuel	296 kg (652 lb)
External stores: max	800 kg (1,764 lb)
with max fuel	600 kg (1,323 lb)
Max T-O weight: A	1,350 kg (2,976 lb)
U	1,470 kg (3,241 lb)
U (with external stores)	1,900 kg (4,189 lb)
N	1,600 kg (3,527 lb)
Max wing loading:	
A	91.5 kg/m² (18.75 lb/sq ft)
U	99.7 kg/m² (20.42 lb/sq ft)
U (with external stores)	128.8 kg/m² (26.40 lb/sq ft)
N	108.5 kg/m² (22.23 lb/sq ft)
Max power loading:	
A	5.03 kg/kW (8.27 lb/shp)
U	5.48 kg/kW (9.00 lb/shp)
U (with external stores)	7.08 kg/kW (11.64 lb/shp)
N	5.96 kg/kW (9.80 lb/shp)

PERFORMANCE (at max Aerobatic T-O weight, ISA):

Never-exceed speed	251 knots (465 km/h; 289 mph)
Max level speed at 1,525 m (5,000 ft)	181 knots (335 km/h; 208 mph)
Cruising speed (75% power) at 3,000 m (9,840 ft)	164 knots (305 km/h; 189 mph)
Max speed for flap extension	129 knots (240 km/h; 149 mph)
Stalling speed, engine idling:	
flaps up	65 knots (119 km/h; 74 mph)
15° flap	61 knots (113 km/h; 71 mph)
flaps down	55 knots (101 km/h; 63 mph)
Max rate of climb at S/L	588 m (1,929 ft)/min
Time to height:	
3,000 m (9,840 ft)	5 min
5,000 m (16,400 ft)	11 min 30 s
Service ceiling (engine limited)	7,620 m (25,000 ft)
T-O run	195 m (640 ft)
T-O to 15 m (50 ft)	310 m (1,017 ft)
Landing from 15 m (50 ft)	360 m (1,181 ft)
Landing run (without propeller reversal)	210 m (689 ft)
Min ground turning radius	10.80 m (35 ft 5 in)
Range at 6,000 m (19,685 ft) with max internal fuel, 30 min reserves	approx 809 nm (1,500 km; 932 miles)
Endurance, conditions as above	more than 5 h
g limits	+7/−3.5 aerobatic; +2.7 max sustained

MARSH

MARSH AVIATION COMPANY, 5060 East Falcon Drive, Mesa, Arizona 85205, USA

During 1986, it was announced that Grumman Corporation had been selected by the government of Taiwan to update 32 Grumman S-2 anti-submarine aircraft operated by its Air Force under Naval control. Modifications will include the installation of turboprop engines, in place of existing piston engines, and upgraded avionics. Marsh Aviation Company is flight testing a similar turboprop conversion of the Tracker, directed initially at the many companies that operate former military aircraft for aerial firefighting throughout the world.

MARSH/GRUMMAN S-2 TURBO CONVERSION

The Marsh Aviation modifications to the Tracker include extensive aerodynamic changes to the fuselage and engine nacelles, to reduce drag, and replacement of the S-2's original Wright R-1820 piston engines with Garrett TPE331-14 turboprops, each driving a Hartzell five-blade reversible-pitch propeller. The aim was to increase cruising speed by 60 knots (111 km/h; 69 mph) by comparison with the standard S-2, with a 50 per cent reduction in fuel consumption at high speed. Other performance improvements were expected to include a 30 per cent reduction in take-off and landing runs, and an increase of about 230 m (750 ft)/min in single-engine rate of climb at max T-O weight.

For its first flight, on 21 November 1986, the TPE331-14 turboprops of the first Marsh S-2 Turbo conversion were each flat rated at 932 kW (1,250 shp), instead of their max rating of 1,227 kW (1,645 shp). In this form, during subsequent early testing, it demonstrated true airspeeds in excess of 287 knots (531 km/h; 330 mph) and initial climb rates of up to 1,225 m (4,020 ft)/min. This aircraft has computerised engine controls to reduce pilot workload and enhance reliability.

Following certification, scheduled for the summer of this year, the S-2 Turbo will be evaluated in the firefighting role by the California Forestry Department. Marsh Aviation foresees a market for between 60 and 80 conversions worldwide.

Prototype of Marsh Aviation's S-2 Turbo Tracker conversion

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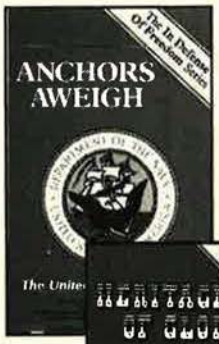

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First Prize, Festival dei Popoli
This award-winning compilation on the Vietnam War utilizes footage from numerous sources, including suppressed footage shot by a Japanese television crew. Not recommended for children.
MP 1326 B/W 60 Minutes
Not Rated $29.95

VIETNAM: In the Year of the Pig
This is one of the most powerful films ever produced on the subject of Vietnam. From the French involvement in Vietnam to the U.S. escalation, it offers a thought-provoking examination of that country and the brutality of war.
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A night of training in a "fighter trench" on the Greenland ice cap was no fun, but it prepared airmen to survive the coldest part of the cold war.

Harry Allen's ARCTIC Survival School

BY MAJ. GEN. DALE O. SMITH, USAF (RET.)

Faces partially obscured by the condensation of their own breath, Col. Harry Allen (right) and General Smith pause in a partially completed fighter trench. What few amenities there were had to do double duty—the candle provided light and "heat," while the hash tin was the vessel for both food and drink.

HARRY Allen should have been made a general, but I didn't have enough clout to swing it. In 1961, he commanded the air wing and station at Thule in northern Greenland, one of the garden spots of my 64th Air Division. The 64th consisted of 108 isolated stations, mostly radar early warning, across the top of North America.

The cold war was still being waged, and we were the coldest part of it. An attack over the North Pole was a possibility, and we, along with the Canadians, were ready to greet any uninvited intruders. Since then, it has been decided that the air-breathing threat has diminished, and our northern defense system has been given a lower priority.

Harry Allen must never have slept, judging from the way he kept Thule in such apple-pie order. Everything worked. Everything was military and on time. Surprisingly, in this frozen armpit of Air Force bases, morale was high.

Innovative Harry always kept the troops busy. In winter, when the sun never rose above the horizon, he constructed a huge extra landing strip on the deep ice of North Star Bay, pumping up water at hardstands until the ice was fifteen feet thick and able to support B-52s.

Then he invited SAC to come try it out, and it worked fine. He had a road sign posted at the end of the ice landing strip: "Road Closed in Summer."

Nothing grew at Thule so he built a thirty-foot Christmas tree of scrap metal and festooned it with colored lights for a yuletide celebration. He arranged for frequent USO shows to be flown in up there. Most entertainers—some top ones, too—volunteered because of the adventure.

His F-102 fighters exercised repeatedly in the coldest weather. The crews wore "moon suits" that were supposed to be watertight and permit survival in the event of a wet landing. Harry had each crewman go for a swim in supercold North Star Bay and then crawl onto an iceberg. It wasn't exactly comfortable, but they did survive.

In the winter darkness, the few pedestrians huddled in fur-lined parkas with only their noses showing. There was no way of telling an officer from a GI. But when the sun peeked above the horizon (Harry ran a pool on the exact time) in early summer, he felt it time for the men to show a little more military courtesy than had been the case previously.

One winter I decided to spend some time at Thule to see how Harry performed this miracle of command in the nearly perpetual darkness. I flew up there in my trusty C-54, *The Arctic Queen*. A hundred miles out from the air base it was high noon, but the sky was so black I felt as if we were suspended in nothingness. Then I spotted running lights off our left wing. More appeared off the right wing. I switched to fighter frequency.

"Is that you, Snow White?"

"That's us, Big Dog. We thought we'd welcome you and escort you in to our winter resort."

"Very thoughtful, Snow White. I was getting lonesome."

I have since wondered if, without those running lights and with no airborne radar, I could have seen a UFO or a Soviet fighter. Those Japanese airline pilots who recently reported seeing UFOs might just have been intercepted in the dark.

The Graduation Exercise

After the usual briefings and inspections, Harry explained that he had organized an Arctic survival school. His program would gain notice and respect, he felt, if the Old Man would take the course. What could I say?

After I reluctantly agreed, Harry informed me that the graduation exercise required us to spend a night on the Greenland ice cap with only the survival gear found in a parachute pack: a double sleeping bag, four candles, matches, a flashlight, four small flat tins of hash, a short snow saw, and a first-aid kit. I was glad to learn that the course didn't require us to bail out.

General Smith (center) and Colonel Allen are briefed on the location of the exercise. General Smith's smile belies the dauntingly harsh conditions that they will face, including access to only rudimentary provisions and exposure to temperatures of thirty-eight degrees below zero.

North of the timberline, improvisation is an integral part of Christmas. This thirty-foot, scrap-metal Christmas tree was an impressive stand-in for the real thing in 1960.

One afternoon, still in the stygian darkness with the temperature at thirty-eight below zero, a snow cat dropped Harry plus the crew of *The Arctic Queen* on the encrusted hard-packed snow, which may be thousands of feet deep. In survival school, we'd been taught first to build a small igloo about the size of a dishpan and place a lighted candle in it. This made a beacon that could be seen for many miles from the air—in clear weather.

Next we went to work building the "fighter trench." With the saw we cut big slabs of compressed snow and leaned them together over the trench from which the slabs had come. It sounds easy, but it was *labor*! Once a rectangle was sawed, the hard-packed snow stuck on the bottom of the slab as if it were glued to the ice cap. Breaking it loose was a contortionist's nightmare. Eventually what seemed like a snow coffin or grave began to evolve. One end was left open as an entrance, which we were to close with a final snow block.

My flashlight expired from the cold before I was half through, and I lit a candle and stuck it in the snow. The high altitude made my heart pound, and I was soon near exhaustion. Sweat streamed down inside my parka.

Sturdy Harry Allen had com-

pleted his fighter trench and now sat, amused, on a block of snow watching our amateurish efforts. I was embarrassed to have him help me put the finishing touches on my snow coffin and close the opening after I had wiggled in.

I lit a candle and poked a pencil hole through the block above it for ventilation. This was not only for light but also to raise the temperature by some fifteen degrees (so we had been told) to a cozy minus twenty-three.

Next, I attempted to squirm into the sleeping bag. The zippers must have frozen, too. We were supposed to remove all our sweat-soaked clothes before getting inside, then pull the bag up over our heads and enjoy a pleasant night's sleep. But there wasn't enough room for me to reach my boots, and I was growing numb anyway, so I crawled into the bag clothes and all. Then I discovered that the bag only came up to my chest. It was obviously made for a midget. [Editor's note: General Smith is six feet seven inches tall; from his perspective, *most* of us are midgets.]

I was suddenly overcome with thirst. As per the SOP, I partially opened a tin of hash with a P38 and stuck the turned-back lid into a block of snow so that the tin rested over the candle flame. When the hash thawed, I wolfed it down, quickly filled the can with snow, and again centered it over the candle. After what seemed an eternity, the snow melted into about two ounces of water. I repeated this agonizingly slow process again and again, but my thirst was never slaked.

Through the Long Night

I looked at my watch. I had been in this snow coffin for less than two hours. I felt as if my sweat had frozen, and I shivered uncontrollably. How could I survive the night?

Then the cramps started. First in my calves, then my thighs and groin. I massaged my legs wildly. If only I could stand and work out the dreadful, knifing pains. But then I'd flunk the course, and Harry Allen would never forgive me. The exercise was to end at 7:00 a.m. the next day, and here it wasn't even midnight yet.

Somehow I endured the cramps, and the pain lessened as the night wore on. I thawed and ate all my hash and tried melting snow in all four tins over a single candle flame. I studied my watch repeatedly. Surely my watch must be broken.

I tried reciting poems I'd learned in my youth and lyrics to songs, did multiplication and division in my head, and wrote mental letters, but I didn't dare sing lest the others think I had turned the corner.

Seven o'clock came just about as I was ready to throw in the towel. I kicked away the two slabs of snow and shot out of that torture chamber like Neptune rising from the sea. Oh, how good it felt just to be standing up!

I wasn't alone. "Fighter trenches" burst open all around like exploding bombs. The crew of *The Arctic Queen* was free.

Some months later, Harry called me at my headquarters in New York. "A -102 and a T-33 collided over the ice cap, Boss."

I groaned. "Any eject?"

"Our radar station spotted chaff ejected from the chutes. That's all we know. We have a good fix on their positions, but the weather is lousy. Bad whiteout on the ice cap, and our rescue cats are in trouble."

"How come the collision, Harry?"

"The weather turned bad. The -102 was making a simulated attack on the T-Bird. There was no visibility."

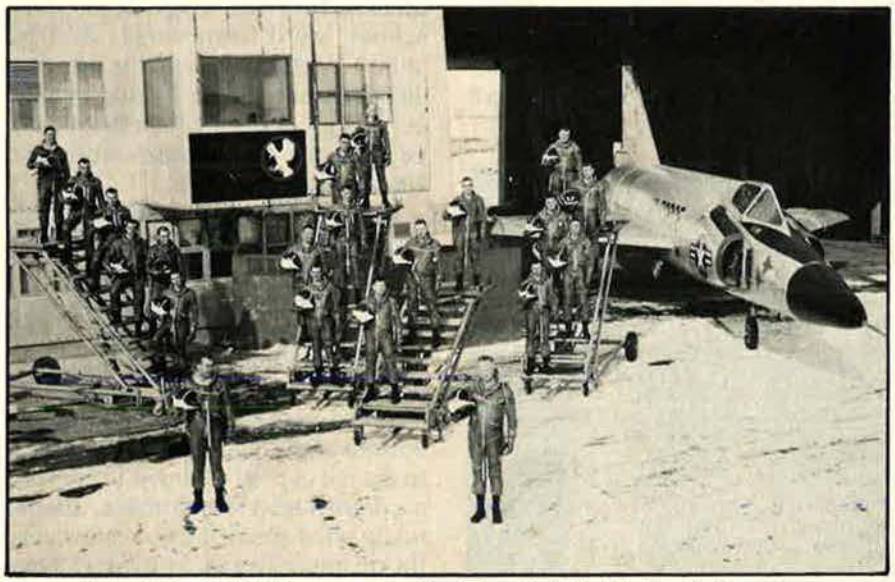
"Okay, Harry. Tough shake. I know you'll do everything possible. Keep me informed."

"Our hands are tied with this whiteout, Boss. The cats can't navigate and could run into a crevasse. I'm afraid we'll just have to wait until the weather breaks before we can get to them."

"I see. Well, do your best." I was confident Harry Allen would do everything humanly possible to rescue the downed flyers. All I could do was pray.

Three days later, the whiteout lifted, and they found the wreckage. The pilot of the fighter had never ejected. It looked as if he'd been killed in the collision. The rescuers found the two T-Bird pilots. They were buried in a deep fighter trench, alive and unfrozen.

Harry Allen's Arctic survival school had paid off. ■



These pilots of the 332d FIS, whose proud sobriquet—"World's Top Fighter Squadron"—is not merely a geographical reference, are depicted here in their "moon suits." This distinctive garb would permit survival in the event of a wet landing.

Maj. Gen. Dale O. Smith, USAF (Ret.), is a frequent contributor to this magazine. His by-line last appeared here in the January 1987 issue with his profile of General LeMay, "The Airman Who Shook the World." A 1934 graduate of West Point, General Smith commanded a bomb group in England during World War II. After the war, he commanded several air divisions (one of which was the 64th, described in this article) and served in high-level assignments at the Pentagon before his 1964 retirement, when he began his second career as a writer.

Meanwhile, the Salute climbs into its second million for USAF-related charities.

Gabreski's the Ace at Iron Gate

BY JAMES A. McDONNELL, JR.
MILITARY RELATIONS EDITOR

AMERICA'S top living ace, Col. Francis S. "Gabby" Gabreski, USAF (Ret.), was the honoree of AFA's New York City Iron Gate Chapter's twenty-fourth annual national Air Force Salute in early April. The Chapter paid tribute to Colonel Gabreski by sponsoring a Falcon Foundation scholarship in his name.

The Falcon Foundation provides one-year scholarships to selected students, allowing them to attend preparatory school in order to have a better chance to compete for admission to the United States Air Force Academy. This is the fourth such scholarship established by the Iron Gate Chapter.

During his twenty-seven-year career as an Air Force fighter pilot, Colonel Gabreski recorded thirty-four and a half aerial combat victories, twenty-eight of them in World War II and the other six and a half in jet combat during the Korean War. A member of the Eagles Hall of Fame and the National Aviation Hall of Fame, Colonel Gabreski served as President of AFA's Iron Gate Chapter in 1979–80. He is one of four aces who have been Iron Gate Chapter members.

During the evening, Chapter President Dan F. Huebner presented Aerospace Education Foundation Jimmy Doolittle and Ira Eaker Fellowships to several Salute guests. Denis R. Brown, the immediate past Chapter president, and Salute Committee members Sid Birns, Bruce M. Bullock, Richard A. Freytag, and Walter M. Hartung all received Doolittle Fellowships. The Chapter has sponsored 125 Jimmy Doolittle Fellowships to date, making them the leading sponsor among all AFA chapters.

Among the honored guests at the Iron Gate Chapter's 1987 national Air Force Salute were, from left to right, JCS Vice Chairman Gen. Robert T. Herres, USAF Chief of Staff Gen. Larry D. Welch, AFA President Sam Keith, and America's top living fighter ace, retired Col. Francis S. "Gabby" Gabreski. The Salute annually raises funds for Air Force-related charities. (Photo by Sid Birns)

Ira Eaker Fellowships were presented to Gen. Robert T. Herres, Vice Chairman of the Joint Chiefs of Staff, and to Maj. Gen. Donald J. Kutyna, Vice Commander of Space Division, AFSC.

The Salute, a major fund-raiser for Air Force-related charities, is successfully raising its second million dollars. The money raised is distributed among the Air Force Assistance Fund, the Falcon Foundation, the Air Force Historical Foundation, the Air Force Museum, the National Aviation Hall of Fame, and AFA's own Aerospace Education Foundation. Proceeds are also set aside for scholarships for the Civil Air Patrol and USAF Academy cadets.

The crowd of more than 1,100 was entertained by the USAF Academy Cadet Chorale. The 100-voice group's repertoire includes patriotic, military, and popular songs from across the years.

Next year's Air Force Salute will take place in New York City on Saturday, April 9, 1988. ■

AIRMAN'S BOOKSHELF

The First Air Force

The Birth of Independent Air Power, by Malcolm Cooper. Allen & Unwin, Winchester, Mass., 1986. 169 pages with illustrations, notes, bibliography, and index. $24.95.

In forming the Royal Air Force (RAF) on April 1, 1918, Britain created the world's first independent air service. Considering that Britain had entered the war in 1914 with fewer than 200 ill-assorted aircraft divided between the army and navy, the new air service was a considerable achievement.

Today, almost seventy years after the RAF was established, the decision to form a separate service remains poorly understood. Previous studies have generally focused on the peacetime pressures that affected the RAF's growth. What distinguishes *The Birth of Independent Air Power* from other historical accounts is author Malcolm Cooper's analysis of the wartime experiences that led to the creation of the RAF. Mr. Cooper stresses that that experience—the undeniable reality of exploding German bombs—set Britain firmly on the road to establishing an independent air force.

Set against the background of the buildup of airpower during World War I, Cooper identifies specific factors that made the RAF a reality. Deepening political concern at failures in home air defense, public demands for retaliatory air action against Germany, problems of mobilization, and expansion in the aircraft industry combined to create conditions favorable to the establishment of an independent air force. The author argues that the antagonism between the army and naval air services, which eventually led to the disappearance of both, arose simply because material resources were insufficient to under-ite their respective policies and needs.

Attempts by the British to influence the course of the war through the direct use of airpower by the RAF and its predecessors against tactical or strategic objectives brought mixed results. On paper, however, the numbers looked impressive: 7,054 enemy aircraft downed, 6,942 tons of bombs dropped, more than 900,000 hours flown, and 10,500,000 rounds fired at ground targets. Even so, when the German army began to retreat, British aircraft were unable to cause serious confusion in the German ranks. Why?

Simply put, the aircraft of that era had relatively little impact on most targets, since most were armed only with two machine guns and a few hundred pounds of bombs. Furthermore, the lack of a clear tactical doctrine relegated Britain's air forces to a secondary role—reconnaissance. But the RAF did manage to implement a large home air defense network, which included searchlight and gun batteries, barrage balloons, interceptor squadrons, and early warning stations.

Mr. Cooper points out the startling fact that the air force with which Britain ended World War I was actually larger than that with which it entered World War II in 1939. The RAF had nearly 300,000 people and 22,000 aircraft at the conclusion of WW I and was arguably the most effective air service in the world at that time.

Immediately after the Armistice, however, the RAF suffered a massive reduction, shrinking from almost 200 front-line squadrons to thirty-three. Contracts were canceled, large quantities of equipment destroyed, and only a small percentage of trained pilots offered permanent peacetime commissions. The implicit lessons of the war did not carry over to ensure the RAF's unfettered independence following World War I. At the time of the Armistice, the RAF lacked both administrative tradition and doctrinal coherence. The air service functioned first and foremost as an ancillary to the army and navy.

During the interwar period, the British Air Ministry had to struggle hard to give substance to the legislative identity granted to the RAF in 1917–18. This process drove a wedge between the RAF and the other services, launching it on a strategic course that assumed a direction and momentum of its own. The RAF grew into an air force that operated separately from the remainder of the defense community.

Readers will find this book to be well documented. Author Cooper, a Research Fellow in History at Downing College in Cambridge, has based his analysis on an extensive study of official documents and private papers. The manuscript is also amply illustrated with contemporary photographs of people and aircraft.

The Birth of Independent Air Power will appeal to the serious student of military affairs. Readers will gain invaluable understanding of the roots of British aerospace doctrine and of the difficult political, military, and economic issues that must be resolved in establishing any separate military service. Perhaps most important, the reader can expect to gain a deeper understanding of how the seemingly modest beginnings of the world's first independent air service have affected the development and execution of naval and air warfare over the past half century.

—Reviewed by Maj. Michael B. Perini, USAF. Major Perini is a student at the Armed Forces Staff College in Norfolk, Va., and a frequent contributor to this magazine.

Timeless Design

Lockheed SR-71 Blackbird, by Paul F. Crickmore. An Osprey Air Combat Book; available from Zenith Aviation Books, Osceola, Wis., 1986. 200 pages with illustrations, appendix, and index. $14.95.

"All you have to do is look at it. Its sinister black shape exudes Mach 3 from every angle." Any aviation enthusiast—veteran or novice—will immediately know that the aircraft being described is none other than the amazing Lockheed SR-71.

Though it will mark its twenty-third anniversary of operational service this year, the SR-71 remains the world's fastest air-breathing airplane.

It can cruise above ninety-nine percent of the earth's atmosphere at speeds in excess of 2,100 miles per hour.

Now that the twenty-year cloak of secrecy has been lifted a bit, author Paul Crickmore is able to reveal the magnitude of the technical achievement that resulted in this remarkable high flyer. He begins his examination with a brief review of reconnaissance history up to the beginning of "Kelly" Johnson's A-12 program, codenamed Oxcart, which was to be the genesis of the SR-71.

Of particular note is the chapter entitled "Technical." Here Mr. Crickmore has outdone himself. Bringing the reader to the intricate design of the SR-71, he painstakingly details every facet of the aircraft's design and construction. He also spells out the aeronautical engineering processes used to fabricate what became a technological quantum leap.

Mr. Crickmore points out several problems encountered during the Blackbird's construction. For instance, a line drawn with a Pentel pen on a titanium sheet will eat a hole through it in about twelve hours because of the chemical reaction between ink and metal. In order to forestall this highly aggravating problem, all Pentel pens were checked at the beginning of each day's work.

The Lockheed Skunk Works team in Burbank, Calif., found also that early spot-welded panels produced during the summer months failed, but panels produced during winter lasted indefinitely. During the summer, the Burbank water supply is heavily chlorinated to prevent the formation of algae. Welds washed with the chlorinated water would repeatedly fail because of chemical reaction. Subsequently, all parts were washed with distilled water.

Such insights as these, scattered throughout the book, give the reader an eerie sense of looking over Kelly Johnson's shoulder during design and assembly of the Blackbird.

The operational life of the Blackbird is discussed in detail as well. Mr. Crickmore takes the reader on a tour of the main nesting place of the high flyer, Beale AFB, Calif., as well as its overseas operating locations at Kadena AB on Okinawa and RAF Mildenhall in the UK. In addition, he lists all of the speed records held by the aircraft as well as accidents that have occurred (at least, those on the public record).

Mr. Crickmore's last operational insight is perhaps his most timely one. He closes the volume with an inside look at participation by the SR-71 in the Eldorado Canyon mission, the April 1986 raid on Libya. Complementing the interesting text on SR 71 poststrike missions are Blackbird photos that provide graphic detail of the damage done by the Aardvark crews out of RAF Lakenheath.

I found this volume to be remarkable in its accuracy and detail. Airplane lovers everywhere are sure to value this book as a welcome addition to their library.

—Reviewed by Capt. Ronald A. Lovas, USAF, Contributing Editor.

New Books in Brief

Design for Air Combat, by Ray Whitford. This introduction to aerodynamic design may appear daunting to the novice at first glance, but the author has endeavored with modest success to render the arcana of aeronautical engineering understandable to a person of reasonable perseverance. Following a brief overview of basic principles, the reader enters the world of wing fences, relaxed static stability, and thrust vectoring. Many readers may be surprised to learn that the aesthetically pleasing forms of their favorite aircraft actually constitute major design compromises that have been carefully crafted to result in performance optimized for particular parameters. The text is liberally complemented by photos, charts, and line drawings that help immensely in coming to grips with this complex subject. With references and index. Jane's Publishing Inc., New York, N. Y., 1987. 224 pages. $30.

Taking Charge, by Maj. Gen. Perry M. Smith, USAF (Ret.). General Smith, a former Commandant of the National War College, undertakes in this commendably readable work "a practical guide for leaders who head large and complex organizations." Stressing the necessity for leaders actively to make a difference, the author examines several pitfalls that leaders of large organizations should avoid and provides pragmatic rules of thumb to follow in setting standards, dealing with subordinates, and establishing goals. General Smith's "how-to" approach, handy checklists, and case studies steer clear of excessive philosophizing and focus on day-to-day leadership concerns. Leaders at every level will benefit from his sage advice. With selected bibliography and index. National Defense University Press; available from Superintendent of Documents, US GPO, Washington, D. C., 1986. 234 pages. $7.

—Reviewed by Hugh Winkler, Assistant Managing Editor.

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AFA INTERCOM

By Robin Whittle, AFA DIRECTOR OF COMMUNICATIONS

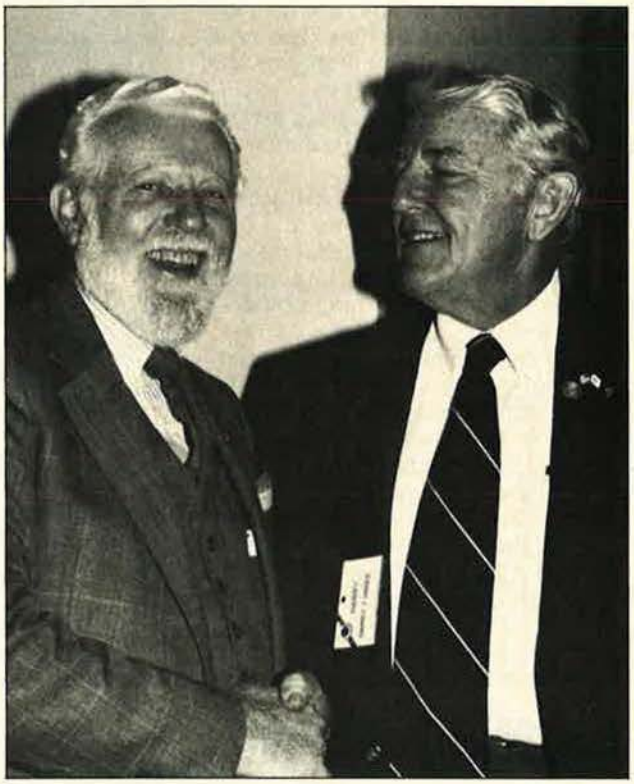
Oregon AFA Leader on MacNeil/Lehrer NewsHour

AFA Eugene Chapter President Harry Hance still thinks his horse got better coverage than did his opinion on the issue at hand during the Oregon Public Broadcast program that went national when it aired on the MacNeil/Lehrer NewsHour on April 6. A segment that included Mr. Hance's opinion on the importance of the Ground Wave Emergency Network (GWEN) was taped at his ranch, but only a single sentence survived the final edit—along with scenic shots of his horse.

Still, the program captured both sides of the controversy that has swirled around the proposal to erect a GWEN tower in Eugene, Ore. And despite Mr. Hance's efforts, which included pro-GWEN op-ed pieces in the Eugene *Register-Guard* and stormy public meetings during which Mr. Hance, Treasurer Ed Kelly, and other Eugene Chapter officials battled for the GWEN tower in Eugene, the Air Force finally proposed to move the site south to Klamath Falls.

The GWEN tower resembles a small AM radio transmitter 299 feet high. The Air Force plans to erect up to 127 such towers nationwide to provide a secure, EMP-hardened communications link between the National Command Authorities and US nuclear retaliatory forces in the event of a nuclear attack. That such a small but vital item for the nation's security could provoke such stirrings of protest has more to do with Eugene and the way the government explained the need for GWEN to local citizens than it does with GWEN itself.

There are dozens of antidefense groups feeding off student activism at the local university. Several years ago, when Mr. Hance encountered an anti-Peacekeeper missile display inside the Lane County courthouse, he decided that the local AFA chapter needed to broaden its base to include more concerned citizens. He founded the "Defense Education Committee" and sought like-minded citizens who would work to counter the antidefense atmosphere that had permeated the town. The committee was also involved in the GWEN battle and worked with AFA to try to prevent Eugene and Lane County from being declared "nuclear-free zones," which, despite the committee's efforts, occurred last year.



Eugene Chapter President Harry Hance, right, and Chapter Treasurer Ed Kelly congratulate one another at the conclusion of a successful dinner that the Chapter cosponsored with several other local organizations. The dinner featured SDIO official Dr. Richard Joseph, who spoke on the Strategic Defense Initiative effort.

The battle for GWEN will continue elsewhere in Oregon. One proposed site is Klamath Falls, where Mr. Hance and other Oregon AFA leaders have organized a new AFA chapter. In fact, the Klamath Basin Chapter was chartered on March 31. The new Chapter President is John C. Crocker. Kingsley Field ANGB is five miles southeast of Klamath Falls, and public attitudes there are more supportive of the military. Still, the anti-GWEN forces are organizing there as well.

In other Eugene Chapter news, officials cosponsored a dinner featuring Dr. Richard Joseph, special assistant to SDIO Director Gen. James A. Abrahamson, with the local Navy League, Retired Officers Association, and the Defense Education Committee on March 18. Billed as "the first authoritative report on SDI in this area of Oregon," the event generated coverage in the Eugene *Register-Guard.*

Texas AFA Essay Contest Winner Named

James H. Williams, a senior at Coronado High School in El Paso, won Texas AFA's Earle North Parker Essay Contest, reports Texas AFA President Ollie Crawford. Mr. Williams was honored at the Texas AFA spring executive council meeting hosted by the Aggieland Chapter at the College Station Hilton and Conference Center in March.

Writing on the theme "What Thomas Jefferson Would Say About America Today," Mr. Williams cited Jefferson's enthusiasm about citizen involvement in politics. Mr. Williams said Jefferson's greatest pleasure would be in observing the durability and application of the Declaration of

Independence. "Thomas Jefferson drafted this document and thus is responsible for the lofty ideals it sets forth. We are ever nearing his ideal of having 'all Men created equal . . . with certain unalienable Rights,'" Mr. Williams wrote. "It was Jefferson's opinion that citizens should abolish their government if these rights were taken away. The checks and balances envisioned during his time have worked so well that this has not been necessary."

"This year's winner is a very articulate, fine young man and a very good representative of AFA," Mr. Crawford said. A National Merit Scholar, Mr. Williams is active in a variety of extracurricular activities and hopes to pursue a career in medical research.

INTERCOM

Inland Empire Chapter Supports Area AAS/AF Conclave

AFA's Inland Empire Chapter in Spokane, Wash., helped underwrite the cost of the recent Arnold Air Society/Angel Flight Area XVI Conclave, which attracted more than 120 cadets and angels from throughout Washington and Oregon. A highlight of the three-day event was an address by Washington State University alumnus Gen. Robert D. Russ, Commander of Tactical Air Command, who discussed "the time-honored values for all good officers of virtue, loyalty, and professionalism," according to AAS Capt. Scott H. Griffis.

General Russ was honored with a special Washington State sweatshirt with four stars on each shoulder and the words "General Alumnus" on the back and with "Washington State Cougars" emblazoned on the front. AAS Area XVI Commander Keith Lu and Conclave Chairman Clayton M. Barnard made the presentation.

AFA National President Sam E. Keith, Jr., right, presents a check to Col. Rodney V. Cox, Jr., President of the Community College of the Air Force, to help defray the cost of the College's fifteenth anniversary celebration held last April at Maxwell AFB, Ala. AFA was instrumental in the establishment of the College, which boasts more than 300,000 registered students and some 54,000 graduates.

During a recent spring executive council meeting, Texas State AFA honored the winner of its 1987 Earle North Parker Essay Contest. Those present at the ceremony included, from left, El Paso Chapter President Frank Gallagher, contest winner James H. Williams, Air Force Recruiting Service Commander Brig. Gen. William J. Porter, and Texas AFA President Ollie Crawford.

In addition to the financial support for the Conclave, AFA's Inland Empire Chapter also contributed to the "Teenage Suicide Prevention Program" sponsored by the Washington State University ROTC unit, the Conclave's hosts. Teenage suicide prevention, POW/MIA awareness, and a visit to Fairchild AFB were on the Conclave agenda. Inland Empire Chapter President Don Krause and Past President Andy Kelly participated in the Conclave, as did Washington State AFA President Charlie Burdulis and Vice President Al Lloyd of the Greater Seattle Chapter.

On the Scene

Arkansas President **Tom Williams** reports that the first AFA State President, **Frank Bailey,** has been inducted into the Arkansas Aviation Hall of Fame. While the induction occurred last November, a resolution honoring Mr. Bailey was passed at the 1986 Arkansas AFA convention and was presented to him last February 14 during the David D. Terry, Jr., Chapter's Valentine Dance. A retired major gen-

eral, Mr. Bailey is a former commander of the Arkansas Air National Guard. He was instrumental in founding the Terry Chapter in Little Rock and guided it through its lean years, which culminated in a push that resulted in a growth of 1,400 members, the resolution states.

A command pilot with more than 10,000 hours, Mr. Bailey guided the Arkansas ANG from pre-World War II facilities and equipment to modern units with supersonic airplanes. In recognition of his achievement, **Maj. Gen. John B. Conaway,** Director of the Air National Guard, introduced Mr. Bailey at the induction ceremonies. Also inducted were **M. T. "Cy" Bond,** military pilot, airport builder, and Arkansas's oldest practicing flight instructor, and **Earl Rowland,** barnstormer, test pilot, and cross-country racer.

Pennsylvania AFA Vice President **Ron Chromulak** used background materials available to AFA leaders from AFA's Communications Department to fashion a series of op-ed pieces that recently appeared in several local newspapers on subjects ranging from the need for scientific and technical literacy to Soviet strategic developments.

Gen. John L. Piotrowski, former Air Force Vice Chief of Staff and current Commander in Chief of NORAD and US Space Command, addressed AFA's Cheyenne, Wyo., Chapter at its spring banquet on March 30. The Chapter is "now on the map," thanks to the hard work of President **Irene Johnigan** and her fellow officers. The event received excellent coverage in the Cheyenne *Eagle* and *State Tribune*.

Also receiving excellent coverage recently was the seventeenth annual awards banquet cosponsored by AFA's Antelope Valley, Calif., Chapter and the Lancaster Chamber of Commerce. The two groups teamed up in March to honor outstanding personnel at Edwards AFB, Calif. Extensive coverage subsequently appeared in the Antelope Valley *Press*.

Writing in the Northeast Region's newsletter *Northeaster,* National Vice President **Jack Flaig** discussed "AFA effectiveness" and said, "We need young people interested in AFA programming, not old people trying to hold on [in] AFA power politics. We have long urged involvement with AFROTC, CAP, and the young people who are the future of our Air Force. Even you older folks will think young if you forcefully support programs for our young people," Mr. Flaig wrote. As the immediate past Pennsylvania AFA President, Mr. Flaig worked specifically to bring in young leaders. As a result, three of Pennsylvania's four officers are under the age of forty.

In New Jersey's Union Morris Chapter's newsletter *Plane Talk,* business cards of its Community Partners are printed, and members are encouraged to frequent these business establishments.

How do you get Community Partners? Simply ask. That's the advice of Greater Seattle Chapter President **Joe Jackson,** a Medal of Honor recipient, who simply asked his dentist. The dentist agreed, and Greater Seattle now has its first Community Partner.

In Anchorage Chapter news, longtime AFA leader **Ed Monaghan** forwarded a column by **William J. Tobin** that appeared in the Anchorage *Times* in March. Mr. Tobin quotes from **Capt. Rana Pennington's** article on a first-of-its-kind tactical exercise that took place at Eielson AFB last October. Captain Pennington is Chief of the Threat Analysis Division for the Intelligence Section of Alaskan Air Command. Her article, "Yukon Lightning," appeared in AIR FORCE Magazine's March 1987 issue.

Florida AFA Vice President and Florida Highlands Chapter Secretary **Roy Whitton** thanked the outgoing 56th Tactical Training Wing Commander at MacDill AFB, **Col. (Brig. Gen. selectee) Joseph W. Ralston,** for his support of the Chapter and enlisted personnel at the Avon Park Range. Mr. Whitton presented him with a Keith Ferris lithograph of the F-105 Wild Weasel, an aircraft Colonel Ralston flew in combat in Vietnam. Colonel Ralston's new assignment is at Langley AFB, Va., as Deputy Director of Operations at Hq. TAC.

ATC Commander Lt. Gen. John A. Shaud recently addressed a meeting of the Concho Chapter that also saw the election of new officers. Pictured are, from left, General Shaud, new Chapter President Frank Sanders, outgoing Chapter President Roger Dolliver, and Goodfellow TTC Commander Brig. Gen. Paul L. Roberson.

In Texas, former Alamo Chapter President **Bill Roth** is the advisory director of the newly formed Officer Training School Alumni Association, which presented the first of ten plaques to be displayed on a monument honoring the almost 90,000 officers who have graduated from OTS. The $100,000 monument will be financed entirely through private donations. OTS grads who want more information can write the Association at P. O. Box 27218, San Antonio, Tex. 78227-0218.

Lt. Gen. John A. Shaud, Commander of Air Training Command, addressed more than 250 guests at a dinner sponsored by AFA's Concho Chapter in San Angelo, Tex., in February. During the event, Chapter officers were elected: **Frank Sanders,** President; **John Fender,** Vice President; **Dick Howard,** Secretary; and **B. P. "Beep" Cain,** Treasurer. Chapter officials say General Shaud gave an excellent briefing on ATC activities and noted that Goodfellow AFB will become the location of the Intelligence Training Consolidation Program. Virtually all Air Force intelligence train-

Correction

In the February 1987 article "1986 SCAMP Scholarship Winners," it was reported incorrectly that Lt. Col. Robert M. Brown, USAF, and Lt. Col. Robert J. Panek, USAF, both missing in action in the early 1970s in Southeast Asia, were "subsequently returned to the US." Both men are, in fact, now reported officially as killed in action. Further, SCAMP scholarship winner Kristin Panek resides in Schaumburg, Ill., rather than in Joliet, Ill., as was reported in the article.—THE EDITORS

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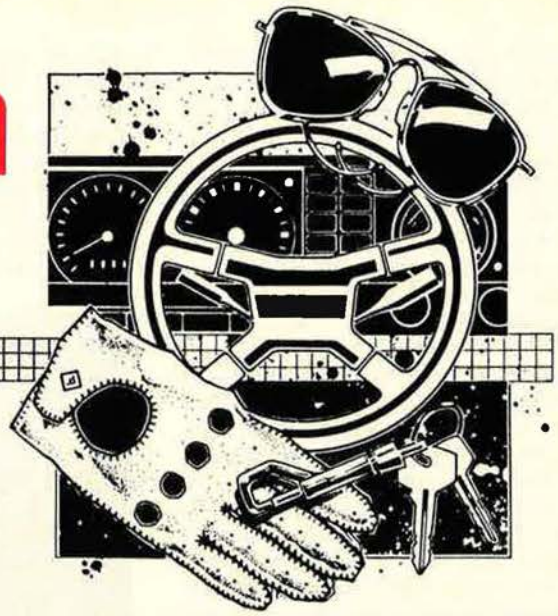

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☐ Power mirrors ☐ Power windows
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☐ Power seats: ☐ Driver ☐ Passenger ☐ Bench ☐ Reclining
☐ California emission ☐ High altitude emission
☐ Air conditioning ☐ Auto. temperature control
☐ Battery, H.D. ☐ Cooling H.D.
☐ Bumper guards ☐ Impact strips
☐ Cruise control ☐ Console
☐ Defogger, rear window
☐ Door edge guards
☐ Floor mats (F&R)
☐ Glass, tinted
☐ Gauges ☐ Electronic gauges
☐ Headlamp control ☐ Light group
☐ Luggage rack
☐ Mirrors, remote LH ☐ RH manual ☐ Other _____
☐ Visor, vanity, illuminated
☐ Moldings, bodyside ☐ Rocker panel ☐ Other _____
☐ Paint stripe ☐ Two-tone paint
☐ Radio, AM ☐ AM/FM stereo ☐ AM/FM stereo w/ cassette ☐ AM/FM stereo w/cassette & premium sound
☐ Roof, full vinyl ☐ Other _____
☐ Seat trim ☐ Cloth ☐ Vinyl ☐ Leather
☐ Seats, bench ☐ Notchback 55/45 ☐ 45/45 ☐ Bucket ☐ Other _____
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ing will be relocated to Goodfellow AFB by 1988.

AFA has, in addition to the Klamath Basin Chapter, two new chapters: Keweenaw Chapter in Calumet, Mich., led by President **Richard M. Rupley,** and the General Nathan F. Twining Chapter in Palm Harbor, Fla., led by President **Mack A. Blevins.** Four chapters have been deactivated: Beaches of Jacksonville (Florida), Air Commando (Florida), War Eagle (Alabama), and Greater Bellingham (Washington). Four chapters have changed their names: Garden City (Kansas) to the Contrails Chapter, Spudland (Maine) to the Maj. Charles J. Loring, Jr., Chapter, Rio Grande Valley (Texas) to the Ghost Squadron Chapter, and Sedona (Arizona) to the Barry Goldwater Chapter. ■

Coming Events

June 5–7, **New York State Convention,** Albany . . . June 5–7, **Washington State Convention,** Spokane . . . June 12–14, **Georgia State Convention,** Rome . . . June 13, **Louisiana State Convention,** Barksdale AFB . . . June 19–21, **New Jersey State Convention,** Cape May . . . June 19–21, **Ohio State Convention,** Warren . . . June 20, **Maine State Convention,** Bangor . . . June 20, **Montana State Convention,** Malmstrom AFB . . . June 26–27, **Oklahoma State Convention,** Tinker AFB . . . July 17–18, **Wisconsin State Convention,** Milwaukee . . . July 17–19, **Mississippi State Convention,** Biloxi . . . July 17–19, **Pennsylvania State Convention,** Harrisburg . . . July 17–19, **Texas State Convention,** Dallas . . . July 18, **Nevada State Convention,** Tonopah . . . July 24–25, **Oregon State Convention,** Portland . . . July 31–August 1, **Colorado State Convention,** Lowry AFB . . . July 31–August 2, **Florida State Convention,** MacDill AFB . . . July 31–August 1, **Missouri State Convention,** Kansas City . . . August 7–9, **Arkansas State Convention,** Fort Smith . . . August 19, **Delaware State Convention,** Dover AFB . . . August 20–23, **California State Convention,** Vandenberg AFB . . . August 21–23, **Utah State Convention,** Salt Lake City . . . August 28–30, **Arizona State Convention,** Sedona . . . August 29, **Illinois State Convention,** Glenview NAS, Chicago . . . August 29, **Indiana State Convention,** Fort Wayne . . . September 14–17, **AFA National Convention and Aerospace Development Briefings and Displays,** Washington, D. C. . . . September 25–26, **North Dakota State Convention,** Minot.

UNIT REUNIONS

Reunion Notices

Readers wishing to submit reunion notices to "Unit Reunions" should mail their notices well in advance of the event to "Unit Reunions," AIR FORCE Magazine, 1501 Lee Highway, Arlington, Va. 22209-1198. Please designate the unit holding the reunion, time, location, and a contact for more information.

Correction
In the April 1987 issue, on p. 122, we announced that members of the 314th Composite Wing would hold a reunion July 16–19 in Nashville. The notice should have said that the Hq. and Hq. Squadron of the 314th Composite Wing, Fifth Air Force (former V Bomber Command), would meet in Nashville, Tenn., July 16–19, 1987. **Contact:** Bob Kindell, Lou Buddo, or Mel Hiller, Box 35372, Louisville, Ky. 40232. Phone: (502) 459-1121. Our apologies for the "disinformation" in April.

AACS Alumni Ass'n
Airways and Air Communications Service alumni will hold their eleventh reunion on October 8–11, 1987, in Austin, Tex. **Contact:** Bruce Hilton, 10501 Spicewood, Austin, Tex. 78750. Phone: (512) 258-2872.

Air-Sea Rescue Squadrons
Members of the Army Air Corps Air-Sea Rescue School, Keesler AFB, Miss., along with members of the 6th and 7th Emergency Rescue Squadrons will hold a forty-year reunion on September 10–13, 1987, at the Regency Resort Hotel in Scottsdale, Ariz. **Contact:** Harry B. "Hap" Arnold III, 4411 Crestwood Way, Sacramento, Calif. 95822. Phone: (916) 441-0811.

Instructors and Supervisors
Instructors and supervisors based at Barksdale, Bryan, Enid, Kelly, Lubbock, and Randolph Army Airfields during the 1940s will hold a reunion on September 18–21, 1987, in Lubbock, Tex. **Contact:** Dudley Faver, 4202 88th St., Lubbock, Tex. 79423. Col. John F. Nuding, USAF (Ret.), 8617 Utica, Lubbock, Tex. 79424.

Kelly/Hondo Navigation School
Navigation school personnel based at Kelly and Hondo Army Airfields from 1941 through 1945 have scheduled a forty-fifth-year reunion for mid-October 1987. **Contact:** Edward M. Osander, 7709 Broadway, #222, San Antonio, Tex. 78209. Phone: (512) 826-1414.

NORAD Commanders/Staff Members
North American Aerospace Defense Command (NORAD), Peterson AFB, Colo., will hold a thirtieth-year anniversary reunion for former commanders and headquarters staff members on September 12, 1987, at Peterson AFB, Colo. **Contact:** Maj. Len Campaigne, Canadian Forces, Staff Officer, Military and Political Affairs, Hq. NORAD/NPX, Stop 7, Peterson AFB, Colo. 80914-5001. Phone: (303) 554-2953.

RAAF/WAFB Veterans Ass'n
Veterans of Roswell AAF/Walker AFB, N. M., will hold a reunion on September 25–27, 1987, at Roswell Inn in Roswell, N. M. **Contact:** RAAF Veterans Association, P. O. Box 8092 (Linda Vista Station), Roswell, N. M. 88201.

Red River Valley Pilots Ass'n
Members of the Red River Valley Fighter Pilots Association are planning a reunion tour to Thailand on October 31–November 8, 1987. **Contact:** Jack S. Douglas, P. O. Box 9097, Salt Lake City, Utah 84109. Phone: (801) 484-7144.

Wright Field Pilots
Pilots who served at Wright-Patterson Field, Ohio, in bomber, fighter, or cargo flight tests during World War II will hold a reunion at Wright-Patterson AFB on September 14–16, 1987. **Contact:** Thomas P. Leary, 218 S. 95th St., Omaha, Neb. 68114.

1st Air Commando Ass'n
The 1st Air Commandos will hold a reunion on September 17–20, 1987, in Colorado Springs, Colo. **Contact:** Lt. Col. R. E. Moist, USAF (Ret.), P. O. Box 466, Broderick, Calif. 95605.

1st Strategic Air Depot Ass'n
Members of the 1st Strategic Air Depot Association will hold a reunion on September 22–30, 1987, in London and Honington, England. **Contact:** Herbert H. Kaster, 720 Society Hill, Cherry Hill, N. J. 08003.

1st and 2d Staff Squadrons
Members of the 1st and 2d Staff Squadrons and other units at Bolling Field, D. C., during World War II will hold a reunion on October 9–11, 1987, near Andrews AFB, Md. **Contact:** William Fahr, 34 Weather Oak Hill, New Windsor, N. Y. 12550. Phone: (914) 564-7523.

3d British Flying Training School
Members of the 3d British Flying Training School based in Miami, Okla., from 1941 through 1945 (RAF and USAAF cadets, instructors, and ground crew) will hold a reunion at the Confederate Air Force Air-Sho on October 9–11, 1987, in Harlingen, Tex. **Contact:** Harry Witt, 4207 Cliffwood Cove, Austin, Tex. 78759. Phone: (512) 345-0005 (RAF contact). George Mayer, P. O. Box 1468, Miami, Okla. 74354. Phone: (918) 542-1829 (USAAF/staff contact).

8th Photo Recon Squadron
Members of the 8th Photo Reconnaissance Squadron will hold a reunion on October 8–12, 1987, at the Marriott Hotel in Kansas City, Mo. **Contact:** Andy Kappel, 6406 Walnut, Kansas City, Mo. 64113. Phone: (816) 363-0261.

9th Photo Recon Squadron
Members of the 9th Photo Reconnais-

sance Squadron will hold a reunion on October 9–11, 1987, in Amana, Iowa. **Contact:** Clair Sauter, 703 W. Hilton, Marengo, Iowa 52301. Phone: (319) 642-7162.

12th Tactical Recon Squadron
The 12th Tactical Reconnaissance (Aero/Observation) Squadron will hold its seventieth-year anniversary reunion on October 1–3, 1987, in Orlando, Fla. **Contact:** Leon "Abe" Lincoln, 3013 Trentwood Blvd., Orlando, Fla. 32812.

17th Bomb Group Ass'n
Members of the 17th Bomb Group will hold a reunion on October 8–11, 1987, in Louisville, Ky. **Contact:** W. D. Baird, 6776 E. Northwest Hwy., Dallas, Tex. 75231.

19th LSS/ATS
Veterans of the 19th Logistics Support Squadron/19th Air Transport Squadron stationed at Kelly AFB, Tex. (1951–70), will hold a reunion on November 6–8, 1987, at the Wyndham Hotel in San Antonio, Tex. **Contact:** Lt. Col. Robert A. Betterton, USAF (Ret.), 7217 Bandera Rd., San Antonio, Tex. 78238.

22d Bomb Wing Ass'n
Members of the 22d Bomb Wing and supporting units will hold a combined reunion with the Fifteenth Air Force Association on October 14–18, 1987, at the Clarion Hotel in Colorado Springs, Colo.**Contact:** Lloyd L. Hager, 7406 Hobble Dr., San Antonio, Tex. 78227. Phone: (512) 673-3754.

27th Tactical Fighter Squadron
The 27th Tactical Fighter Squadron will hold a seventieth-year anniversary reunion and a Golf Tournament/Dining-In on July 17–19, 1987, at Langley AFB, Va. **Contact:** Maj. Bryant Dougherty, USAF, 17 Diamond Hill Rd., Hampton, Va. 23666. Phone: (804) 764-7391. AUTOVON: 574-7391 (reunion contact). Capt. Steve Twombly, USAF, 689 Willow Oaks Blvd., Hampton, Va. 23669. Phone: (804) 764-7391. AUTOVON: 574-7391 (Tournament/Dining-In contact).

33d Air Depot Group
Members of the 33d Air Depot Group will hold a forty-fifth-year reunion on October 2–4, 1987, at Warner Robins, Ga. **Contact:** Herbert L. Cooper, 643 Reynosa Ct., Berea, Ohio 44017. Phone: (216) 234-9007.

33d Photo Recon Squadron Ass'n
The 33d Photo Reconnaissance Squadron will hold a reunion on October 9–11, 1987, in Dayton, Ohio. **Contact:** Leo E. Shelton, 610 W. Michigan Ave., Hammond, La. 70401. Phone: (504) 345-4253. Lt. Col. Burl R. Stokes, USAFR (Ret.), 311 Glendale St., Creve Coeur, Ill. 61611. Phone: (309) 699-6616.

34th Bomb Group Ass'n
The 34th Bomb Group will hold a reunion on September 10–13, 1987, in King of Prussia, Pa. **Contact:** Ray L. Summa, 2910 Bittersweet Lane, Anderson, Ind. 46011. Phone: (317) 644-6027.

35th Fighter Control Squadron
The 35th Fighter Control Squadron, Thirteenth Air Force, will hold a reunion on

UNIT REUNIONS

September 17–20, 1987, in New Orleans, La. **Contact:** Kenneth "Bogy" Bogart, 512 W. Kirwin, Salina, Kan. 67401. Phone: (913) 823-3604.

Class 40-F
Flying Cadet Class 40-F will hold a reunion on October 2–4, 1987, in Orlando, Fla. **Contact:** Col. Herbert Rosenthal, USAF (Ret.), 5108 Brittany Dr. S., St. Petersburg, Fla. 33715. Phone: (813) 866-3721.

Class 42-A
Class 42-A (Brooks Field) will hold a reunion on October 29–November 1, 1987, at the Marriott Hotel in New Orleans, La. **Contact:** Jim O'Brien, Morgan City, La. 70380. Phone: (504) 384-5105.

Class 43-G
Cadet Class 43-G (Williams Field, Ariz.) will hold a reunion on September 10–12, 1987, in Niagara Falls, Ontario, Canada. **Contact:** Chuck Schumacker, P. O. Box 371, Youngstown, N. Y. 14174.

45th Air Depot Group
Members of the 45th Air Depot Group will hold a forty-first-year reunion on September 17–20, 1987, in Norfolk, Va. **Contact:** Charles F. Guemelata, 119 Aigler Blvd., Bellevue, Ohio 44811. Phone: (419) 483-4371.

49th Fighter Group Ass'n
The 49th Fighter Group will hold a reunion on October 8–10, 1987, at the Ramada Hotel in Albuquerque, N. M. **Contact:** John Roth, 1017 Adams S. E., Albuquerque, N. M. 87108. Phone: (505) 268-2903.

75th Troop Carrier Squadron
Members of the 75th Troop Carrier Squadron will hold a reunion on September 10–13, 1987, at the Marriott Motel in Indianapolis, Ind. **Contact:** Robert C. Richards, 139 Kiser Dr., Tipp City, Ohio 45371. Phone: (513) 667-3827.

86th Fighter-Bomber Group Ass'n
Members of the 86th Fighter-Bomber Group who served in Europe and North Africa during World War II will hold a reunion on July 23–25, 1987, in Seattle, Wash. **Contact:** Robert B. Walsh, 6922 Mount Tacoma Dr. S. W., Tacoma, Wash. 98499. Phone: (206) 584-0955.

98th Bomb Group Ass'n
Veterans of the 98th Bomb Group will hold a reunion on September 9–12, 1987, in Colorado Springs, Colo. **Contact:** Maj. Samuel D. Wareham, USAF (Ret.), 639 Mulder Dr., Lincoln, Neb. 68510. Phone: (402) 483-5548.

107th Tactical Recon Squadron
Veterans of the 107th Tactical Reconnaissance Squardron who served during World War II will hold a reunion on July 17–19, 1987, at Selfridge ANGB, Mich. **Contact:** Col. Chalmer E. Hunter, USAF (Ret.), 1590 Old Mill Rd., Springfield, Ohio 45502.

304th Fighter Squadron
Members of the 304th Fighter Squadron, 337th Fighter Group, will hold a reunion during September 1987 in Norfolk, Va. **Contact:** Tracy P. Little, 3011 Westover St., Shreveport, La. 71108. Phone: (318) 635-2426.

306th Bomb Group Ass'n
The 306th Bomb Group will hold a reunion on September 16–20, 1987, at the Crystal City Hyatt Regency Hotel in Arlington, Va. **Contact:** William S. Rader, 1108 Key Dr., Alexandria, Va. 22302.

306th Bomb Wing
Members of the 306th Bomb Wing (McCoy AFB, Fla.) will hold a reunion on November 5–8, 1987, in Orlando, Fla. **Contact:** Robert E. Grierson, 6616 Beret Dr., Orlando, Fla. 32809.

309th Fighter Squadron
The 309th Fighter Squadron will hold a reunion on September 10–12, 1987, in Pueblo, Colo. **Contact:** Ralph Apple, Box 41, Crowley, Colo. 81033. Phone: (303) 267-3721.

310th Tactical Fighter Training Squadron
Members of the 310th Tactical Fighter Training Squadron, including former members who served in the 310th Fighter-Bomber Squadron during World War II and Korea, will hold a reunion on September 18–19, 1987, at Luke AFB, Ariz. **Contact:** Lt. Col. John B. Gibbs, USAF, Commander, 58th Tactical Training Wing (TAC), 310th TFTS/CC, Luke AFB, Ariz. 85309. Phone: (602) 856-7730.

313th Fighter Squadron
The 313th Fighter Squadron, 50th Fighter Group, will hold a reunion on September 17–21, 1987, in Reno, Nev. **Contact:** George Condern, 4510 Gorl Way, Reno, Nev. 89502. Phone: (702) 826-3127.

315th Bomb Wing Ass'n
The 315th Bomb Wing will hold its reunion on October 8–10, 1987, at the Wyndham Hotel in San Antonio, Tex. **Contact:** William E. Cooper, 901 Stemmons Tower East, 2700 Stemmons Freeway, Dallas, Tex. 75207. Phone: (214) 631-0834. Col. George Harrington, USAF (Ret.), 4600 Ocean Beach Blvd., #505, Cocoa Beach, Fla. 32931. Phone: (214) 784-0342.

316th Fighter Squadron
The 316th Fighter Squadron "Hell's Belles" will hold a reunion on October 16–17, 1987, at the Royal Palms Inn in Phoenix, Ariz. **Contact:** Col. William F. Barns, USAF (Ret.), 5409 E. Camello Rd., Phoenix, Ariz. 85018. Phone: (602) 231-2357 (office) or (602) 840-6368 (home).

346th Fighter Squadron
The 346th Fighter Squadron, 350th Fighter Group, will hold a reunion on Septem-

ber 3–5, 1987, in Portland, Ore. Members of the 345th and 347th Fighter Squadrons are also welcome. **Contact:** Lt. Col. George W. Miles, USAF (Ret.), 7224 N. Washburn Ave., Portland, Ore. 97217. Phone: (503) 285-8645.

368th Fighter Group
Members of the 395th, 396th, and 397th Fighter Squadrons, 368th Fighter Group, will hold their reunion on September 17–19, 1987, at the Antlers Hotel in Colorado Springs, Colo. **Contact:** Lt. Col. Frank S. Kerchner, USAF (Ret.), 2524 Rimrock Dr., Colorado Springs, Colo. 80915.

388th Bomb Group Ass'n
The 388th Bomb Group and attached units will hold a thirty-eighth-year reunion on November 8–15, 1987, at the Sheraton World Hotel in Orlando, Fla. **Contact:** Edward J. Huntzinger, 1925 S. E. 37th St., Cape Coral, Fla. 33904. Phone: (813) 542-4807.

405th Fighter Group
The 405th Fighter Group, along with the 509th, 510th, and 511th Fighter Squadrons, will hold a reunion on September 10–12, 1987, in Colorado Springs, Colo. **Contact:** Col. Reginald G. Nolte, USAF (Ret.), 9326 Sturbridge, San Antonio, Tex. 78250. Phone: (512) 684-1724.

421st Night Fighter Squadron
Veterans of the 421st Fighter Squadron who served in World War II will hold a reunion on October 15–18, 1987, at the Hyatt Regency Hotel in Atlanta, Ga. **Contact:** Bill Gorman, 3258 N. Embry Circle, Chamblee, Ga. 30341. Al W. Lockard, 3101 Tigertail Dr., Los Alamitos, Calif. 90720. Phone: (213) 598-9151.

451st Bomb Squadron
The 451st Bomb Squadron will hold a reunion on October 2–3, 1987. **Contact:** James J. Crumbliss, 2014 Shady Grove Dr., Bossier City, La. 71112.

453d Bomb Group
The 453d Bomb Group will hold a reunion on September 20–22, 1987, at the Holiday Inn in Fairborn, Ohio. **Contact:** Milton R. Stokes, P. O. Box 64, Westtown, Pa. 19395.

454th Bomb Squadron Ass'n
Members of the 454th Bomb Squadron, 323d Bomb Group, Ninth Air Force, will hold their twelfth-year reunion on September 2–6, 1987, at the Crystal City Sheraton Hotel in Arlington, Va. **Contact:** Joseph R. Havrilla, 1208 Margaret St., Munhall, Pa. 15120. Phone: (412) 461-6373.

456th Bomb Squadron
The 456th Bomb Squadron will hold a reunion in October 1987 in Niagara Falls, Ontario, Canada. **Contact:** George Weaver, Box 309, Fredonia, N. Y. 14063. Phone: (716) 366-3299.

461st/484th Bomb Groups
Members of the 461st and 484th Bomb Groups will hold their reunion in conjunction with the Fifteenth Air Force Association on October 14–18, 1987, at the Clarion Hotel in Colorado Springs, Colo. **Contact:** Bud Markel, 1122 Ysabel St., Redondo Beach, Calif. 90277. Phone: (213) 316-3330.

463d Bomb Group Historical Society
The 463d Bomb Group and squadrons of the 463d Tactical Airlift Wing will hold a reunion on October 1–4, 1987, in Norfolk, Va. **Contact:** Rev. Eugene E. Parker, P. O. Box 127, Edwardsport, Ind. 47528.

483d Bomb Group Ass'n
The 483d Bomb Group will hold its reunion on September 9–13, 1987, in Boston, Mass. **Contact:** John Vecchiola, 73 Bicknell St., Apt. G-19, Quincy, Mass. 02129. Phone: (617) 773-5703.

557th Bomb Squadron Ass'n
The 557th Bomb Squadron, 387th Bomb Group, will hold a reunion on October 1–4, 1987, at the Suite Simpatica Hotel in Farmington, N. M. **Contact:** R. C. "Bob" Allen, 9215 Cherokee Pl., Leawood, Kan. 66206. Phone: (913) 649-6606.

559th Bomb Squadron
Members of the 559th Bomb Squadron, 387th Bomb Group, will hold their reunion in September 1987 in Myrtle Beach, S. C. **Contact:** Pasquale A. Razzano, 10 Robin Hood Rd., Suffern, N. Y. 10901. Phone: (914) 357-5983.

584th Bomb Squadron
Veterans of the 584th Bomb Squadron, 394th Bomb Group, are planning to hold a reunion on September 11–13, 1987. **Contact:** Carl Marsh, 4650 Mooresville Rd., Indianapolis, Ind. 46241. Phone: (317) 856-5790.

782d Bomb Squadron
The 782d Bomb Squadron, 465th Bomb Group, will hold a reunion on October 14–18, 1987, in Colorado Springs, Colo., in conjunction with the Fifteenth Air Force Association. **Contact:** Chester J. Milczarek, 529 Fairfield Dr., Corpus Christi, Tex. 78412. Phone: (512) 991-6136. William F. Bruce, Jr., 1683 Eggert Rd., Buffalo, N. Y. 14226. Phone: (716) 834-8144.

801st/492d Bomb Group Ass'n
Members of the 801st/492d Bomb Group "Carpetbaggers" stationed at Alconbury, Watton, and Harrington, England (1943–45), are planning a memorial dedication in England on September 16–20, 1987, and a reunion with the 8th Air Force Historical Society on October 14–18, 1987, in Pittsburgh, Pa. **Contact:** Sebastian H. Corriere, 4939 N. 89th St., Milwaukee, Wis. 53225. Phone: (414) 464-8264. Douglas D. Walker, 10020 De Koven Dr., Tacoma, Wash. 98499. Phone: (206) 588-0991.

7330th Flying Training Wing
The 7330th Flying Training Wing stationed at Fürstenfeldbruck AB, Germany, will hold its thirty-fourth-year reunion on October 15–18, 1987, in Melbourne, Fla. **Contact:** Earle Barber, 2517 S. Forest Dr., Melbourne, Fla. 32901.

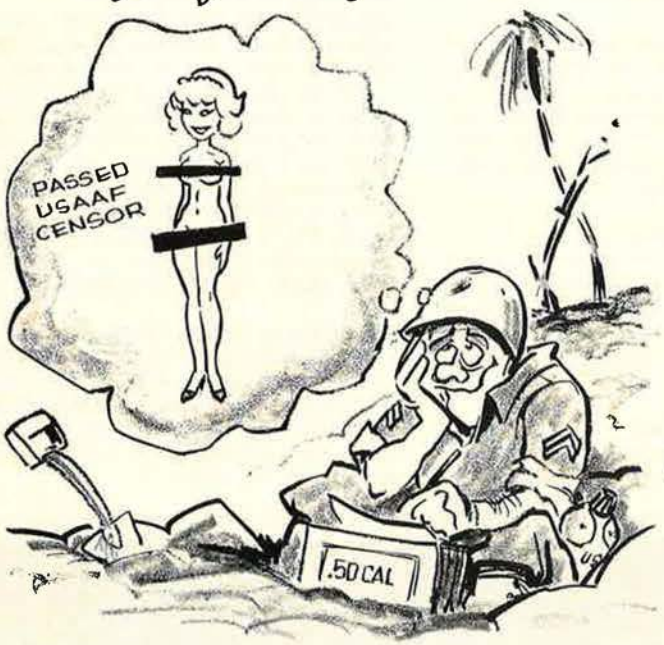
Bob Stevens'

"There I was..."

THE BIT BELOW CRIED OUT TO BE DONE IN THIS SPACE - FLYING OR NO. THESE ARE EXCERPTS FROM ACTUAL LETTERS RECEIVED FROM MOTHERS, WIVES and SERVICEMEN. THEY WERE EITHER MAKING OR CORRECTING APPLICATIONS FOR ALLOTMENTS OF PAY.

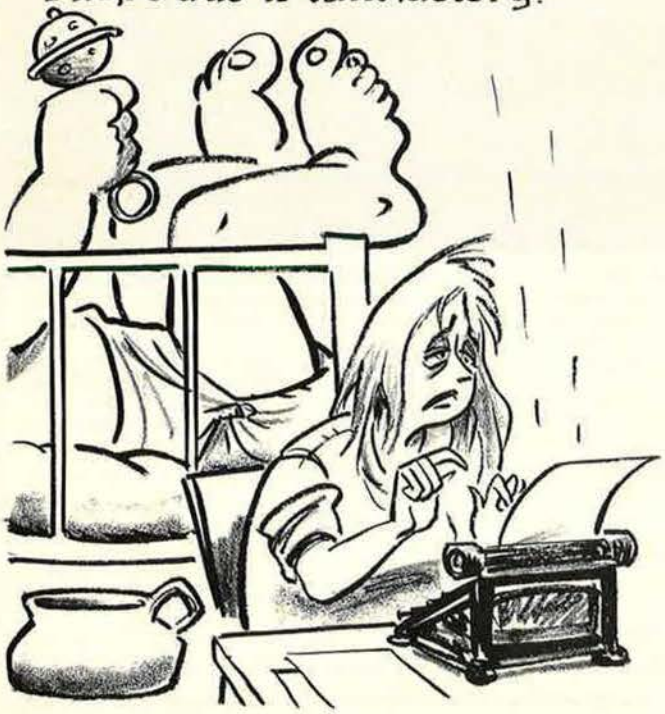
THE TIME : NOVEMBER 1944

"Please send me my wife's form to fill out."

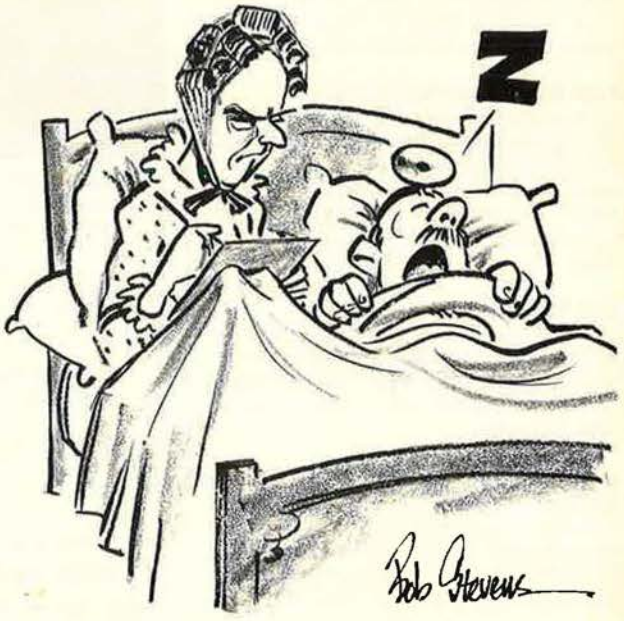


"Sir, I am forwarding my marriage certificate and two children, one of which is a mistake, as you can see"

"In answer to your letter, I gave birth to a boy weighing 101 lbs. I hope this is satisfactory."



"I want my money as fast as you can send it! I have been in bed with a doctor but he don't seem to be doing me much good."



E-SYSTEMS

Our Pledge

I pledge allegiance to the flag
of the United States of America
and to the republic for which it stands,
one nation,
under God,
indivisible,
with liberty
and justice for all.

— Francis Bellamy, 1892

E-SYSTEMS

The science of systems.

THE F-15: KEY PLAYER ON THE USAF TEAM.

FACT: THE LESS TIME OUR FIGHTERS NEED FOR MAINTENANCE AND REPAIR, THE MORE READY OUR DEFENSE.

Air Force fighters must be combat-ready around the clock. Because a crisis can arise anywhere, at any time. That's why the U.S. Air Force relies on the F-15 Eagle. The Eagle has proven itself to be rough, tough and ready to hit more often than any other air superiority fighter.

The Eagle is setting a new level of availability in its class. It's also setting a new level for sortie generation. And, it's proving itself much more reliable than the aircraft it replaces.

How do crew chiefs rate the Eagle for maintainability and reliability? Listen to these Eagle Keepers:

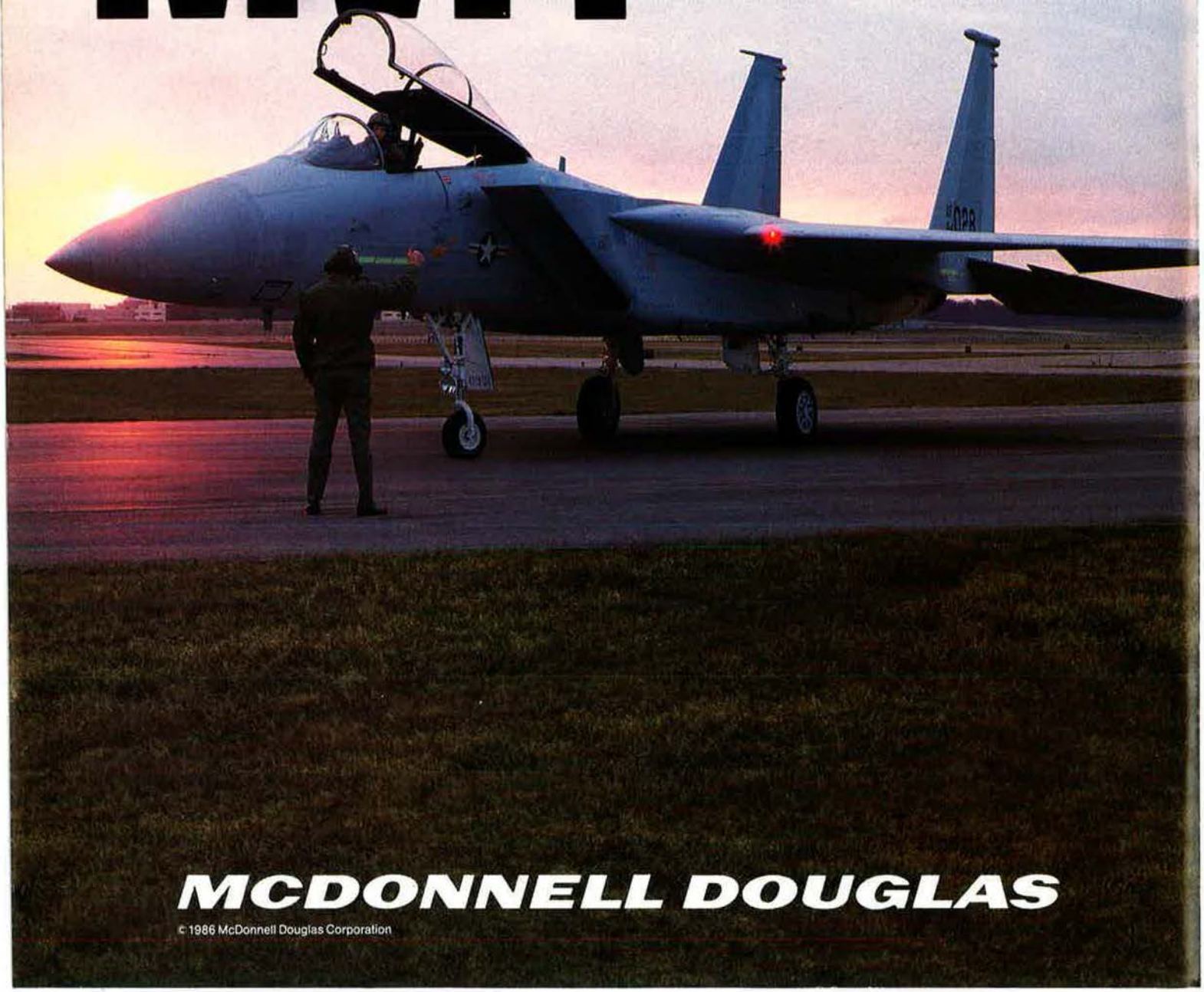
"...an excellent aircraft to maintain."

"...a beautiful aircraft...no other in the world can match it."

"The easiest and most reliable aircraft I've ever had a chance to work on."

For a strong defense, America counts on the Air Force. And the Air Force counts on the F-15 Eagle.

MVP.



MCDONNELL DOUGLAS