JANUARY 1966

Air Force/Space Digest International

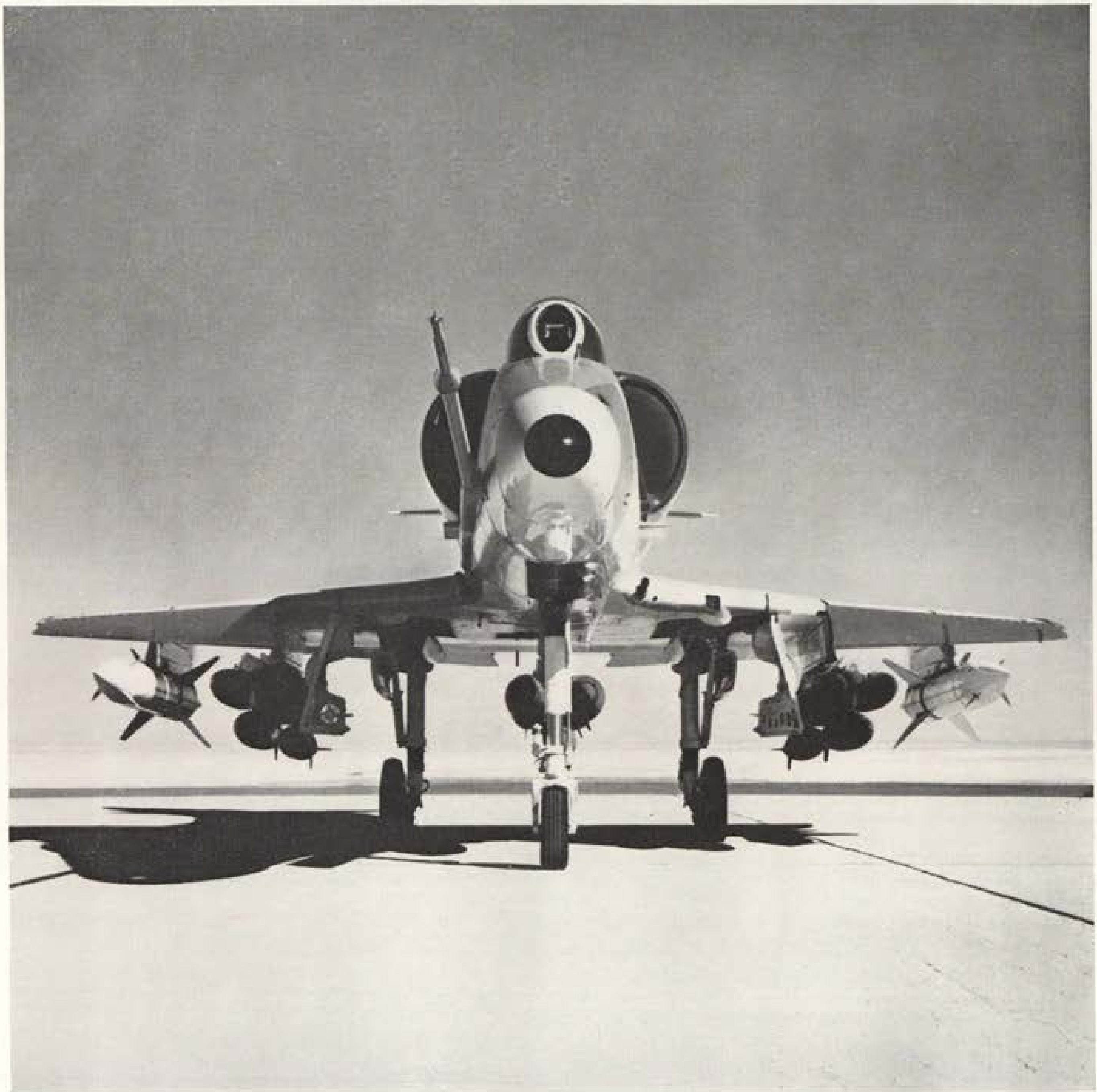
PUBLISHED FOR THE LEADERS OF THE FREE WORLD BY THE UNITED STATES AIR FORCE ASSOCIATION

SKYHAWK...

Long Life and Heavy Loads

Although the Douglas A-4 Skyhawk has been operational for 10 years, no other attack plane in the world has matched its payload-to-weight ratio and low-cost performance. Remarkable innovations in Skyhawk design guarantee it a useful life for years to come.

— *SEE PAGE 11*



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NORTHROP F-5

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Letter from Washington

Aware that the United States is being criticized abroad for its effort to sell arms to its allies, the Department of Defense is throwing up a defense for itself. Chief spokesman for Secretary of Defense Robert S. McNamara, the Pentagon's architect of the new approach, is Henry J. Kuss, who is viewed by some as the "supersalesman" in person. He denies this and says there are "superbuyers" among U.S. allies who need and want American weaponry. In the future there will be more cooperation with the NATO powers in the area of research, test, and evaluation leading to production of modern systems. The effort has been started to prove . . .

The Case for a Common Defense Market

BY CLAUDE WITZE
Senior Editor

Washington, D.C., Nov. 22

There is increasing evidence, most of it in statements by Pentagon officials who appear before U.S. industry audiences, that the U.S. Department of Defense is trying to win friends and influence people. DoD is talking long and persuasively both to Americans and to their allies about what it feels is a sensible and economic approach to the design, development, and procurement of arms for the Free World.

The principal spokesman, of course, is Henry J. Kuss, a Deputy Assistant Secretary of Defense in the office of the Assistant Secretary for International Security Affairs. Mr. Kuss has become well known to the American industry and in capitals abroad. To some, he is plainly the representative of Defense Secretary McNamara, setting out to promote the standardization of weaponry and pooling of talent and productive resources. To others, he is the master of the "hard sell," determined to spread the use of American aerospace products and benefit U.S. industry. The most bitter of these picture the man as almost ruthless, with no regard for the effect of his drive on the economy, prestige, pride, and capability of our allies.

Defense Secretary Robert S. McNamara is credited with being first to propose the creation of a "common market" for defense products within the NATO alliance. But it is Mr. Kuss who is working on the project and earning for himself whatever praise and criticism go with such a job.

The fact that there are criticisms and that Mr. Kuss is sensitive to them is revealed, from time to time, in his public appearances. He has been called a "supersalesman" and even, in some commentaries, pictured as the modern arms peddler.

Mr. Kuss is not modest about what has been done to date. He reported at recent industry meetings in Washington and Los Angeles as to the orders, commitments, and options received from U.S. allies in the past 4 years. His list is as follows:

- The U.S. has received orders, commitments, and options for over $9 billion of military equipment.
- These orders mean more than 1,200,000 man-years of employment for U.S. workers, in all states.
- The cash receipts from these orders will come to almost $5 billion. That will offset about 40 percent of the dollar costs of maintaining U.S. forces abroad.

Mr. Kuss is modest about how this came about. He said that purchases of arms by our allies hold many advantages for them as well as the United States and its industry. And, "in spite of what one may hear from time to time, this buying has been the result—not of supersalesmen—but it has been the result of an increasing number of superbuyers throughout the world."

Then he added:

"Governments have increasingly insisted on purchasing nonproductive defense materials at the lowest possible cost and thereby saving literally billions of dollars for their taxpayers. Therefore, in this respect, we are already in a sort of a common defense market because most of the major governments of NATO have already accepted the principle of buying selectively on the basis of technology and cost/effectiveness in production and use."

It has been made clear that the Defense Department and the Johnson Administration fully expect this trend to continue as the concept of the common defense market wins wider acceptance. The goals have been outlined as follows:

- The development of an efficient,

lowest-possible-cost, highest-possible-quality defense industry.

• Minimum barriers to the free flow of capital, technology, skills, and products for the defense industries within the NATO alliance.

• Development of an effective specialization, with the result that the defense producers in each country apply themselves to those areas of fabrication in which they have the greatest capability and efficiency.

• Exploitation of the "economy of scale"—first on a selective basis and then in broader ways.

• Development of a network of industry-to-industry relationships through technical associations.

From the viewpoint of both the United States alone and of NATO, there are arguments in favor of a common defense market. The McNamara thesis acknowledges that there are negative reactions to the idea and that there are skeptics who simply think it won't work.

The Pentagon argues, on the other hand, that it can be made to work. The Defense Department already has started discussion with the United Kingdom that may lead to the purchase of ships for the U.S. Navy from British shipyards. The proposal still has stumbling blocks ahead because the British industry must be competitive with American industry when the time comes for bidding. And there are reactions in this country, already heard in Congress, against the prospect of buying ships abroad while American shipyards are eager for the contracts.

Robert S. McNamara, Defense Secretary, argues that standardization of weaponry is essential for economy in NATO.

Mr. Kuss replies to this that the ship order will be much smaller than the United Kingdom purchase of American aircraft. And, he adds, the proposal "is starting the two-way street process in the highly competitive manner characteristic of a common-market style operation."

Probably the most lucid explanation of the American attitude has been expressed by Mansfield Sprague, a Vice President of the American Machine and Foundry Company and a former Assistant Secretary of Defense for International Security Affairs. Mr. Sprague, in fact, is quoted by Mr. Kuss in his public appearances.

Mr. Sprague pleads for flexibility. He points out that in 18 years this country, with major responsibility for the defense effort of the Free World, has "run the gamut from outright grant aid to offshore procurement, to military assistance loans, to infrastructure, to joint production, to outright sale and export of United States-produced military hardware.

"The rapid growth of such sales to our allies in recent years is illustrated by the $9 billion of purchase orders and options received from foreign sources for domestic-produced military equipment. It is expected that this level of exports, approximating $2 billion a year, can be maintained over the next 10 years."

Then Mr. Sprague poses the critical question and the one that leads into the case for a common market:

"How long," he asks, "will this trend be allowed by foreign governments to continue without some compensating inducement to them to sell less expensive but essential equipment to us?"

There are a number of basic facts that the Administration feels cannot be ignored. These include, foremost, the American conviction that NATO

(Continued on following page)

Henry J. Kuss is Mr. McNamara's lieutenant in charge of the effort to cultivate a common defense market in NATO.

This is the F-4B Phantom, designed by McDonnell and used by the U.S. Navy and Air Force. Now the British Royal Air Force and Royal Navy will get the aircraft in a version that uses many components made by British industry.

is essential to maintaining world peace. The requirement for a common defense of the free nations also means that the economic burdens must be shared. Then there is the immense American investment in the development and production of weaponry, which makes it possible for our allies to save vast sums by using these weapons. Balancing this, it is acknowledged that there are reasons of national prestige and economic policy that require our allies to join in the effort. There are many areas in which their products are competitive and where they have special capabilities that can benefit all of NATO, the United States included.

It follows, in the reasoning of Washington, that the export of U.S. weapons is essential to (1) give our allies the most effective hardware at the lowest cost, (2) to increase the commonality of weaponry, and (3) to help offset the balance of payments problem created, in part, by the American aid program and by its military units scattered around the world.

The Sprague conclusion, frequently quoted by Mr. Kuss, is explicit:

"No policy to be considered by the United States will have domestic support or foreign credence unless it is rooted in our own self-interest. But self-interest does not require only that it is solely profitable to this country and is a one-way street.

"In fact, our very successful defense export programs will be increasingly counterproductive without the acceptance of the same concept of free flow of trade which dominates international common markets. The common defense market idea is simply a recognition of this fact and proposes an enlightened method for its implementation."

This is the best statement available of the premise under which Washington is pressing for support of the common defense market. It is fully recognized that, while the goal is simple, there are a lot of complexities involved in reaching the goal. There are marginal producers in some countries who could not meet truly free competition. Mr. Kuss does not criticize them for this, but has to consider it as a factor in development of a common defense market. At the same time, it is emphasized that the United States is very willing to trade concessions with our allies in order to fertilize and promote the common defense market concept.

What is done, Mr. Kuss says, will be done on a selective basis. The most obvious and talked-about area is that of tariffs. The Defense Department will ask the Treasury Department to remove these charges when the action appears justified in the interests of the common defense market.

When he turns to specific weapon programs, Mr. Kuss cites a variety of what he calls "selective projects." Included for the future are "systems that meet a wide range of needs throughout Europe, such as the Redeye, the Mark 12 IFF equipment, Sparrow air defense system for the F-104, tanks, and even aircraft." He hopes for cooperative production programs with more and more competition among the nations in the common defense market.

Then, there is the vast possibility for cooperation in research, development, and the exchange of technology. All of this can be applied to armaments useful to the NATO countries.

There is one project into which the Pentagon has put great effort. It is the program for the purchase of McDonnell F-4 Phantom II aircraft by the British Government. Mr. Kuss says that a study of 17 leading export items disclosed that more than 40,000 American suppliers were involved. They were scattered around in the 50 states of the United States and in more than 1,700 cities and towns. This proved that the arms industry is not narrow, confined to a few prime contractors, but that there is room for a vast number of industries to take part in the production of a single system. The introduction of foreign as well as American companies into the production line, with competition, becomes ever more complex.

In the case of the F-4, the McDonnell Corporation has worked out these details on almost 200 components or subsystems. More than 100 British companies have been qualified to compete for subsystems that will be carried in the RAF and Royal Navy versions of the basic American aircraft. Mr. Kuss says there is a good chance that more than $150 million of business will go to these companies.

In all, he predicts, our NATO allies in the next 10 years may purchase a minimum of about $15 billion of military hardware from the United States. Most of these items will be 30 to 40 percent cheaper than their own similar weapons or components, "reflecting the continuing large research and development expenditures for U.S. military products."

Mr. Kuss also expects that in the same 10 years our allies will spend at least another $50 billion in their own countries and with their own industry. They will do this because they have their own specializations, they can save money, and it will protect their own industrial capability. On top of this, there will be, he anticipates, combined requirements handled by international production and development programs. That will add up to $5 billion or $10 billion.

At a meeting held recently in Los Angeles, California, major home of the U.S. aerospace industry, Mr. Kuss was supported on the platform by Ronald

(Continued on page 9)

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Ronald M. Murray, from the Pentagon's Office of Research and Engineering, is pressing for the joint development of new weapons to utilize talent, cut high costs.

M. Murray, an Assistant Director of Research and Engineering at the Pentagon. Mr. Murray is particularly interested in the development of military aircraft through international cooperation.

In this area, Mr. Murray says, we are interested in joint projects for reasons of both technology and economy. He is the first to declare that many Free World countries, particularly in Europe, have made great technological advances. Some of these have been in areas where the United States has no outstanding talent or, more frequently, the U.S. has ignored or neglected the possibilities. He cites the examples of the work on V/STOL aircraft in Britain, France, and Germany. It follows that we have much to gain from cooperation with these scientists and engineers.

On the financial side, Mr. Murray points to the strains being felt by every budget in every NATO country. Today's cost levels put an unavoidable limit on the number of projects that any country can pursue, including the United States. Therefore, development and research costs must be shared.

The history of the effort in the area of development can be traced easily, at least as far back as the wide exchange of technical information that has been going on for several years. The formation of AGARD (Advisory Group for Aeronautical Research and Development, NATO), and its success as a depository and communications center is an obvious example. From this pooling of what we know, the United States now is eager to push on into a pooling of talent for what we can do in the development of better weaponry.

Mr. Murray points with pride to some of the programs already under way. There is a joint project with Great Britain on the utilization of beryllium in jet engines. There are 10 American and United Kingdom contractors involved in the development, each nation contributing its own specialized know-how. The United States and Germany are working together on V/STOL. Joint design studies and joint military studies are under way.

Again, with Great Britain, there will be an agreement on the development of an advanced lift engine, probably for application to V/STOL aircraft. Rolls-Royce, an experienced and highly competent British firm, already is involved. The U.S. contractor has not been selected. Mr. Murray also cites the current joint flight testing of the Hawker Siddeley P.1127 V/STOL aircraft. The United States, Great Britain, Canada, and West Germany had pilots in the first evaluation squadron.

Back of these efforts, and influencing the choice of new ones in the future, are certain ground rules governing American participation:

• The United States must recognize a need for the work. A need, in this sense, is not necessarily a requirement. The need can be for purely technical advance, for an evaluation or for some new military prospect under investigation. Some of these must justify the expenditure of American money.

• There must be a promise that the project will be of value to the U.S., with good return for money expended.

• The funds put in by this country have to come out of the Defense Department's regular funding for research, development, test, and evaluation. No special funds are available. This means, of course, that the project will be competing for support with some domestic efforts paid for out of the same funds.

• The United States must retain design and production rights, using the end product, or knowledge, the same as it would for a purely domestic project. This country will pay its own reasonable part of the costs. It will pay royalties, and expects to collect them, when justified.

• Sales of the end product, if there are any, must remain competitive.

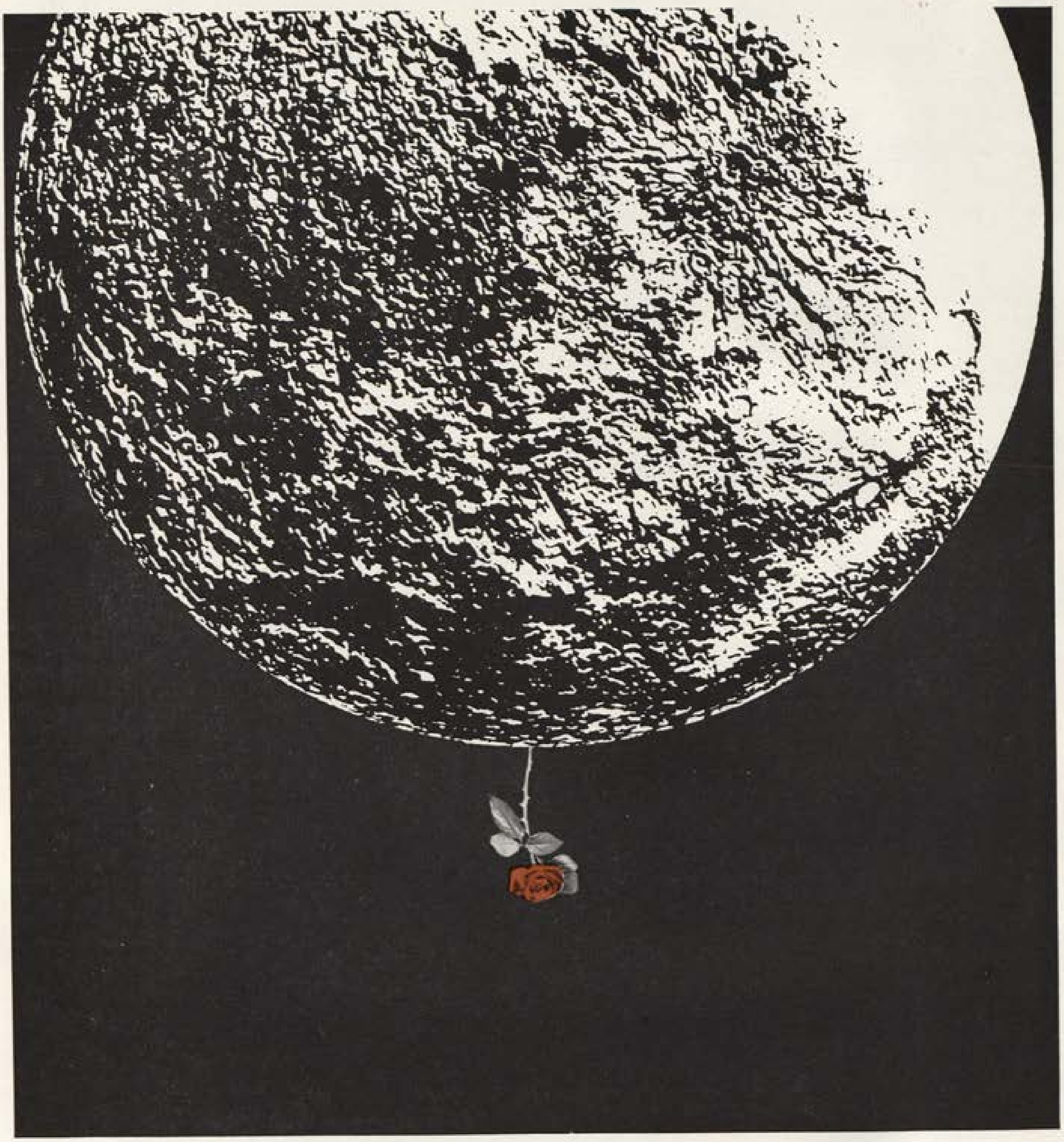
It is understood, through all this, that there must be industrial compatibility. The contractors must agree to do business, just as French and British contractors have agreed to work together on the Concorde supersonic transport.

Through all of the current discussion, which has aroused intense interest in the American aerospace industry, government spokesmen have shown sensitivity to what appears in the press about the American effort to promote the common defense market. Mr. Kuss splits this material into fact and rumor, and is disturbed about much of the latter.

In his recent public statements he has referred many times to the "communications problem" and the difficulty of avoiding misunderstanding of the American attitude and proposals. Language is a factor, but so are national pride, simple economics, and the wide prejudice against anything falling into the category of what Americans call "NIH." This means "Not Invented Here," and there is a tendency in all nations to look askance on foreign developments.

The common defense market, as viewed by the McNamara administration in the Pentagon, is proposed as a solution to all these difficulties. It is proposed as a way to finance collective defense efforts on the level required. Some way must be found, certainly, for survival itself may depend on this kind of cooperation. ☆☆☆

This Hawker Siddeley P.1127 is a British development in the V/STOL area. The first squadron, formed to evaluate the aircraft, had pilots from 4 NATO nations. There are several other projects in development that involve contractors from at least 2 nations, with still more to follow.



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Built under Korean wartime pressures, to specifications that seemed near impossible at the time, the Douglas Aircraft Company's A-4 Skyhawk was first introduced into U.S. Navy and Marine squadrons in 1956. Since that time it has shown—through 5 major model changes comprising almost complete redesign—a record of growth and performance that has made it the principal low-cost ground-support aircraft in the U.S. military inventory. With the U.S. Navy planning to keep the A-4 in its inventory at least until 1974, with a good combat record in Vietnam, and with the general rise in interest in small, single-purpose tactical aircraft all over the Free World, the Skyhawk has a great potential . . .

SKYHAWK: A Proud Past and a Promising Future

BY J. S. BUTZ, JR.
Technical Editor

Backbone and pride of Navy and Marine Corps attack aviation, 4 Skyhawks are shown, above, in perfect formation. The first Skyhawks entered squadron service in 1956. The line is slated to remain operational with Navy combat units at least until 1974. The TA-4E, the 2-seat trainer version of the Skyhawk, will be in service for much longer.

The basic design of the Douglas A-4 Skyhawk series took definite shape from 1950 to 1952—one of the most active, hectic, and prolific periods in aircraft development history.

All of the ingredients of crisis were present late in 1950. The Korean War was only a few months old, and things were not going well. The U.S. military had not recovered from a punishing austerity drive. U.S. setbacks at the hands of the North Korean Army had shocked the nation.

In aircraft technology the situation was scarcely less serious though not as much of a public issue. The U.S. Air Force and Navy were still transitioning to jets, with the major portion of their strength still in piston-driven aircraft. Jet-powered airplanes of the day, which were mostly fighters, had 2 great advantages—vastly superior speed and altitude performance, compared with propeller-driven aircraft.

Beyond these advantages, however, the jet record had not been excellent. The most serious performance problem was short range, only a small fraction of that of piston-engine aircraft. Payload, the companion performance factor which trades off with range, also

(Continued on following page)

The outstanding bomb load, combat radius, and short-field performance of the latest member of the Skyhawk series, the A-4E, and the extensive improvements in performance which can still be expected from the basic design, are illustrated at right. The Rolls-Royce Spey-powered CA-4E has been proposed by Douglas to a number of nations. The configuration has great political as well as military attractiveness in Europe where, if selected, it probably would be built by a consortium of companies from several nations.

A-4 FAMILY COMPARATIVE PERFORMANCE SUMMARY

			A-4E	CA-4E	CA-4E with Spey engine
Sea-level Static Thrust	Engine		J52-P-6	J52-P-8	RB168-20
	lb		8,500	9,300	12,000
	(kg)		(3,855)	(4,220)	(5,440)
Takeoff Gross Weight	Maximum	lb	24,500	27,420	27,420
		(kg)	(11,115)	(12,440)	(12,440)
	Clean (Full Fuel)	lb	16,216	16,300	17,058
		(kg)	(7,355)	(7,395)	(7,740)
Empty Weight		lb	9,853	9,937	10,695
		(kg)	(4,470)	(4,510)	(4,850)
Takeoff Distance	Maximum	ft	5,280	6,320	3,820
		(m)	(1,610)	(1,930)	(1,165)
	Clean	ft	1,710	1,610	1,200
		(m)	(520)	(490)	(365)
4,000-lb. (1,815 kg) Bomb-Load-Combat Radius	Lo-Lo-Lo (Tanks Retained)	n mi	290	330	412
		(km)	(540)	(610)	(760)
Maximum Speed	Combat Configuration	knots	585	581	590
		(km/hr)	(1,085)	(1,075)	(1,095)
Stall Speed	Approach	knots	92	92	96
		(km/hr)	(170)	(170)	(180)
Landing Distance		ft	3,410	1,600	1,750
		(m)	(1,040)	(490)	(535)
Ferry Range	Tanks Dropped	n mi	2,195	2,120	2,575
		(km)	(4,070)	(3,930)	(4,770)
	Tanks Retained	n mi	1,980	1,900	2,345
		(km)	(3,670)	(3,520)	(4,345)

was severely limited. Jets simply were not in the same league with piston-powered aircraft in carrying large loads of conventional weapons for attacking ground targets.

In addition, the jets were much heavier than propeller aircraft for any given mission. The increased weight, plus the greater complexity of the higher-performance jets and rising production costs, pushed their price up substantially—more than 5 times over the aircraft of 1940. A budget that would have bought 1,000 first-line fighters in 1940 would buy fewer than 200 in 1950.

This picture was further darkened by maintenance difficulties. Many of the major jet systems, including the engines, were brand new designs and not based on firmly established technology. The best jet engines had less than one-third the overhaul life of piston powerplants. Unscheduled engine removals for major malfunctions were much higher on the jets. Maintenance experience was even worse with electronic navigation and weapon-delivery systems, which, of necessity, were of a new order of complexity to handle the higher jet speeds. Total maintenance man-hours (including overhaul) per flight hour were up into the hundreds. The British even reported that one of their jet aircraft, after it entered service, required a total of 1,000 maintenance man-hours per flight hour.

The future was indeed not bright in 1950. Most advanced aircraft requirements called for flying at supersonic speeds, raising a whole new set of difficulties. The new aircraft could only make supersonic dashes for short periods, and they had to cruise at high subsonic speeds. Consequently, they were what is called "2-design-point" airplanes, compromised so that top performance was not achieved at either speed. Range remained critical. Production costs continued to go up because a new order of manufacturing skill was demanded to maintain the proper skin smoothness. Designs continued to become more complex. New black boxes were needed to improve stability and handling qualities to allow the pilot to use the aircraft effectively at all speeds.

And so it went.

Despite the problems, requirements for new military aircraft in 1950 generally called for pushing ahead to higher speeds, higher altitudes, and more sophisticated equipment. The steady advances in aviation technology in Western Europe and the Soviet Union, plus the operational experience in Korea, left no doubt that the U.S. must move toward higher performance to retain its position as the world leader in aviation.

In this milieu the A-4 Skyhawk series was conceived and the original development completed in near record time.

The Skyhawk is important because it was the first aircraft with which a concerted effort was made to reverse the trend toward larger airframes, increased complexity, and higher costs.

The key to building smaller, less costly airplanes always has been to simplify components and thereby reduce weight. Airframe and engine de-

Skyhawks are heavily engaged in carrier combat operations in the South China Sea. The aircraft have operated with success in the close support of troops in South Vietnam and in interdiction strikes against targets in North Vietnam. A good record has been logged from the standpoints of combat effectiveness, ability to sustain damage, and ease of maintenance.

signers know from frustrating experience that this is a tedious, often impossible, job. Airplanes are stubborn about surrendering pounds.

Ed Heinemann, then Douglas Chief Engineer, personally directed the Skyhawk design groups, and he set about the job with a vengeance. He set his sights very high, and seldom has there been a more effective weight-reduction program.

Heinemann and his colleagues had a head start on their task when the first Skyhawk design contract was let by the U.S. Navy in June 1952. Many of them had participated in the company's design simplification studies in 1950-51, which had attracted the Navy's interest. This study had dual benefits, both vital to the speedy completion of the Skyhawk development. First, it gave the Douglas people some concrete experience in analyzing complex systems with an eye to simplifying them and cutting weight. Second, and perhaps more important, the study raised serious questions about the Navy's specifications in many areas and led to changes which aided the weight reducers.

Many of the Skyhawk designers also had a part in preparing the proposal for a compact fighter-interceptor, which was submitted to the Bureau of Aeronautics early in 1952. This proposal was based heavily on the simplification-study results, and it was the direct forerunner of the Skyhawk. The Navy bought the basic idea, but they wanted to switch the design from the fighter-interceptor mission and have it optimized for the ground-attack role. The intent was to procure a lightweight, carrier-based replacement for the piston-powered AD-5 (later redesignated A-1E).

Even coming close to duplicating the A-1's long-range attack performance with a jet aircraft was a prodigious task back in 1950. Recent experience in Vietnam has proven eloquently that there still is no match for the A-1 in the inventory when it comes to hauling a large armament load a long distance, orbiting in the combat area for well over an hour, or making multiple runs on ground targets.

Many models of the A-1 have been built, but, on the average, a ground-attack version weighs a little under 12,000 pounds (5,440 kg) empty and normally has a takeoff weight of slightly less than 20,000 pounds (9,070 kg). The "normal" maximum bomb load is around 8,000 pounds (3,630 kg). At a maximum takeoff weight of 25,000 pounds (11,340 kg), the A-1 has carried as much as 12,000 pounds (5,440 kg) of bombs. Combat radius with a significant load of about 2,000 pounds (907 kg) of armament goes up to around 1,000 miles (1,610 km). The main drawback to the A-1 is its relatively low speed. A higher attack

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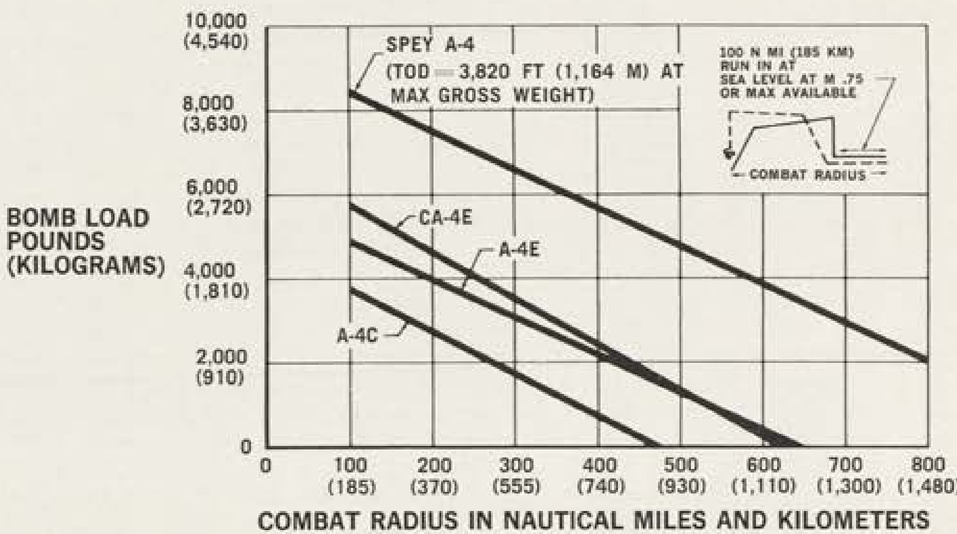
One of the strong arguments for single-purpose aircraft is illustrated at right. The A-4 was designed strictly to carry large external loads for long distances at high subsonic speeds. Not many of the new supersonic aircraft can match the A-4C performance shown here. The dramatic improvements in A-4 performance with the operational A-4E, the proposed CA-4E, and the Spey A-4, are made possible by improved engines with lower fuel consumption. The mission illustrated here involves a 100-nautical-mile (185 km) run at sea level into the target and out again. It is relatively difficult and the aircraft has a better range-bomb load capability for many other missions.



speed was needed to cope with modern defenses. And, just as important, a higher cruise speed was needed to cut the wear and tear on pilots. The A-1's best cruise speed is under 200 mph (320 km/hr), and long-range missions take 12 hours or more.

The original Navy specifications for a "lightweight," jet-powered A-1 replacement called for a top speed of 500 mph (805 km/hr), combat radius of at least 460 miles (740 km), the ability to carry 1,000-pound (454 kg) bombs, and a maximum gross weight of 30,000 pounds (13,610 kg). The range was considerably advanced over fighters of that day, most of which couldn't fly out 300 miles (480 km) and return, even without armament and without spending any time in the combat area. The weight target also posed a stiff challenge compared to other aircraft taking shape on the drawing boards. One relatively long-range Navy interceptor had a maximum takeoff weight of more than 35,000 pounds (15,880 kg), and Air Force long-range, supersonic fighters were approaching 50,000 pounds (22,680 kg).

The new TA-4E, Navy-Marine Corps advanced combat trainer, made its first flight last June. It is equipped with all A-4E avionics, 5 external-stores stations capable of carrying over 9,800 pounds (4,445 kg) of ordnance, 2 20-mm cannon, Pratt & Whitney J52-8 engine, wing-lift spoilers for crosswind landings, Douglas-built zero-zero ejection seats.

Heinemann's group had some rather startling ideas as to how these requirements could be bettered. Navy Commander John Brown, then in charge of attack aircraft design and procurement for the Bureau of Aeronautics, followed Heinemann's lead and assigned himself as the Navy's project leader. He worked with the Douglas team on a full-time basis to iron out the design and the exact specifications.

At the signing in June 1952, the development contract called for Douglas to deliver an airplane with an empty weight of 8,136 pounds (3,690 kg) and a maximum gross weight of 15,000 pounds (6,800 kg). Its very small size and the fact that it was soon dubbed "Heinemann's Hotrod" gave a false impression of the Skyhawk's capacity. It might look like one of those tiny, stripped-down cars built only for speed in the clean configuration with no bombs under its wings, but the Skyhawk proved to be a champion weight lifter with exceptional range for a jet aircraft. The first model, the A4D-1 (now called the A-4A), could meet the Navy's 460-mile (740 km) combat-radius requirement with a small bomb load, and over short distances it could deliver 8,055 pounds (3,653 kg) of armament. Its empty weight was 8,400 pounds (3,810 kg), slightly higher than specified in the June 1952 contract, but the increase paid off well for it made a maximum takeoff weight of 22,000 pounds (9,980 kg) possible.

The success of the Skyhawk weight-reduction project can be attributed primarily to 3 things. First, one of the most advanced engines available in 1952 was selected, the Curtiss-Wright J65, a version of the British Sapphire turbojet. It had a thrust-to-weight ratio of about 2.8 to 1 and a specific fuel consumption near 0.91.

Second, the fact that the Skyhawk was strictly a 1-mission, single-design-point airplane was of great importance. The wing, engine installation, and the entire configuration were designed to give optimum performance while cruising at subsonic speeds over long distances with large loads hung externally from the wings. No compromise was necessary to give the aircraft dual purpose, to make it the equal of contemporary fighters in air-to-air combat at any altitude or in bad weather.

The third element was plain, straightforward attention to detail, with a good bit of engineering ingenuity thrown in. An example was a major effort to reduce the drag of bombs, rockets, incendijel containers, fuel tanks, atomic weapons, and all other containers hung beneath the aircraft. The Douglas Company made a real contribution in this area. The meticulously streamlined series of bodies had considerably lower drag than the equipment then in service, and they played a material part in giving the Skyhawk good range. The industry as a whole also benefited, and "Douglas-shapes" appeared on many configurations.

Another example was the consolidation of the avionics gear into a single package. The communications, navigation, and identification equipment was packaged as a single unit, which was sealed and filled with nitrogen gas to protect against the elements and to increase reliability. The package was bolted to the fuselage frame just ahead of the cockpit. It had a single cabling outlet, and the whole affair could be removed from the aircraft by one man in a matter of minutes, an important maintenance advantage. It was estimated that this packaging saved 48 pounds (22 kg) over a conventional installation.

The avionics package was a major item in the weight-cutting program for, according to the aircraft designers' quick rule of estimating, the Skyhawk group had to cut between 1,000 and 2,000 pounds (453 to 907 kg) of dead weight to get the maximum gross down near 20,000 pounds (9,070 kg). That is, the first generation of "Heinemann's Hotrod" weighed about 10,000 pounds (4,540 kg) less than the original Navy estimate of 30,000 pounds (13,600 kg) for a maximum gross weight "lightweight" attack airplane. By the designers' rule, every pound (.45 kg) cut from the aircraft's empty weight will actually reduce the maximum gross weight by 5 to 10 pounds (2.3 to 4.5 kg), because it reduces the necessary structural weight, the fuel needed to travel a given range, and the size of the powerplant needed. So the Skyhawk group worked to cut 1,000 to 2,000 pounds (453 to 907 kg) from the dead weight and ended up

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Marine Sergeant Bruce G. Gregory arms an A-4 squadron VMA-225 at Chu Lai, Vietnam. Skyhawks operating from this field have taken part in operations in both South and North Vietnam.

Heavily armed A-4 is directed out for takeoff at Chu Lai by Marine Pfc. Ray Markley. The aluminum matting forming the Chu Lai strip was laid on deep sand stabilized with asphalt.

Air view of Chu Lai shows A-4 maintenance being conducted out of doors. Tail section of the aircraft at upper left has been removed, exposing the engine. Marines are encamped in tents.

Gun camera sequence above shows an A-4 Skyhawk attacking a train in North Vietnam with high-speed Zuni rockets. In the top photo the rocket has just been launched. At the bottom, the Zuni kicks up a geyser of earth near the train. In the several months that the A-4 has been in action in Vietnam a great deal of information has been gathered on its performance. The aircraft has flown thousands of sorties with low loss rate.

Colonel J. D. Noble, commanding officer of Marine Air Group-12, is the first to land (above) at the Chu Lai airfield after its construction by ground troops. The portable arresting gear in the foreground is used regularly to shorten the ground roll during landing. Construction of the Chu Lai facility is the Vietnam major accomplishment to date for U.S. Marine Corps and Navy engineers.

with a very small aircraft that was still extremely efficient.

Development of the first Skyhawk proceeded rapidly. A team of engineers went to Korea immediately to update their information on the problems of operating attack aircraft from carriers and land bases. By October 1952, this data, plus the initial design information, had been incorporated in the first mockup.

The Navy's usual procedure of building and testing some experimental models before fixing the design was waived. Preparation of the production tooling began almost at once. Production of the first 10 Skyhawks was begun in November 1952. By January 1953 the production tooling was essentially complete, and high-volume production began on many components. The second mockup inspection was completed in February 1953, and the first aircraft was rolled out of the El Segundo plant in February 1954. The first flight, delayed several months because of technical difficulties, took place on June 22, 1954, with Douglas test pilot Bob Rahn in the cockpit. The second aircraft flew the following September, and soon afterward intensive flight testing with several aircraft began. About 2 years later, in 1956, the first squadron of Skyhawks was declared operational. Moving from initial design to squadron service in only 4 years is still extremely good program performance.

The Skyhawk's service record has been exemplary.

In October 1955, the aircraft even set a world speed record of 695.163 mph (1,118.725 km/hr) over a 500-km (310 miles) closed course. More important, it has been an effective attack aircraft. Its maintenance requirements have been relatively low. And its over-all operational costs might be called rock bottom in the jet-powered world. The latest Skyhawk—the A-4E—sells for about $720,000, completely equipped, with an average expenditure of approximately 13 maintenance man-hours per flight-hour at the squadron level.

During the 15 years since 1950, the cost/effectiveness picture has improved for all jets, including the most advanced, high-performance, supersonic, multipurpose, fighter-attack aircraft. In fact, nobody in 1950 foresaw just how much the effectiveness of jet operations would improve and how much cost/effectiveness would improve. Still, however, no available jet aircraft can yet match the cost/effectiveness of the Skyhawk for the mission of carrying heavy armament over long distances.

The Navy has purchased 4 combat versions—the A-4A, A-4B, A-4C, and the A-4E. Each has been improved in various ways. The newest version, the A-4E, retains almost the same external dimensions and wing and tail configuration as the original Skyhawk, but its empty weight is up 1,453 pounds (660 kg)—to 9,853 pounds (4,470 kg)—and its maximum takeoff weight has gone up more than a ton (.9 mt), to 24,500 pounds (11,110 kg). Attack performance has been greatly improved. The maximum bomb load is now 9,155 pounds (4,150 kg) and can be carried at 5 wing stations instead of 3. The most important improvement, however, is in range. The A-4E can carry 2,000 pounds (907 kg) of bombs nearly 700 miles (1,125 km), fight, and return 700 miles (1,125 km). The main reason for this improvement is the Pratt & Whitney J52 engine, with a higher thrust-to-weight ratio and a lower specific fuel consumption than the J65 in the A-4A.

The A-4E and A-4C also enjoy an improved electronic package with autopilot, a low-altitude bombing system, and terrain clearance radar that are not in the earlier models. Substantial structural improvement also has been necessary with each new model to improve operational characteristics and accommodate the higher weights, while retaining the Skyhawk's ability to withstand 7-G loads in the attack.

Production runs of the Skyhawk have been substantial. A total of 165 A-4As, 542 A-4Bs, and 638 A-4Cs were built, with 500 A-4Es either built or on order in a production program that is due to be completed late in 1966.

A 2-place trainer version of the Skyhawk, now in production for the Navy, also could be classed as an operational aircraft. This airplane, the TA-4E, is an improvement over the A-4E in many respects because it is powered by a new version of the Pratt & Whitney J52, which has slightly better thrust-to-weight ratio and fuel specifics than the version in the A-4E. The first TA-4E has flown, and the initial contracts call for production of 139 aircraft. However, the estimates for the number of new operational trainers needed by the Navy range from 400 to 500.

A wide variety of armament loads can be accommodated on the A-4. One of the most important weapons, the Martin-Maxson Bullpup, is shown being launched above. The Bullpup has been used in action many times in Vietnam by A-4 pilots, employing its radio guidance feature to destroy pinpoint targets such as radar antennas, antiaircraft emplacements, vehicles, and concrete command posts.

Current plans call for the U.S. Navy to keep the A-4E in squadron service, backed with a full support system, at least until 1974. The trainer version undoubtedly will be around many years longer.

During the last few years, as close air support and attack aviation have come to the forefront as a major military problem, the A-4 has been evaluated by a number of groups outside the Navy. The aircraft has fared well in these evaluations, both the paper type and the flight and field trials. In most cases, the U.S. Navy and Marine Corps experience in short-field, forward-area operations has been revalidated.

The nub of any of these evaluations, of course, is the old debate about the multipurpose vs. the single-purpose airplane in the tactical air war picture. But on one point there is universal agreement among the military of all Western nations: Tactical aviation must be beefed up. Many nations began reequipping their fighter forces with high-performance aircraft, such as the Lockheed F-104, several years ago.

The F-104 is now operational in 14 countries. And recently the specialized lightweight attack aircraft and lightweight dual-purpose fighters, such as the Northrop F-5, have been receiving more attention. The F-5 now has been selected by 9 nations. Argentina is negotiating with the U.S. for the purchase of a force of 50 A-4Bs, and these aircraft will be overhauled and modified by Douglas before delivery.

Several air forces are currently in

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The A-4 has displayed the ability to absorb considerable punishment in Vietnam. Despite severe antiaircraft damage to the wing of his A-4E, Navy Pilot Lieutenant Michael Weakley flew this aircraft back to carrier MIDWAY. Another time an A-4 was hit by 4 37-mm cannon shells and still returned 230 miles (370 km) to its base. A fine maintenance performance also has been posted, with 95 percent of A-4s available each day.

Snakeye bombs are among the new weapons being employed against the Viet Cong. The cross-shaped drag brake slows the bombs rapidly to allow the aircraft to pull away from them and escape blast damage during low-level attack. The A-4 also is equipped with 2 20-mm guns in the wings and others in pods to lay down heavy fire in low-level assault maneuvers, in support of combat infantry.

the process of selecting new aircraft. More competition is expected in the future.

Two Air Force evaluations probably will be influential in the selection of new equipment in many Free World air forces, as well as for the USAF. One of the evaluations, code-named Spring Robin, was a paper study of the A-4, the Northrop F-5, the Grumman A-6, and the Ling-Temco-Vought A-7 to see if any of them would be suitable as an interim aircraft to reinforce the USAF Tactical Air Command before the new FX lightweight fighter becomes available in the early or middle 1970s. Sparrow Hawk, a field competition using the same 4 aircraft, was run this past summer, and the final results submitted to higher USAF headquarters for review.

Another type of evaluation, now under way, probably will have the most influence on future aircraft selection in the non-Communist nations. This is the air activity in Vietnam. The operational details of this action undoubtedly will not be made public for many months and possibly many years. Enough information is available, however, to indicate some trends. First, the Skyhawk has done well in the 2 major types of Vietnam action—the close support of troops in South Vietnam and the interdiction operations against targets in North Vietnam.

The aircraft's availability rate has been very high for Marine units operating from forward airfields and for Navy squadrons on carriers. An average of 95 percent of the A-4s have been available for service each day. The squadron rates of maintenance man-hour per flight-hour did not rise when the aircraft entered combat. The A-4 also has shown an ability to absorb considerable punishment. For example, one Skyhawk was hit by 4 37-mm cannon shells and still was able to return 230 miles (370 km) to base.

Vietnam is also producing other data of even greater interest, which could otherwise be obtained only through very elaborate field exercises, if at all. Such data involves tactics, radar cross-section, vulnerability, attrition rates, the aircraft's success in attacking defended targets, its success as an antiaircraft destroyer, and so on. This kind of data is closely held military information, but it could have a controlling effect on the future of all the aircraft currently used in Vietnam and on the tactical philosophies of the services.

Douglas obviously is pleased with the A-4's record in Vietnam and optimistic about its chances for being selected by many Free World air forces. This is indicated by the company's offering of 2 new Skyhawks for export—the single-place CA-4E and the 2-place CA-4F.

Regardless of what happens in the future, "Heinemann's Hotrod" is assured of a prominent place in aviation history. The design precedents it set as a lightweight, low-cost, long-range, heavy-payload, attack aircraft, and the fact that it will stay in the U.S. military inventory for at least 18 years in its various combat versions, will guarantee that place. The renewed worldwide emphasis on attack aviation and the Vietnam action may combine to bring the Skyhawk into new prominence, to stretch its useful life far into the future, and to leave it with an ever brighter place in aviation history. ☆☆☆

An In-Depth Interview with USAF Secretary Harold Brown

The new Secretary of the U.S. Air Force, Dr. Harold Brown, is not only a distinguished scientist in his own right, but also has a record of virtuoso performance as Director of the U.S. Department of Defense's Directorate of Defense Research and Engineering, the post he held before assuming civilian leadership of the Air Force. The following interview with Dr. Brown provides some deep insights into his views of the complex problems the U.S. Air Force is facing in an era that simultaneously features the exploration of the military utility of space and the waging of wars with limited objectives in distant lands, and where the development of military doctrine is a day-to-day job. Both of these tasks have to be attacked, while at the same time the continuing credibility of the U.S. general-war deterrent must be maintained beyond any doubt.

U.S. Air Force Goals and Priorities

Reprinted with permission from the October 1965 issue of THE AIRMAN magazine, official journal of the U.S. Air Force.

"Our capability to survive a thermonuclear attack by an aggressor and to strike back . . . is so enormously important that if we were to lose this capability, our existence as a nation would be in grave danger."

Q. Dr. Brown, what do you consider to be the most important jobs confronting the Air Force, both long and short range?

A. I would put first the maintenance of this nation's deterrent forces, in which U.S. Air Force missiles and aircraft play the predominant role. Our capability to survive a thermonuclear attack by an aggressor and to strike back with sufficient force so he no longer constitutes a viable society is so enormously important that if we were to lose this capability, our existence as a nation would be in grave danger. Preserving this capability, which we now have, will require continuing careful attention to the maintenance of the present high probability of survival our retaliatory forces now enjoy, and involves continued reliability of its mechanical operation in the delivery process, and high penetrability through any possible defenses.

The second vital job confronting us,

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one which requires even more attention from the Air Force because great increases in capability can be achieved, is that of tactical air: tactical reconnaissance, interdiction, air superiority, and, of very great importance, the close support of our ground forces. Studies and combat experience both show that without air superiority and the strong air support of ground troops, success by conventional land forces is gravely endangered, if not impossible. Of course, we must not only be able to do these jobs well, but we must be able to do them at the right places and at the right time. In this regard, the long range of current and programmed Air Force tactical aircraft enables us to move enormous striking power anywhere in the world on short notice—a reassuring capability for our allies.

". . . The long range of current and programmed Air Force tactical aircraft enables us to move enormous striking power anywhere in the world on short notice—a reassuring capability for our allies."

But we must improve target acquisition abilities and equip our aircraft with systems which current technology can make available to navigate to the target and deliver ordnance with high accuracy. The spectrum of combat across which these tactical air capabilities are required ranges from massive land battles down to counterinsurgency operations in remote and underdeveloped areas of the world.

Our third key job involves the massive delivery of troops and materiel. Our airlift capability has increased over 100 percent in the past 4 years, and we expect to increase this by another factor of 2 during the next 4 or 5 years. Although this is an enormous challenge, requiring new airlift systems, careful organization, outstanding management, and trained professional personnel, the payoff is very great. It will enable the United States to project its power great distances in short times to meet trouble wherever it arises. Within a combat theater, a correlated capability—which can be called "retail delivery"—is a challenging one to the Air Force because it involves a new dimension of logistic support to ground troops.

The fourth job, or category, includes a variety of missions, largely based on the technologies in which the Air Force is particularly well qualified. These include communications, observation, and space systems.

Q. Do you anticipate any major changes in Air Force policy or shifts in emphasis?

A. The course which [my predecessor] Eugene Zuckert steered in the past years has been extremely productive. Of course, the Air Force will continue to face new challenges. For example, the combat in Vietnam highlights the need for the ability to carry out close-support missions, and a variety of other tactical air missions mentioned earlier. These challenges must be met as they arise, and I know the Air Force will meet them.

Q. Would you please discuss your views on the future roles of missiles and manned aircraft?

A. In strategic war the missile revolution has already occurred. Assessing the situation from the standpoint of assured destruction and damage limitation, the survivability, penetrability, and the short flight time of ballistic missiles play a major role both for ourselves and for the Soviet Union. Nevertheless, I believe a bomber component should and will remain part of our strategic forces for the foreseeable future. All examinations of this problem indicate that the additional defenses which an enemy is forced to build because of our bomber component make a mixed bomber-missile force the optimum one.

In tactical war, which we are facing right now, the aircraft is predominant as a delivery system for bombs, for close-support fire, for reconnaissance, and potentially as a survivable command post from which the commander can direct a combined air-ground battle. In tactical war, air-to-surface missiles play a considerable role. But since they are launched from airborne platforms, the aircraft remains queen of this particular mixed force.

"Our airlift capability has increased over 100 percent in the past 4 years, and we expect to increase this by another factor of 2 during the next 4 or 5 years. . . . [The capability] will enable the United States to project its power great distances in short times to meet trouble wherever it arises."

My answer to the question perhaps explains why expenditures on aircraft have risen in the past year or two, and why a large variety of new aircraft, including the F-111, SR-71, the C-5A, etc., are being procured in large numbers. It is also why a large number of additional aircraft such as the F-12, the OV-10A, the XC-142, etc., are in development. The increased level of combat in Vietnam gives even more weight to this need.

Q. Would you comment on the role of the military man in space?

A. Let me answer the question this way. First, the Defense Department has a very large space program, and practically all of it is vested in the Air Force. Costs now run somewhere between \$1.5 to \$2 billion yearly. About 40 percent of this is in operational systems, so it is perfectly clear that we can do many things from space better or cheaper than we can do them from other media. Therefore, for every clearly defined and validated mission where a space system proves to be the best way to accomplish it, we have a program, either operational or in development now. With respect to man in space, I believe it is still an open question as to the extent which, for specific military missions, the extra weight and complexity introduced by the man and his supporting systems are balanced or exceeded by the additional capabilities you gain. I refer to man's ability to operate, adjust, assemble, repair, judge, and select among alternative actions. Although it is impossible to know for sure, the chances that the answer is affirmative are high enough so that \$150 million has been included in the Fiscal Year 1966 budget for development of a Manned Orbiting Laboratory. The MOL should provide us with definite answers to such questions.

"With respect to man in space, I believe it is still an open question as to the extent which, for specific military missions, the extra weight and complexity introduced by the man and his supporting systems are balanced or exceeded by additional capabilities you gain."

Q. What do you consider to be the most important characteristics that a young man should have to be a success in the Air Force?

A. First, devotion to his country and its security. Second, willingness to make the sacrifices—in peace and in war—that military service requires to achieve that objective. Third, a professional attitude toward his job, be it operational, support, technical, or managerial. Fourth, a burning desire to get the job done, which I have always considered to be an outstanding characteristic of the Air Force as a military service.

Q. The Air Force of today seems to require a mix of operational, scientific, and management-oriented leadership. Would you care to comment on the ratio of this mix and their interdependence?

A. It would be wonderful, of course, if all Air Force personnel had outstanding abilities, training, and experience in each of these areas, but that is obviously an impossibility. A mix of these characteristics is therefore required in the Air Force as a whole, and also in many individuals. Which of them is uppermost as a requirement will depend upon the time, the place, and the job to be done. In the future, more specialization is likely to be required, but the hardest man to find, and the most valuable one, will be the one who is a generalist with an outstanding capability in some particular area.

Q. What one thing would you most like to achieve in the next few years?

A. An analytical capability for the Air Force to equal its drive, its excellence in management, and its great spirit. I want to help organize the talents which already exist within the Air Force to still further improve its materiel, training, and combat capability, so that it can play its part for the best interests of the United States and the Free World. I know that all members of the Air Force, from the Chief of Staff on down, as well as all civilian employees of the Air Force, have this identical goal.

Q. Sir, your comparative youth has been noted in the public press. Some people feel it will be good for the Air Force; others disagree. Would you like to say anything concerning this matter?

A. The Air Force is a youthful service—in years, in outlook, in vigor. It has a tradition of placing young people in positions of command and leadership which date back to World War II. It is heavily dependent on technology, which is both of recent vintage and associated with young people. I am neither as young as the Air Force (I am 38, and the Air Force, as a separate service, is 18), nor as vigorous. But I am certainly going to do my best to try to match it on both counts. For many years, I have been connected in various ways with the military, and specifically with the Air Force. I have shared in some of its triumphs, and sympathized with some of its difficulties. I am glad now to be the civilian head of the Air Force team, and look forward to working with all of its members. ☆☆☆

"I want to help organize the talents which already exist within the Air Force to still further improve its materiel, training, and combat capability, so that it can play its part for the best interests of the United States and the Free World."

Budgetary realities involving the pressures of the Vietnamese War, competition with other important U.S. programs, and the fact that space efforts now undergo quite sophisticated legislative analysis, are combining to make the job of U.S. space planners much harder than it ever was before. NASA has sizable proposals for successor programs to the Apollo moon-landing project, but they are more difficult to sell than in the past. Probably a Lyndon Johnson-style compromise on NASA funding and plans will set the pace for the near-term U.S. space programs.

U.S. Space Planners' Problem: How to Do More on Less Money

BY WILLIAM LEAVITT
Associate Editor

NASA's Dilemma

Washington, D. C., Nov. 18

January is budget month in Washington, and the time when Administration officials work mightily to explain commissions and omissions in their estimates for the coming Fiscal Year, which, in its confusing way, runs from July 1 to June 30. Thus, correspondents are briefed in January 1966 on plans for Fiscal Year 1967, which actually begins on July 1, 1966.

This is written somewhat in advance of the budget briefings, by way of suggesting some of the problems being faced now by U.S. space planners in the formulation of programs they wish to advance. The problems are mostly those of the National Aeronautics and Space Administration, which, in U.S. Government parlance, is an independent agency responsible directly to the President.

NASA is now in its eighth year of operation. During its relatively short life, it has lived through a series of contrasting Administration attitudes toward space policy and expenditures. From 1958 through 1960, the agency operated under the watchful and financially cautious eye of the Eisenhower Administration. General Eisenhower took a dim view of ambitious plans for manned spaceflight and large-scale scientific investigation of space and was virtually forced by the then-opposition party, the Democrats, into entering the space competition.

The advent of John F. Kennedy in 1961 gave the space agency a new lease on life with infusions of money and personnel. This did not quite happen overnight. In his first few months in office, President Kennedy's proposals for fattening the NASA program were disappointing to NASA partisans and observers of the space program who had expected much more than the modest increases in the funding of the Saturn booster program announced shortly after Mr. Kennedy took office.

But by May of 1961—and after the manned orbital flight of Russia's Yuri Gagarin and the Bay of Pigs fiasco in Cuba—Mr. Kennedy seized on the NASA program to help recoup lost American prestige, enhance the national technology, and spur the economy through aerospace expenditures.

His enthusiasm was reflected in the quickly reached decision to commit the country to the manned lunar expedition called Apollo. The NASA budget increased sharply, and the agency was given what some critics called a carte blanche to go to the moon.

The Apollo proposal moved with incredible rapidity through Congress, and there was scarcely a ripple of opposition across the country. In fact, it was not until 1963, while Mr. Kennedy yet lived, that opposition began to harden within the scientific community—among liberals who wanted to see more money spent on social problems such as slums, air pollution, land transportation, and education; among conservatives who generally opposed large spending programs of any kind; and among critics who believed that too much money was being budgeted for civilian space efforts and not enough for military-oriented space projects.

Less than 2 months before his death, Mr. Kennedy seemed to be sensing the combined strength of this opposition.

The Apollo service module propulsion system, which was test-fired recently at Cape Kennedy, Florida, is shown above being manufactured by Aerojet-General Corporation. It will provide power after booster separation for the trip to the moon and the return.

Many observers attributed his September 1963 speech before the United Nations (in which he called for a joint U.S.-Soviet moon program) to a recognition of the criticism being leveled against the Apollo program by that time.

But more importantly, it was in that waning autumn of the young President's life that NASA, for the first time, really began to live in a new policy milieu. An increasingly sophisticated Congress, once prone to accept without question proposals and assurances from scientists and engineers, was by then developing the expertise required to keep track of NASA's wide-ranging efforts. Some of the criticism in Congress and within the scientific community was admittedly carping, but, on the whole, the new spirit of questioning was considered refreshing by most observers.

Then, on November 22, 1963, the course of American history altered with the accession of Lyndon B. Johnson to the Presidency. Although he was committed, in the main, to the domestic and foreign policies of his predecessor, the new President has always been undoubtedly a man of far different style. In many ways he is much more tough-minded than John F. Kennedy. In the space area, he had the advantage — and disadvantage — of having been a principal architect of the NASA program as a Senator and as Vice President and Chairman of the Space Council. As did his predecessor, Mr. Johnson faced the criticism of the NASA program that had increased in intensity from all the quarters mentioned above.

Among the first decisions Mr. Johnson made was to serve notice on NASA that the era of the carte blanche had ended. During his time in office that policy has continued. NASA had assumed earlier that its budgets would be generally based on 1 percent of the Gross National Product of the United States—a GNP figure that in a decade may be approaching $1,000 billion. This assumption has long since disappeared. Since Mr. Johnson's arrival in the White House, NASA budgets have hovered at slightly over $5 billion each year.

And there, apparently, they will stay, for at least the next several years. NASA now has to compete on more or less equal terms with other U.S. Government agencies for its share of the U.S. Federal budget. It is no longer the privileged child it was in 1961 and 1962. To further complicate the agency's planning and funding problems, the leveling-off pressures applied by President Johnson to the NASA budget have been intensified by the rising costs of the Vietnamese War.

Despite budgetary problems, every Government agency lives in eternal hope. It is reported in Washington, for example, that NASA, obviously conscious of the pressures to keep its spending down, has nevertheless approached the Bureau of the Budget, the fiscal branch of the White House, with requests for more than $5.5 billion for the 1967 Fiscal Year. It is, of course, a standard pattern to ask for more than one expects, but $5.5 billion is really quite a bit more than the approximately $5.25 billion granted last year.

The chances are that NASA will get no more than it got last year. This will create difficulties for the agency that may require some slowdowns in future plans. NASA is quite anxious to get started on what it now calls the Apollo Applications Program, described in the November issue of AF/SD INTERNATIONAL by Dr. George E. Mueller, Associate Administrator for Manned Space Flight at NASA. This program would utilize the Saturn booster and Apollo modules, now under development for the moon-landing program, for a wide-ranging series of earth-orbital studies, lunar-orbiting survey efforts, and post-Apollo-landing lunar-surface exploration.

NASA currently has some $60 million to spend on Apollo Applications study, a low figure attributable to the fact that the AA program is not an approved program in the manner of Gemini and Apollo. But to get Apollo Applications started in a reasonably big way, the agency would require probably at least $300 million or more in the Fiscal Year 1967 budget.

Even with the pressures of rising Vietnamese War costs, that figure might not be so formidable if it were not for the fact that the Gemini 2-man orbital-rendezvous program has already run far over its original estimates, which were in the hundreds of millions of dollars. The cost of Gemini has already surpassed $1 billion.

Also the NASA Surveyor program to soft-land a probe on the moon in advance of the Apollo landing is now some 4 years behind schedule and costing much more than anticipated. Equally significant is the fact that the

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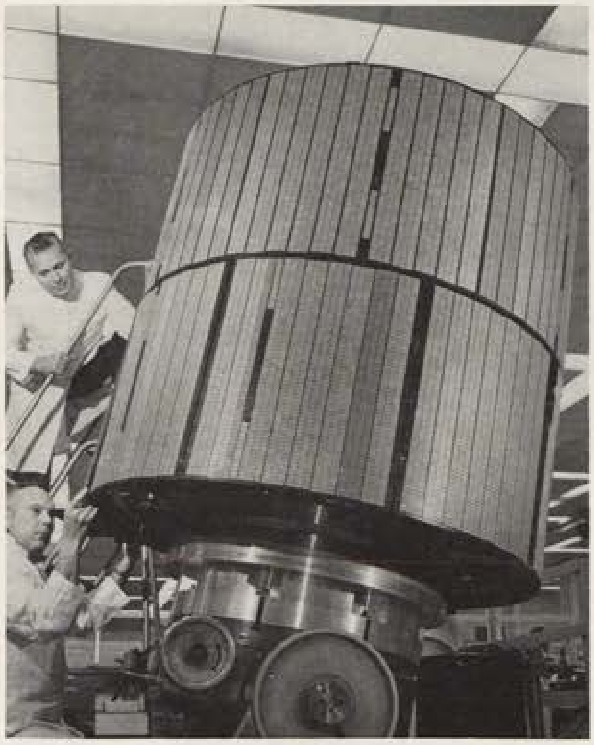
A new family of scientific satellites, called ATS (for Applications Technology Satellites), is being built by Hughes Aircraft Company for NASA. Five ATS spacecraft will be launched, beginning in late 1966. At right, in final assembly, is a structural model of a synchronous-altitude ATS spacecraft that will be spin-stabilized by gas jets. Later versions will uncoil 4 130-foot (39.6 m) weighted booms—a gravity gradient experiment to keep the satellite's antenna continually facing earth.



expected peak of spending on the Apollo moon-landing has not occurred as soon as anticipated. Yet without some sort of Apollo Applications program, NASA points out, there would be a sad waste of the booster capability being gathered in the Apollo development. This experience, NASA says, ought to be put to work as soon as possible, not only to provide continuity, but also to keep relatively intact the NASA and industrial teams which have produced the capabilities now or soon to be available.

But there are practical limitations in terms of money available. The heavy costs of the NASA manned spaceflight effort have already cut into NASA's unmanned scientific satellite and probe program, to the great pain of the people in NASA who run the unmanned efforts. A case in point is the fact that no early follow-on to the highly successful Mariner probe of Mars is planned. The successor project to Mariner, called Voyager, which would land a scientific capsule on Mars, is still being defined—in fact, redefined in view of the apparent lack of water and extreme thinness of the Martian atmosphere reported by the Mars Mariner.

Thus, there may be no further Martian probes until the early 1970s, which is a long time off. This upsets many observers, who point out that despite their difficulties with interplanetary probes in the past, the Russians are still banging away with new ones. Two Soviet probes are now en route to Venus. But it is more than a matter of prestige, in the view of planetary-probe enthusiasts. It is a question of losing some of the scientific initiative provided by the Mariner success.

Another potential victim of budget cuts at NASA is the agency's nuclear space-propulsion effort, which slowly but surely is establishing the feasibility of nuclear energy as the basic mode for deep-space manned missions, particularly the manned Martian exploration mission that is in the back of the minds of most NASA planners. At this time, there is no specifically approved manned Martian exploration program, and it is assumed that the decision to go ahead with a program must await, not only the successful Apollo moon-landing, but also the availability of much more data on Mars from unmanned probes.

In short, NASA is facing a lengthy moment of truth. It has to find ways to live on less money, yet do enough in the field of space exploration and utilization to keep its technology dynamic and to use the technology as continuously as possible.

What will probably happen is fiscal compromise. The Gemini program will run its course and demonstrate the rendezvous and docking capability basic to the Apollo moon-landing program. At the same time, the nuclear propulsion effort will continue at levels high enough to keep it alive but no more. And enough of the Apollo Applications effort to keep it alive will be approved, probably with an emphasis on the earth-orbital flights (NASA sees the possibility of 45-day flights by 1970) that could lead to large multipurpose space-station capability in the late 1970s. At the same time, some financial commitment will probably be made by the Administration to those parts of Apollo Applications that pertain to post-lunar-landing surface exploration for perhaps as long as 2 weeks. The last thing President Johnson would want to be remembered for would be a "one-shot" weekend on the moon.

All the technical difficulties NASA has experienced in the past are as nothing compared with the funding and decisional problems it has to face these days, now that it has developed the capabilities to do more in space than there may be money for and the desire to achieve.

USAF MOL Astronauts

The Air Force has announced the selection of the first 8 aerospace research pilots to be assigned to its Manned Orbiting Laboratory program (MOL).

A dozen more pilots will be chosen in future selections and be assigned to MOL in the summer of 1966 and the spring of 1967. The first manned flights of MOL are scheduled for 1968.

Six of the new selectees are Air Force officers, and 2 are U.S. Navy officers. One of the Air Force officers had previously been chosen for the now-canceled Air Force X-20 Dyna-Soar manned orbital glider project.

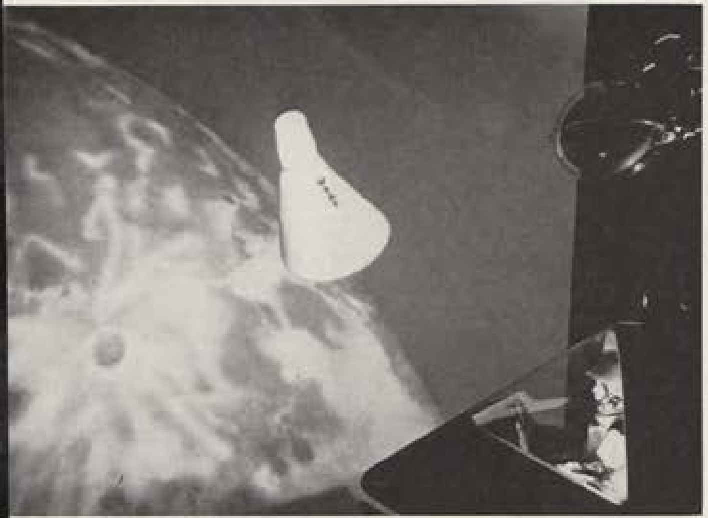
The MOL pilots are all graduates of the USAF Aerospace Research Pilots School at Edwards Air Force Base, California. They are: Major Michael J. Adams, 35; Major Albert H. Crews, 36, and formerly designated for the Dyna-Soar program; Captain Richard E. Lawyer, 33; Captain Lachlan Macleay, 34; Captain F. Gregory Neubeck, 33; Captain James M. Taylor, 34; Lieutenant John L. Finley, 29; and Lieutenant Richard H. Truly, 28. The last 2 are U.S. Navy officers. All hold degrees in engineering or physical sciences.

The 8 new MOL pilots will begin training at Edwards Air Force Base early in 1966.

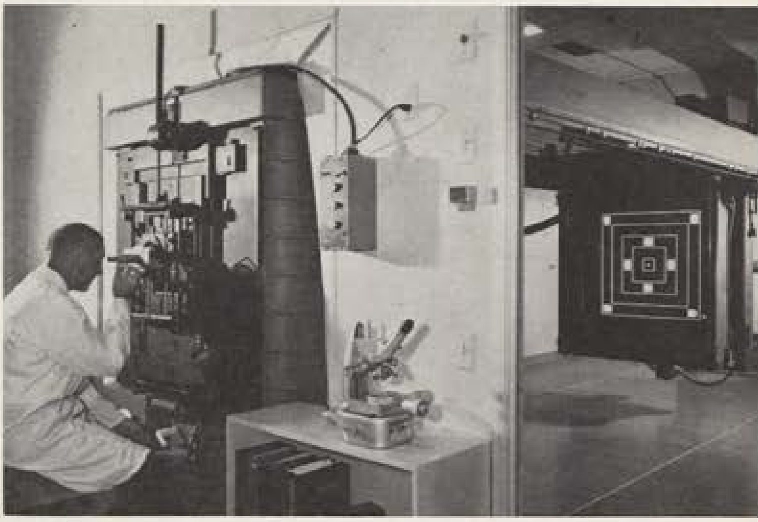
The California Experiment

One of the fascinating potential "fallouts" of the aerospace industry in the United States is the application of systems-engineering skills developed in large aerospace hardware projects to solutions of serious social ills here on earth.

During the last several years, many legislators in Congress, some Defense Department officials, and many aerospace industry representatives have



Many kinds of space missions can be flown in this visual flight simulator built by the Boeing Company at its new Space Center in Kent, Washington. With television cameras projecting 3-dimensional models, and a device displaying complete star fields, pilots rendezvous in space or make lunar orbits and landings.

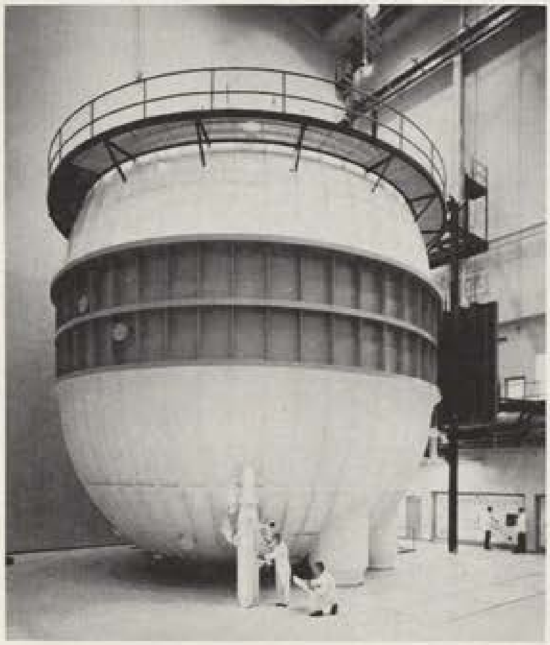


This photo-reduction camera, 1 of 3 in the Microelectronics Laboratory at Boeing's Space Center, is capable of reducing the circuit pattern shown at right to 1/200th of its original size, and can repeat the process indefinitely until lines in the pattern are only 1/10,000th of an inch (.00254 mm) thick.

suggested that the systems engineering skills of the aerospace industry might contribute heavily to the analysis and solution of public problems in the United States ranging from air pollution to transportation, and even crime.

The state of California has recently served as a laboratory for a small but important test of this idea. Out of the effort has emerged a significant demonstration of the values of systemic approaches to all problems, no matter whether they involve purely physical phenomena or the full range of social dilemmas.

California was an ideal site for such an experiment. Not only does it have the greatest concentration of aerospace industry in the United States, but it also has in great quantity most of the social ills that beset modern technological societies, such as pollution of air and water, insufficient transit, waste disposal, crime and delinquency, and insufficient information-gathering and -distribution facilities.



It looks like an overgrown pumpkin, but it is the largest of 11 vacuum chambers in the Boeing Space Center. This one is 50 feet (15.2 m) high and 39 feet (11.9 m) in diameter, big enough to hold almost any spacecraft in the U. S. inventory. It produces a vacuum equal to that at an altitude of 400 miles (645 km), along with temperatures as low as minus 320° F (–251° C). With minor modifications, it could be used in testing manned spacecraft.

With the support of California's Governor, Edmund G. Brown, 4 of the major aerospace firms in the state were given study contracts to analyze these problems. The contracts amounted to some $100,000 each. Although the contracts were scarcely moneymakers for the firms involved, the state of California, at least, apparently believes the effort was well worth the cost.

Under the program, Space-General Corporation studied the problem of crime and control of criminals. Lockheed Aircraft Corporation studied information collection. Aerojet-General Corporation analyzed the waste-disposal problem. And North American Aviation studied transportation requirements.

Aerojet's analysis of the waste problem revealed some frightening prospects for the future. The corporation found that the cost of disposal of wastes in California, including garbage, factory effluents, sewage, radioactive products, and other refuse, would rise to the multibillion-dollar level by 1990—only 25 years from now—unless an over-all disposal system were devised to replace the diversified methods now used. Present methods often result in cleaning up one area at the cost of polluting another locality. Using present systems, the 1990 cost could be as much as $1 billion a year.

North American, studying transportation requirements, found that demands for transportation of people and commodities may increase by as much as 500 to 700 percent during the coming 50 years. The company proposed that a computer model of an over-all transportation system for the state be devised, with 6 submodels of transportation subsystems that could be used independently for specific purposes.

Lockheed's analysis of the state's information-handling problem was split

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into 2 phases. The first phase involved analysis of information availability and flow in 80 organizations—state, city, and county political units. During the second phase, Lockheed produced a conceptual design for a statewide information system, based on modern computer techniques, in which pieces of information would be received only once by each agency and be made available to any authorized Government agency with ease and speed as requested.

The study of California's crime problem was in some ways the most interesting. Space-General Corporation, whose business is ordinarily far afield from such questions, found, among other things, that there was a district in the city of Los Angeles that promised to be a serious trouble spot, in view of the environmental difficulties faced by its people. The name of the district was Watts, which not long after the Space-General study exploded into a riot that cost more than 30 lives among its predominantly Negro population and damages running into millions of dollars.

There is little doubt that the application of systems-engineering thinking to such socio-economic problems as those examined by the 4 companies could produce many of the solutions required.

This Exer-Genie exercise device, shown being demonstrated in Lockheed Missiles & Space Company's space chamber at Sunnyvale, California, could help astronauts keep in good physical condition in the weightlessness of space. The device consists of a small metal cylinder through which a nylon line is pulled. The force required to pull the line through the cylinder can be varied.

The real problem is political consensus. The political structure of the United States is incredibly complex, with Government units ranging downward from the Federal Government to regional units set up for specific purposes, to the traditional state governments, to the city, town, and numerous other units which vary from state to state, depending on local history and custom.

In order to apply systems-engineering solutions to public problems, the consent or at least cooperation of most of these units—all of them representing many different interests and "publics"—has to be obtained. Very often, only an emergency is enough to dramatize the requirements for concerted action. One such emergency was the recent massive power failure in the northeastern section of the U.S., which may lead to a drastic re-examination of the technological approaches to serving electrical needs of the area. Another example is the developing water shortage in the state of New York.

At any rate, despite the political problems, an important demonstration of what aerospace systems engineering techniques could contribute to the solution of growing public problems was provided by the experiment in California. Now it is up to the politicians. ☆☆☆

This 40-foot-diameter (12 m) model of the Northrop Corporation's Cloverleaf parachute descends with test sled in flight test of the controllable gliding chute at DoD Parachute Facility near El Centro, California. Under a new NASA contract, Northrop Ventura will develop a large Cloverleaf, test vehicle, and control system for pinpoint recovery of 5,000-pound (2,270 kg) vehicle leading toward precise landings of space vehicles.

Value engineering has been used in U.S. industry for some time to find less expensive methods of manufacturing, without lowering quality. For the last 3 years, the U.S. Department of Defense has been including value-engineering clauses in its contracts. These provide contractors with a monetary incentive by ensuring that the producer gets a fair share of the savings incurred by his cost-reduction proposals . . .

Value Engineering: New Avenue to Profits

BY BRIGADIER GENERAL FRANK E. ROUSE, USAF
Commander, San Antonio Air Materiel Area

U.S. Government contractors are rapidly discovering a new avenue to profit: sharing value-engineering savings realized by the Government.

As an organized, creative approach to identifying unnecessary costs, value engineering is not particularly new to industry. In the last few years, many progressive companies have used it to drive their manufacturing costs down and swell their profits. What is new to industry is the value-engineering clause in U.S. Government contracts.

The Department of Defense now includes value-engineering clauses in many of its contracts to provide contractors a monetary incentive to direct their value-engineering efforts toward reducing the Government's costs.

Since first introduced into Government contracts about 3 years ago, value-engineering contractual provisions have been progressively improved to ensure that the contractor gets his fair share of the savings. To further encourage contractors to submit cost-reduction proposals, the U.S. Armed Services Procurement Regulation was changed recently to provide additional arrangements for sharing savings. (See Section I, Part 17, Armed Services Procurement Regulation as changed by Defense Procurement Circular No. 11, October 9, 1964.)

The Department of Defense has 2 kinds of value-engineering contract provisions. There is the "incentive clause" which offers the contractor a monetary reward if he is able to control and reduce the Government's costs while performing on the contract, and there is the "program-requirements clause" which obligates the contractor to engage in value engineering as an item of work. Generally, but with

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The author, General Rouse, took command of the San Antonio Air Materiel Area, San Antonio, Texas, in July 1965. He had been, since 1963, Director of Logistics for the U. S. European Command in Paris. Prior to that assignment, he was Deputy for Materiel for the USAF Air Defense Command. In his over 32 years of service he has served in several Pentagon staff posts.

some limitations, the value-engineering incentive provision is included in all advertised and negotiated procurements in excess of $100,000, and the value-engineering program-requirements clause is included in all cost-plus-fixed-fee contracts in excess of $1 million.

Currently, there are 3 types of value-engineering cost savings realized by the Government in which a contractor may share, depending on the terms of the specific contract. First, a contractor may share savings realized against the items on the contract. Second, he may share in savings to be realized in the procurement of additional quantities either by the receipt of a single lump sum reward payment, based on estimated future requirements, or by receipt of royalty payments tied to actual delivery of any additional quantities procured. Third, he may share collateral savings that accrue in areas such as operations, logistics support, and training.

Under the value-engineering incentive clause, the contractor's share of savings realized against items on a contract is usually about 50 percent. His share of future acquisitions savings may be up to 40 percent and his share of collateral savings is 10 percent.

To illustrate as simply as possible how these provisions translate into profit, let's assume that a firm receives a Government contract for the manufacture of 50,000 items machined from nonstandard stainless-steel tubing which sell for 3 dollars each, or a total of $150,000, including $13,500 profit. Let's also assume that the contractor value engineers the item and suggests that standard heat-treated aluminum tubing of adequate strength be substituted for the stainless steel to reduce cost. Since the extra strength of the stainless steel is not needed and aluminum has the necessary corrosion resistance, the contractor's proposal is accepted. This results in a new unit selling price of 2 dollars, changes the total selling price to $100,000, and effects a total net price reduction of $50,000.

The total savings to the Government would then be determined by considering this net price reduction, collateral and implementation costs, and other applicable factors. If actual savings to the Government were determined to be $45,000, and the contractor's share of this was 50 percent, the value-engineering effort would be worth $22,500—almost twice the profit estimate of the original contract.

Now, let's further assume that this contract contains a royalty-sharing agreement. The Government then would pay the contractor a royalty on subsequent deliveries of this item for a specified period up to 3 years. He would receive this royalty even if the item were purchased from another firm.

The lump-sum method of sharing savings from future acquisitions is an alternate to the royalty-sharing arrangement. Here is an example of a situation in which it would apply: The Government is reasonably certain that it will buy a total of 190,000 generator seals over a period of 3 years; however, because funds are limited, or other conditions, it initially awards a contract for only 50,000 seals. A value-engineering change proposal received

Examples of Value-Engineering Savings—and Bonuses

Many contractors are increasing the profits on their U.S. Government contracts by receiving a fair share of the money saved by cost-reduction proposals. Here are 2 examples:

- An engine overhaul contractor was paid a bonus of over $56,500 when he designed a stainless-steel sleeve for worn oil pump bearings that permitted overhaul of rear engine cases previously rejected.
- An aircraft-arresting-barrier contractor was paid more than $34,000 when he greatly reduced the price of a contract by presenting a value-engineering proposal for the elimination of some unnecessary parts and the substitution of less expensive components without decreasing the reliability of the barrier.

Value engineering is being practiced within the military, as well as by its contractors. The USAF San Antonio Air Materiel Area (SAAMA) was credited with more than $18 million in savings during the first half of Fiscal Year 1965. Here are some specific examples:

- Over $57,000 was saved on the procurement of 1,068 generator oil seals by replacing a $57.46 3-piece seal with a 1-piece $2.97 standard seal.
- SAAMA personnel discovered that plastic intake and exhaust shields could be substituted for metal and fabric ones on several types of aircraft. Some of the specific savings were: Plastic exhaust shields for the F-106 cost $144, while the metal ones cost $595. Total saving on procurement of 39 was over $17,500. The AMA bought 912 KC-135 plastic intake shields for $14.60 each, versus $59.21 for the metal type, for a total saving of $40,684.
- A process of nickel braze repair was developed enabling AMA personnel to reclaim T34, T53, J57, J60, and J75 engine parts, which were beyond repair by gas or arc welding. This one development had saved the U.S. Air Force $14.9 million by the end of 1964.
- An innovation in a cleaning procedure that helped prevent damage to the T34 engine reduction gear during cleaning reduced the necessity of condemning these gears by 40 percent, for an annual saving, based on the yearly overhaul requirement, of about $115,000.
- An item on an aircraft spray deicer that had cost $19,691 was replaced with one costing $14,847 for a saving of over $155,000 on the purchase of 32 deicers.

on this initial contract would be evaluated on the basis of the anticipated follow-on buy of 140,000 seals as well as the original buy of 50,000 seals.

Under the lump-sum payment method, the contractor receives payment before the projected buy is actually made. Accordingly, the lump-sum method is used when future requirements are relatively firm. The royalty-payment method is used when future requirements are uncertain. It provides that the contractor will share savings only on actual purchases.

Sharing of collateral savings is one of the newest value-engineering incentives. Contracts with a value-engineering clause normally provide for sharing collateral savings in addition to any of the other incentives. In general terms, collateral savings are the incidental benefits that result from a value-engineering change such as benefits that would accrue to the Government from the reduction in the quantity of spare parts required to support the end product. This type of value engineering decreases the Government's cost in many areas, such as maintenance, warehousing, and accounting.

Some firms, without value-engineering resources of their own, have found it profitable to hire engineering consultants to develop value-engineering change proposals on Government contracts. New materials and better fabricating techniques being developed almost daily provide a potential to decrease the over-all cost of every product, and the monetary incentives offered by the Government are now an important new avenue to profit. ☆☆☆

Getting under way fast in a combat emergency or to outrace the elements has always been a major problem for warship commanders. In today's combat environments, it is a critical problem that can mean life or death for a ship and its complement. Yet the costs of installing extra conventional marine propulsion units for emergency use would be prohibitive in terms of money, weight, and space. A promising solution to this problem is afforded by the installation of . . .

Jet Aircraft Engines For High-Speed Warships

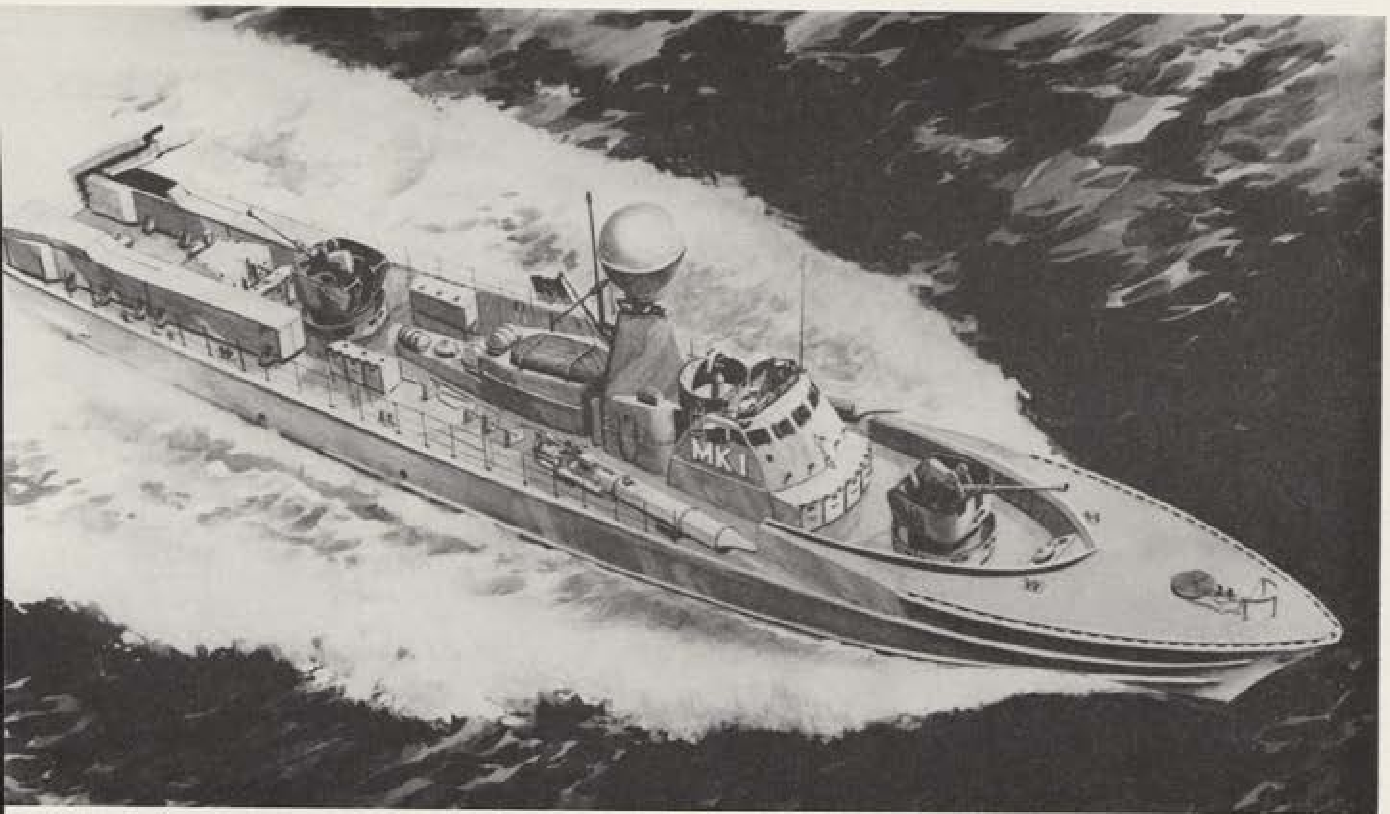
BY STEFAN GEISENHEYNER
Editor for Europe

The history of the sea in peace and in war is a chronicle of ships being lost due to insufficient power in times of emergency. It is obvious that a ship caught in rough waters with only marginal power at its disposal becomes easy prey to the elements. In modern war, to remain more than a few minutes in one location during combat is equivalent to suicide. Even with modern propulsion units such as diesels or highly sophisticated steam-turbine arrangements, from standstill in the harbor it takes from 15 to 18 miutes before a ship has full power available.

On the high seas, the availability of high-speed performance for large as well as small warships becomes mandatory during attack or withdrawal. But, since warships operate for only a fraction of their lifespan on maximum power, it would be totally uneconomical, in terms of basic expenditures as well as weight and space, to install extra-power conventional propulsion units just to be able to meet an occasional requirement for very high speed. This arrangement, although it is technically feasible, would furthermore not satisfy the requirement for the instant power necessary to leave a harbor within a few minutes. It has long been realized that the gas turbine—or jet engine as it is called in aircraft operations—would be ideal to provide instant power for quick acceleration and boost power for occasional high-speed operations in free water. An important consideration is that compact gas-turbine powerplants driving the ship's screws can be installed alongside the conventional prime movers, to be used in emergencies only, thus giving the ship an extraordinarily high degree of operational flexibility without wasting valuable space by using overly large conventional engines.

A survey of applicable gas turbines for use in such combined ship propulsion units soon leads to the conclusion that the simple open-cycle gas tur-

Turbine-powered patrol craft destined for the West German Navy is tested in British waters before its delivery. Engines are built by Bristol Siddeley in England. Ships of this type will join with other German Navy ships of the KOLN class which employ combined diesel and gas-turbine powerplants.



This West German Navy second-generation, turbine-powered patrol boat, as envisioned by a General Dynamics artist, employs diesels as well as turbine engines. Speed and maneuverability, along with Tartar missiles, make it the tactical equal of a destroyer.

bine, as employed for aeronautical purposes, has many advantages over any other contender in terms of simplicity, reliability, compactness, light weight, and easy maintainability. Too, such gas turbines have been in operation for years with the various air forces and airlines of the world, and operating experience is extensive.

Several of the major jet-engine manufacturers of the Western world have adapted some of their larger and medium-size aircraft jet engines to marine use. Bristol Siddeley Engines Ltd., General Electric Company, and Pratt & Whitney Division of United Aircraft Corporation are today in the forefront, producing true marine gas turbines which are used in the ship designs of many nations.

The conversion of an aircraft engine into a marine engine involves several major engineering tasks. Due to the corrosive effects of salt-water spray and the salty air in the expected operational environment, all magnesium alloy components have to be exchanged for parts made of aluminum alloys. Stator and rotor blades of the compressor stages have to be produced from stainless steel, and the fuel system has to be re-engineered to accept conventional ship fuel such as naphtha or other low-grade oil distillates. Since the engine does not produce thrust as in an aircraft application, but shaft horsepower instead, a power turbine which converts the energy of the gas generator's exhaust into usable mechanical power has to be developed.

In designing the mixed powerplant of a ship, incorporating a conventional prime mover and a gas turbine, the first problem to be solved is the division of the available power between the cruise engine, which must be sufficient to reach average speeds, and the boost plant for high-speed operation. If not too high a cruising speed is envisioned, then the large marine diesel engine becomes the favorite for the cruise engine or base-load unit, and the marine gas turbine is used only for the boost load. Such an installation is known as CODAG (combined diesel and gas turbine) machinery.

The German Navy's KOLN-class escort ships use CODAG plants. They are twin-screw vessels of 2,800 tons (2,540 mt) displacement with a total horsepower output of 38,000 shp, giving the ship a maximum speed of 30 knots (55.6 km/hr). Each propeller shaft is driven by 2 MAN diesels rated at 3,000 horsepower, driving through couplings into a reduction gearbox. A Brown & Boveri industrial gas turbine rated at 13,000 shp is connected to each shaft for boost purposes. In this design, the cruise-engine output accounts for approximately one-third of the installed power, enough to propel the ship at speeds up to 15 knots (28 km/hr).

A variation of this machinery arrangement exists where only 1 of the 2 prime movers, gas turbine or diesel, is operated at a given time. This system is called CODOG (combined diesel or gas turbine). In other words, the diesel engine is used for cruising but is eventually shut down after the boost turbine has been started. The gas turbine alone delivers total power to attain the maximum design speed of the vessel. The advantage of this arrangement is the use of unsophisticated automatic clutches, thereby simplifying the operation of the propulsion machinery. The British VOSPER high-speed corvette has been designed to incorporate such a machinery layout. The boost powerplant designated for this 500-ton (453.6 mt) ship is a Bristol Siddeley marine Olympus—a derivative of the famous Olympus jet aircraft engine—rated at 22,000 shp, and a Deltic diesel engine of 2,000 shp on each of

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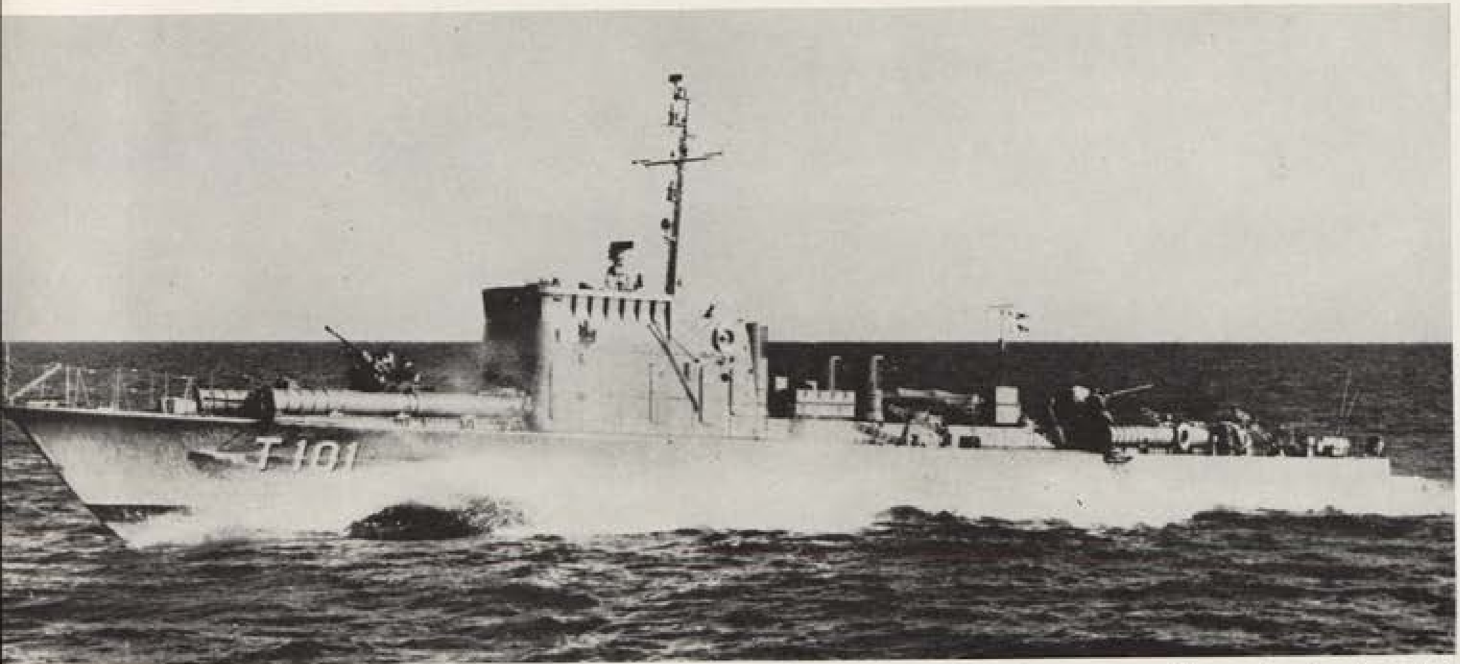

Sweden is conducting tests of this experimental boat, powered by 2 Bristol Siddeley Proteus gas-turbine engines for boost-load power, in addition to conventional diesels. An operational version now under construction will replace the Proteus engines with 1 Olympus powerplant. The new ship will also be one of the first in the world to be completely sealed against atomic radiation.

the 2 propeller shafts. The intention is that for speeds below 15 knots (28 km/hr) only the diesel engines will be operated. All maneuvering will be done on the diesels, which will have integral reversing gearboxes. A clutch is included in each transmission to permit the gas turbine to be connected to the propeller shafts under emergency conditions and at the same time to disconnect the diesel power. The 44,000 shp available for the high-speed run should allow a maximum speed of 50 knots (92 km/hr).

It can be readily seen that the criterion for the successful operation of such combined machinery arrangements is the reliability of the relatively complicated transmission, which has to include clutches and reversing gears. No optimal solution has been found yet to simplify the operation of such gear arrangements. Projects are under way in several countries, however, to equip high-speed ships fitted with mixed powerplants with variable-pitch propellers which would at least eliminate the reversing part of the transmission layout.

The problems which face the procurement authorities of the smaller or newly independent navies of the world have become more acute as the armament and equipment of warships have increased in complexity, with proportionately rising costs. In many cases, the navies of these nations have been operating war vessels bought from the U.S. and British Navies, which are now over 20 years old and practically obsolete. It has been realized for some time by shipbuilders who specialize in constructing warships that it is virtually impossible for a small nation to purchase modern frigates of the type used by the major naval powers due to the high costs involved. The shipbuilders have consequently prepared designs of smaller CODAG or CODOG warships which are within the financial reach of most of the smaller countries.

This breakthrough in shipbuilding activity is due entirely to the fact that gas turbines derived from jet aircraft engines are the only prime movers supplying large power outputs that can be fitted in the small ships, giving them speed capabilites in excess of 30 knots (55.6 km/hr) and still leaving room for adequate armament.

It may be of interest to note here that the industrial gas turbine did not prove to be a success in marine propulsion as did the derivatives of the aviation jet engine. The German Navy, for instance, which had previously planned to develop a completely new marine gas turbine based on existing heavy industrial units, realized from the results obtained from the KOLN-class ships that this was impracticable. Consequently, one of the very first marine Olympus gas generators to come off the production line was sold by Bristol Siddeley to the German Navy. The power turbine for this unit was designed and manufactured by Brown & Boveri of Germany. Highly successful tests of this marine gas turbine have been under way for the past 2 years, and it seems quite certain that the Olympus and its future developments will power the next generation of warships in the German Navy.

The Finnish Navy likewise has purchased the Olympus as boost engine for CODAG warships to be built by the Finnish shipyard company Wartsila Koncernen. Also, the Swedish Navy is experimenting with the Olympus-powered patrol boat which uses 2 diesel engines for base-load power. This highly modern ship will be one of the first which can be completely sealed against atomic radiation. The Italian Navy, too, is presently evaluating several designs of high-speed gunboats powered by diesels and smaller British-designed gas turbines.

The Danish Navy has ordered 2 frigates, each of which will rely on a pair of FT4 gas turbines for boost power in high-speed operations. The Pratt & Whitney FT4 gas generator and power turbine is the marine version of the well-known JT4 jet engine, which powers some models of the Boeing 707 and the Douglas DC-8 series. The turbine has a maximum rating of 30,000 shp but was derated to 20,000 shp so as to extend the engine life. The first Danish frigate featuring a mixed-propulsion plant will be launched and begin sea trials next year. Pratt & Whitney has already delivered several FT4s for the vessels of this class to Stal-Laval Turbine Company of Finspong, Sweden, which is designing the propulsion system.

Danish Navy is acquiring a number of these fast patrol boats employing 3 Proteus turbine engines plus 2 small diesels, offering long cruise range with high-speed capability when needed. Denmark has also ordered a pair of frigates, which will be equipped with 2 Pratt & Whitney FT4 gas turbines for boost power in high-speed operations. FT4 is marine equivalent of engines in Boeing 707.

The U.S. Navy and Coast Guard have started an extensive shipbuilding program centering around smaller CODAG-powered warships. The Coast Guard's new 378-foot (115 m) cutter HAMILTON, now under construction at Avondale Shipyards, will use 2 Pratt & Whitney FT4 engines for high-speed operations and will be powered by twin diesels for cruising. The boost-power FT4s will give the vessel a maximum speed of 29 knots (53 km/hr). The Coast Guard plans to add 38 similar ships to its fleet over the next 10 years.

The FT4 marine gas-turbine engine uses titanium extensively in the compressor as well as cadmium or nickel-cadmium-plated parts where applicable. All magnesium parts have been replaced with aluminum. The FT4 development is part of the Sea Hawk program, a Navy plan to develop a new generation of antisubmarine warfare escort-type ships using high-power aircraft-type gas-turbine powerplants in combinations with other prime movers as the cruising powerplant.

Last summer, 2 U.S. Navy CODAG-powered patrol gunboats (PGM) were launched. These 165-foot (50 m) vessels use, as a boost power unit, a General Electric LM1500 gas generator, which drives a power turbine built by Evendale & Everett. Diesel engines are installed for cruising. The LM1500, a 14,000-shp gas turbine, is derived from the J79 turbojet, which is manufactured by General Electric and powers supersonic aircraft in use throughout the world. The powerplant combination of the new PGMs will guarantee fast acceleration, rapid response to throttle changes, and long loitering time while operating on the diesels, thereby increasing the hitting power of these relatively small vessels.

In using the gas turbine as a boost engine, combinations with other conventional-ship powerplants become feasible. In 1953 the British Admiralty started investigations into COSAG (combined steam and gas turbine) installations. Future wartime requirements were borne in mind, and it was eventually resolved that a steam turbine instead of a diesel was preferred as the base-load plant. At the same time, it was also considered unsound to risk designing a new class of warships with anything less than a powerplant capable of providing 50 percent total power from known conventional sources. In the event of complete failure of the boost gas turbine, such an arrangement would ensure that a speed of approximately 85 percent of that of the combined full-power output of both systems could be achieved. This dictated that a steam turbine should be fitted, since no diesel engine of high enough horsepower, possessing sufficiently low weight and space characteristics to merit installation, was available. In addition to this, a vast amount of operating experience existed in the Royal Navy on geared steam-turbine machinery. As, however, the base-load steam equipment could not be operational from cold in less than 80 minutes, the ships were designed to maneuver and reverse on the gas turbines. After full investigation it was decided to select this mixed machinery concept for 2 new classes of major British warships which were then being designed.

The first, the 2,800-ton (2,540 mt) TRIBAL-class general-purpose frigates, are single-screw ships with a 12,500-shp steam turbine and 1 British A.E.I. G6 gas turbine rated at 7,500 shp. Both prime movers are located side by side in a combined machinery space forward of the gearing. A speed of 28 knots (52 km/hr) can be reached.

Second, the 7,000-ton (6,350 mt) COUNTY-class guided-missile destroyers are twin-screw ships developing a total of 60,000 shp. Each propeller shaft is driven by a high-pressure and low-pressure steam turbine of 15,000 shp, the combined output driving into the main gearbox from forward, plus 2 A.E.I. G6 gas turbines from the aft-end. A number of such destroyers are presently in service. Maximum speed attainable is 33 knots (61 km/hr).

Compared to an all-steam design, this COSAG plant offers an improvement in range of 20 to 25 percent based on a constant weight of machinery plus weight of fuel, a reduced deck height in the machinery compartment, and 10 percent increase in available horsepower.

Another combined plant which has frequently been discussed of late is the gas-turbine base load and gas-turbine boost or COGAG installation

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USS ASHEVILLE, shown emerging from shipyard shed in Tacoma, Washington, is one of U.S. Navy's fast new gunboats, which was to have been commissioned in December. Built of aluminum and using turbine and diesel engines, it will protect coastal shipping.

(combined gas turbine and gas turbine). The object of this plant is to use a lightweight gas turbine for boost purposes as in the CODAG and COSAG arrangements, but, instead of diesel or steam engines, to use a long-life gas turbine as base-load powerplant. The desired long life can be obtained by using lightweight aircraft engines at reduced power in this installation. Waste heat boilers would be utilized, operated by the exhaust gas of the base-load engine, and would supply all the electrical energy for running the ship. This solution offers a high over-all efficiency for the complete installation. Bristol Siddeley is presently investigating such a COGAG plant, which would consist of combined Proteus and Olympus gas turbines. The Proteus would be the base-load unit running at reduced power and the Olympus would be the boost unit.

The Bristol Siddeley Proteus is a highly successful marine gas turbine which is in service with several European navies as the powerplant for PT boats and other fast patrol craft. These ships use the turbines in pairs or, as in the British PT boats of the BRAVE class, 3 side by side. Extremely high speeds up to 50 knots (92 km/hr) can thus be achieved.

The only large ship today, presently under construction and using gas turbines as sole power source, is a new high-speed freighter being built for the U.S. Department of Defense. It is described as a fast roll-on, roll-off ship and is the first such vessel built for military use. The ship will be 672 feet (205 m) long and will have a cargo capacity of 7,000 tons (6,350 mt). Heavy tanks, trucks, trailers, and other vehicles can roll onto the ship with the help of a ramp. Two 20,000-shp Pratt & Whitney FT4 gas turbines will give the ship a speed of 25 knots (46 km/hr) and a total range of 6,000 miles (9,656 km).

The use of pure gas-turbine propulsion, however, is uneconomical for any application where longer periods of average cruise speeds are expected and only an occasional burst of high speed becomes necessary. Destroyers, frigates, corvettes, and patrol craft are, therefore, the logical users of mixed powerplants since the main disadvantage of the gas turbine is its high fuel consumption in comparison to diesel or steam engines.

In a class by themselves are the still largely experimental hydrofoil vessels of various designs which invariably are powered by gas turbines, as these are the most economical powerplants for their weight/space/power ratio. Since hydrofoil boats are mainly built for speed and not for loitering capability, fuel consumption becomes of secondary importance.

During the past few years, the marine gas turbine has demonstrated to the satisfaction of everybody concerned that it is a reliable and useful power source for ship propulsion. Especially in the smaller navies, which cannot afford big ships nor have an urgent need for them, gas-turbine propulsion will find widespread application. The space taken up by the compact turbine is only a fraction of the room needed for a similarly powerful diesel or steam plant. Thus the room saved can be used to house extensive armament, preferably guided missiles, as well as extra fuel, making a relatively small, high-speed patrol boat in coastal waters an even match for ships of the destroyer class.

Purely economic considerations seem to lead to the conclusion that the marine gas turbine is here to stay. It is the most compact, most highly developed, and most readily automated prime mover available to the shipbuilder today. The moderate initial cost of the gas turbine and the simplicity of its installation combine to reduce ship construction costs. The gas turbine's light weight and compactness offer the naval architect greater freedom in the location of the powerplant, resulting in more efficient use of the shipboard space. These inherent characteristics of the marine gas turbine can improve the total economics of seagoing vessels considerably, thereby ensuring widespread acceptance of its use.

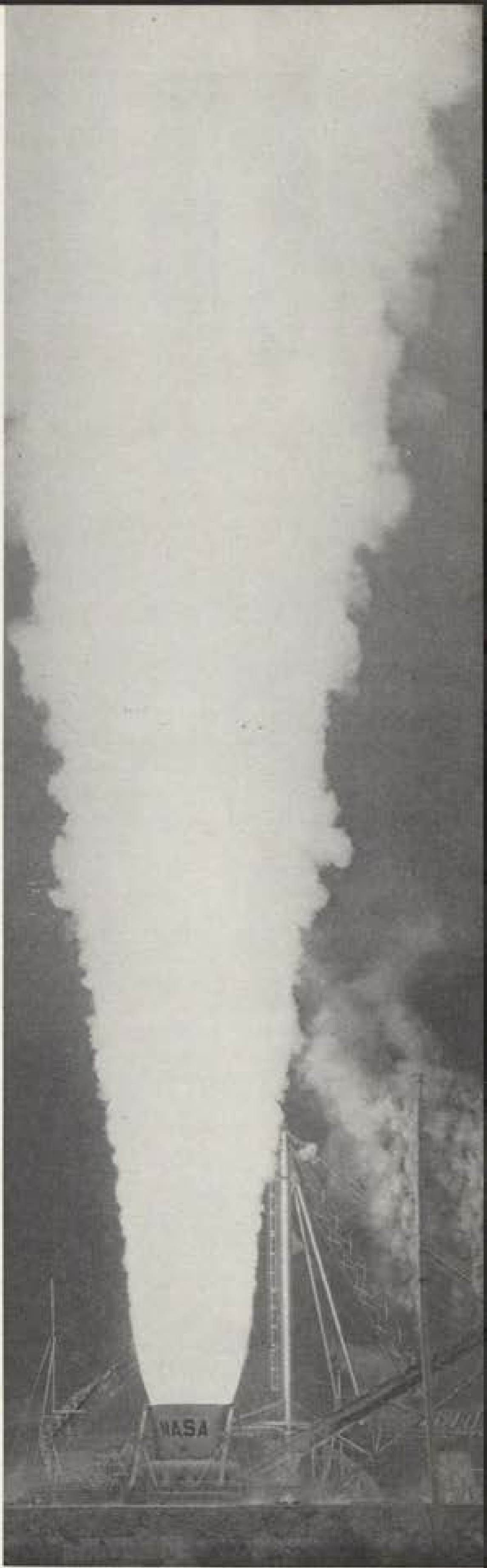
☆☆☆

Among first vessels to employ turbine power exclusively are these British Navy BRAVE-class patrol boats, equipped with 3 Proteus engines mounted side by side. BRAVEs, boasting top speed of 50 knots (92.5 km/hr), have been operational since the mid-1950s.

A significant demonstration of solid-fueled rocket capability against the background of studies of the high cost/effectiveness of solid fuels. . . . A very lightweight antenna for space vehicle applications. . . . Studies of the feasibility of landing helicopters in heavy seas. . . . Development of one of the world's smallest jet-engine starters. . . . A money-saving idea for recovering solid-rocket booster cases. . . . And a pilot plant for the production of boron filaments . . .

Trends and Developments

BY J. S. BUTZ, JR.
Technical Editor



A plume of smoke several hundred feet high rises above the 260-inch diameter (660 cm) solid-propellant rocket recently tested successfully by Aerojet-General Corporation. The motor produced some 3,000,000 pounds (1,350,000 kg) of thrust.

260-Inch-Diameter Solid Rocket Firing Successful

The first 260-inch-diameter (660 cm) solid-rocket motor has been fired successfully in Dade County, near Miami, Florida, by Aerojet-General Corporation.

"Hard" data, made public after a thorough study of the test instrumentation results, showed that the peak thrust was 3,570,000 pounds (1,570,000 kg), the average thrust was 3,160,000 pounds (1,420,000 kg), and that the motor produced significant thrust for 113.6 seconds. NASA officials who are in charge of the program were highly elated because these performance figures all were better than expected, and there were no trouble spots within the motor due to high temperature, excessive erosion, etc. For example, the nozzle throat, which is 6 feet (1.8 m) in diameter, was enlarged 0.75 inches (1.9 cm) during the firing, just as predicted.

The success of this static test has raised hopes that the 260-inch (660 cm) program will be carried forward into Phase II, in which a "full-scale" motor, 160 feet (49 m) long, producing 6,000,000 pounds (2,700,000 kg) of thrust would be developed and fired. The motor just tested was a Phase I motor 80 feet (24 m) in length. Under currently approved plans, there are only enough funds in the large solid-rocket program to allow the firing of one more Phase I motor. However, it is believed that Phase II funding will be provided in the FY 1967 budget which will come before the Congress early in 1966.

Low Costs Forecast for Large Solid-Rocket Vehicles

Cost studies conducted by 9 U.S. aerospace firms and one Government agency show that substantial cost/effectiveness improvements can be made when large solid-rocket motors are used to replace, or to augment, liquid-fueled first stages on large launch vehicles of the Saturn V class. Most of the companies making these studies are engaged primarily in airframe and missile-frame construction and are not directly connected with the rocket business. Their studies were made under Government contract for the most part, and the final results were assembled by a group at the U.S. Naval Propellant Plant at Indian Head, Maryland, for William Cohen, Chief of Solid Propulsion in NASA's Office of Advanced Research and Technology.

Even if substantial allowances are made for discrepancies in bookkeeping procedures, changing value of the dollar, and the proper write-off of existing test, launch, and range facilities, it must be concluded from these stud-

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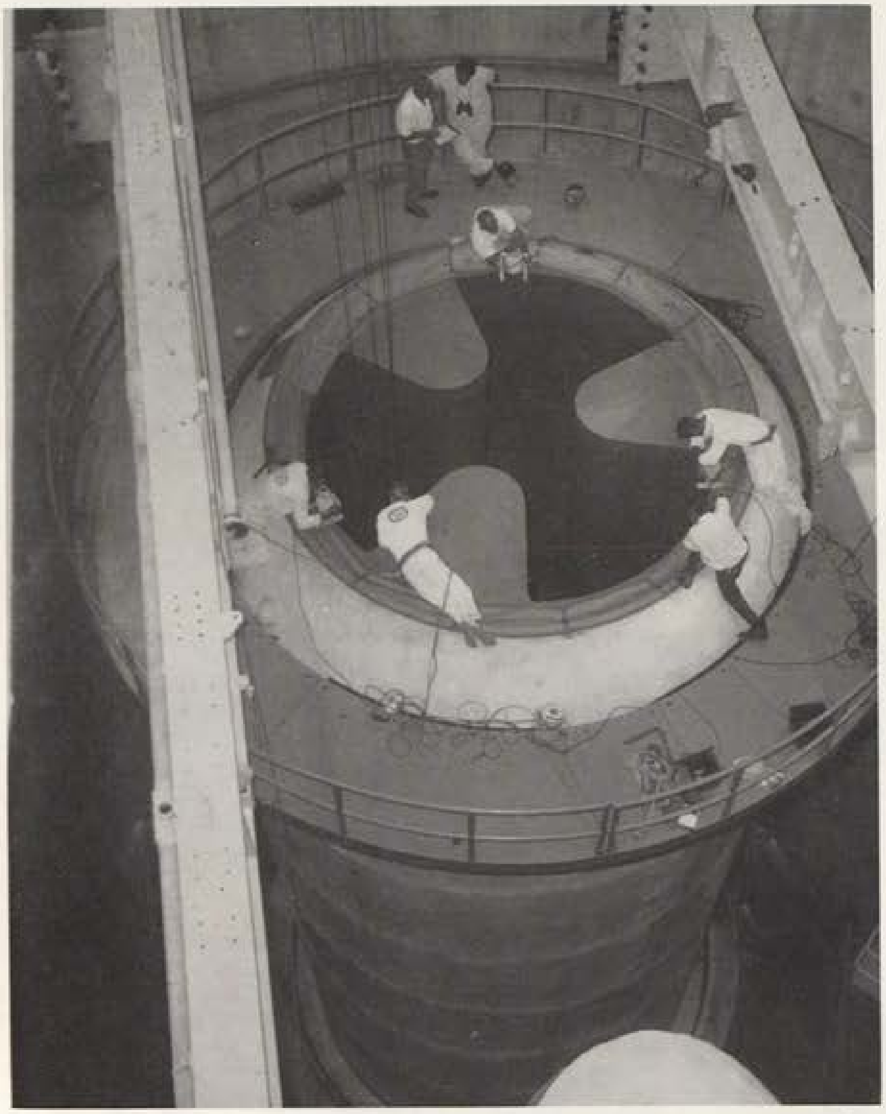

Immense size of the 260-inch (660 cm) solid-rocket motor is illustrated here as technicians check the grain prior to firing. The motor performed as predicted during the firing and it appears that the technology is sufficiently advanced to allow the development of operational motors. Funds for further work are expected in FY 1966 budget.

ies that large solid-rocket motors could make a significant contribution to the space program of any nation. Apparently, the only circumstance in which the use of large solids would not lower total U.S. space-program costs during the 1970s is in the event of a very small effort with only a few manned flights per year. As soon as the U.S. places 3,000,000 to 5,000,000 pounds (1,350,000 to 2,250,000 kg) in orbit each year, the case for investing in large solids becomes very strong. Current NASA plans call for the launching of 6 Saturn Vs and 6 Saturn IBs per year around 1970. This fleet can place nearly 2,000,000 pounds (900,000 kg) in orbit. Air Force space launches, of course, will run the national total up considerably.

A good example of the ability of the large solid rockets to increase cost/effectiveness is provided by the Saturn V. Direct operating costs for this Apollo launch vehicle are estimated to be around $300 per pound of payload placed in low earth orbit. The total program costs, including indirect as well as direct operating costs, are much higher, but they are relatively difficult to estimate, because no one knows how many years this booster will be operational, or how many will be launched each year.

If the Saturn V first stage, the S-IC vehicle (see photo below) is replaced with 3 260-inch-diameter (660 cm) motors, the studies show that the direct operating cost can be brought down to $135 per pound of payload in orbit. For this modified vehicle, the total program costs have been computed on the basis of 100 launches over a 10-year period, using 1963 prices and a $1 billion development cost for the large solid motors.

First S-IC, first stage of Saturn V, was rolled out this fall from its assembly shop at NASA's Marshall Space Flight Center. The Saturn V is the giant rocket vehicle which will send the Apollo astronauts to the moon. The 5 rocket engines in this first stage generate 7,500,000 pounds (3,375,000 kg) of thrust. Captive firing tests with this stage are scheduled to begin early in 1966. First flight test of complete Saturn V is slated for 1967.

Under these ground rules the total program costs would be $4,655,527,000, or $189 per pound of payload in orbit. These are far under the total costs projected for the current Saturn V, which uses all-liquid rockets.

Lightweight antenna made of aluminum-coated nylon mesh supported by fiberglass rods is shown at left. It can be compressed into a briefcase-size package for launching into space, where it then will expand to a 60-foot (19 m) structure for reflecting high-frequency radio signals.

More Than 4 Years for 260-Inch Motor Development

Developing the 260-inch-diameter (660 cm) motor to the point of a preflight rating test (PFRT) probably would require at least another 4 years of work, according to Dr. A. J. Eggers, Deputy Associate Administrator in NASA's Office of Advanced Research and Technology. According to Dr. Eggers' estimate, bringing this motor to its PFRT by 1970 would involve a sizable increase in funding. In the present program, Aerojet-General is firing 2 260-inch (660 cm) motors and has received approximately $25 million in Government funds for this work.

A full-scale development program, including the PFRT tests, probably would involve the static test firing of about a dozen motors, if United Technology Center's program to develop the 120-inch-diameter (305 cm) motors for the USAF's Titan IIIC motors, is an indicator. Fourteen of these 120-inch (305 cm) motors were fired before first flight. Dr. Eggers also estimated that it would be 1971 or 1972 before the 260-inch (660 cm) motor could reach the stage where the 120-inch (305 cm) is today—into its flight-test program. A faster pace is possible, according to Eggers, but this would require extremely large expenditures and a crash program.

Lightweight Antenna for Space Vehicles

A 60-foot-diameter (19 m) mesh net antenna supported by fiberglass rods, which can be compressed into a 36-inch-diameter (91.4 cm) package for launching into space, has been constructed by Electro-Optical Systems, Inc., a subsidiary of Xerox Corporation. The complete parabolic unit with its associated stabilization equipment weighs less than 100 pounds (45 kg), which, according to the developers, makes it 75 percent lighter and more compact at launch than any antenna systems now used for space communications.

The antenna frame consists of one-quarter-inch (.64 cm) fiberglass rods molded from uniaxial filaments in a resin matrix. High strength and exceptional flexibility is needed to fold this large antenna into the small package for launching. The rod frame supports a mesh made of thin strands of nylon coated with aluminum for maximum reflectivity. This mesh is woven into a "hairnet" pattern, which is a reflecting surface for a large portion of the electromagnetic spectrum.

Helicopter Operations in Heavy Seas

A design-feasibility study for a tilt-float system, which will allow helicopters to land in heavy seas and cut their power, has been conducted for the U.S. Navy's Bureau of Weapons by the Vertol Division of The Boeing Company. This design is said to provide an exceptionally steady platform for an indefinite period, without power. In 8-foot (2.4 m) waves, it is predicted that roll motions will not exceed 2 degrees. The tilt-float concept is expected to be applicable to all types of helicopters and V/STOL aircraft and will greatly improve their versa-

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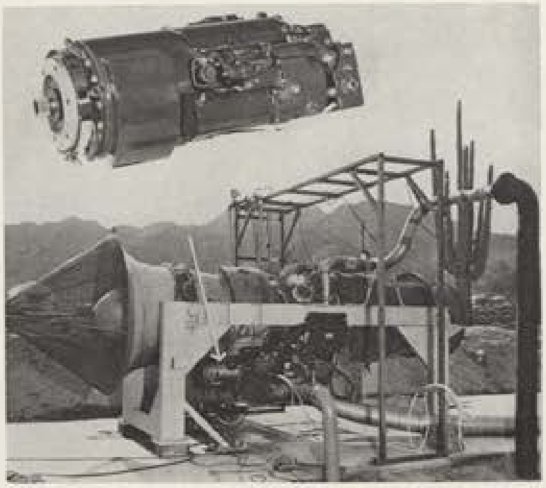
Artist's concept shows Boeing tilt-float equipment, which will allow helicopters to land in heavy seas and lower antisubmarine listening gear into the ocean for long periods. Studies indicate that the tilt-floats are extremely stable and will keep roll motion down below 2 degrees in 8-foot (2.4 m) seas.

tility for antisubmarine, rescue, oceanography, research, and strike-support missions.

New Jet Engine Starter

One of the world's smallest turbine engines has been developed by AiResearch Manufacturing Company to start the largest jet powerplants. The new starter, designated the JFS-100 Jet Fuel Starter, is a free-turbine type with a typical gas generator consisting of compressor, combustion chamber, and turbine section. The entire package, however, is 20 inches (50.8 cm) long, less than 9 inches (22.8 cm) in diameter, and weighs less than 70 pounds (31.5 kg), including the free-turbine section which drives the starter mechanism. It uses the same fuel as the aircraft's main engine.

Successful starts have been demonstrated with TF30 and J57 jet engines. This new starter was designed and developed by AiResearch as an in-house project, and it was financed by the company.



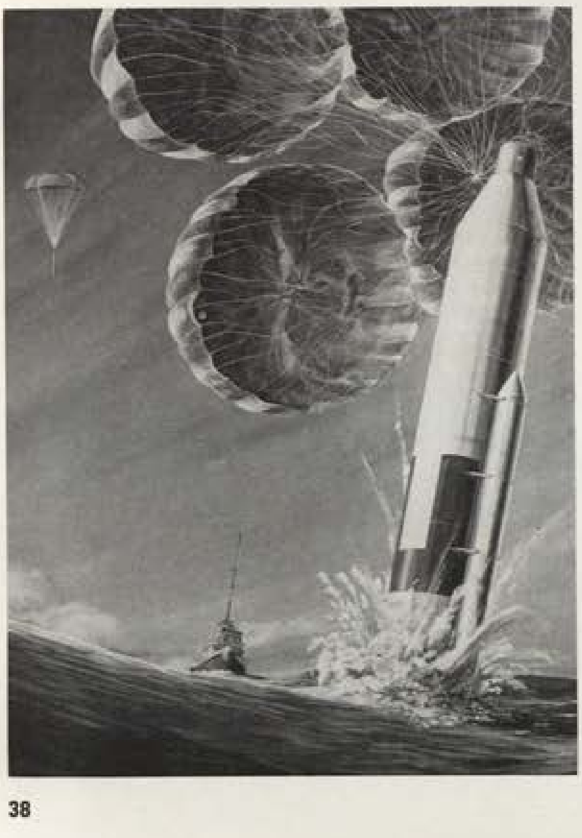
The JFS100 turbine powered starter (inset), which operates on jet fuel, is shown here during a starting test of a J57 engine. The JFS100 was developed by AiResearch Manufacturing Company with company funds.

Recovery of Solid Motor Cases Offers Savings

Savings of 30 to 40 percent of the cost of a major solid-rocket booster program could be achieved through parachute recovery and reuse of the motor cases. This is the major conclusion of the study conducted by United Technology Center on the reuse of the 120-inch-diameter (305 cm) Titan IIIC solid-rocket motors. The exact dollar savings would depend upon the number of launches and the number of times recovered cases were reused. The study allowed for the cost of recovery and refurbishment of the cases.

A simple recovery system is considered feasible for the cases. Recovery of the 10-foot diameter (3 m), 86-foot (26 m) long, 74,000-pound (40,000 kg) cases would be accomplished with 4 100-foot (30 m) diameter parachutes which would be deployed at about 10,000 feet (3,050 m) altitude when the case is traveling at supersonic speeds.

The case would be slowed rapidly by the parachutes and hit the water, nozzle first, at about 60 mph (97 km/hr). The chutes would detach on impact and activate flashing lights and a radio beacon to assist the recovery vessel in locating it. Total weight of the recovery system would be about 3,200 pounds (1,440 kg).



Recovery of 120-inch diameter (305 cm) solid-rocket motor cases is shown in this artist's conception. United Technology Center studies show that major savings can be made in the Titan IIIC flight program with parachute recovery and refurbishment of these motors. Cases could be picked up quickly from the ocean through use of flashing lights and radio beacons.

Pilot Plant for Boron Filament Production

A pilot plant for the production and utilization of continuous boron filaments is to be established by Avco Corporation's Research and Advanced Development Division under 3 U.S. Air Force contracts totaling $880,022.

The bulk of these funds are being supplied by the Advanced Filaments and Composites Division of the Air Force Materials Laboratory, Wright-Patterson AFB, Ohio. They will cover the installation of 4 continuous production lines, 2 of which will be experimental to accommodate process improvement and automation experiments. These lines, when fully operational, will have the capability of producing 20 pounds (9 kg) of boron filament a month. The purpose of this contract is to determine which techniques for boron filament preparation will be the most efficient and economical in volume production.

A second contract will cover the development of new composite materials created by using boron filaments to reinforce various types of sheet metal. A variety of boron-metal composites will be fabricated and tested to gather data on the chemical, physical, and mechanical characteristics of the materials.

Under the third contract, the company will investigate the micromechanical behavior and failure mechanisms of aluminum sheet reinforced with boron filaments and other high-strength fibers. ☆☆☆

Aerospace Review

Lockheed's rigid-rotor design has been chosen by the U.S. Army for its Advanced Aerial Fire Support System, while Boeing-Vertol has proposed an armed version of its CH-47A Chinook. . . . The U.S. and Great Britain are working together on an advanced lift-jet engine, and hydrogen may fuel the powerplants of a hypersonic transport. . . . Three unusual trucks are being developed for the Army, while the Sikorsky CH-54A Skycrane is lifting a variety of heavy cargo in Vietnam. In short, this month's review might be said to feature . . .

Rotors, Motors, and Toters

BY ALLAN R. SCHOLIN
Associate Editor

Technical assessment of the current state of airframe designs proposed for the United States supersonic transport by the Boeing Company and Lockheed Aircraft Company was conducted by the Federal Aviation Agency over a 5-week period just before Christmas.

Both Boeing and Lockheed are working under 18-month contracts that provide for accelerated design effort and testing aimed at aircraft prototype construction. These contracts commenced on July 1, 1965.

The design assessment was conducted by an 82-member joint Government team formed under the FAA Director of Supersonic Transport Development, Brigadier General J. C. Maxwell, USAF. Team members were drawn also from NASA, USAF, and the U.S. Navy. Their studies were carried out in Washington and at FAA Research Centers in Virginia and California.

Emphasis was on operational performance of the proposed configurations in terms of program objectives for a safe, economical aircraft compatible with present airports, airline operating requirements, and engine noise and sonic-boom criteria. Performance characteristics of each design were examined in detail, both analytically and through wind-tunnel tests of submitted contractor models.

U.S. airlines will participate in a review of the performance data generated in the assessment.

Main elements of airframe effort to be accomplished during the present contract phase include:

1. Comprehensive supersonic, transonic, and subsonic wind-tunnel model tests to optimize the performance and economics of configurations.
2. Completion of structural and system design details, final identification of materials and processes, and tests of substantial sections of aircraft structures.
3. Mockup construction in full scale to investigate design problems of critical aircraft elements.
4. Design and development of tooling to establish the capability for preproduction prototype construction.
5. Preparation of comprehensive and detailed technical proposals for the follow-on program to fabricate and test for 100 flight hours 2 preproduction prototype SST aircraft.

The current SST schedule calls for commencement of prototype construction by the end of 1966, entry into the prototype test-flight phase by 1970, and commercial service by 1974.

The Congress has appropriated $140 million to carry forward this contract work during the current Fiscal Year. Previously, $91 million was provided for research and earlier design phases of the program.

Continuing consultation among Government, airlines, manufacturers, airport operators, and other groups concerned has been a primary element both in establishment of requirements in each of these areas and conduct of the program to achieve these requirements.

Engine design proposals will not undergo detailed assessment at this time. Each of the 2 engine contractors, General Electric and the Pratt & Whitney Division of United Aircraft Corporation, will construct and test 3 full-scale prototype SST engines during this 18-month program phase.

* * *

The Minister of Aviation of the United Kingdom, Roy Jenkins, and U.S. Secretary of Defense Robert S. McNamara have signed a Memorandum of Understanding approving a joint project for development of an advanced lift-jet engine. The development work will be performed in close collaboration by Rolls-Royce Ltd., and a U.S. contractor yet to be chosen.

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U. S. and Great Britain have signed an agreement to work on advanced lift-jet propulsion systems. A General Electric lift-jet is employed in this Ryan XV-5A V/STOL aircraft, shown on a recent U. S. Army test hop at Edwards Air Force Base, California.

Engines of this kind are used for takeoff and landing of vertical and short takeoff and landing (V/STOL) aircraft. The development could have wide application to transport as well as tactical military aircraft, should it result in a significant advance in lightweight engine technology. It is expected that a flight engine could be ready for production by 1971.

By collaborating in this project, the U.S. and U.K. hope to achieve substantial savings in development costs, in addition to getting an engine incorporating the best of each contractor's technology. As a further gain, it is hoped that the experience accumulated by the 2 governments, in negotiating this agreement and supervising the project, can simplify the problems of, and encourage further collaboration in Defense research and development.

The U.S. contractor will be selected on a competitive basis. The joint project is scheduled to begin early in 1966.

* * *

A rigid-rotor compound aircraft designed by Lockheed-California Company of Burbank, California, has been selected by the U.S. Army as its future armed escort helicopter. The initial contract calls for 10 prototypes. Lockheed and Sikorsky had been finalists in the competition to develop what the Army calls its Advanced Aerial Fire Support System (AAFSS).

The first helicopter conceived and designed exclusively to provide suppressive fire in escorting troop-carrying helicopters to combat landing zones, it will be capable of cruising at speeds above 200 knots (370 km/hr) —more than 50 percent faster than any other helicopter now operational with the U.S. Army.

Lockheed's rigid rotor, first tested in its experimental XH-51, offers a highly maneuverable as well as extremely stable platform at all speeds and while hovering. It incorporates a thrusting pusher propeller, short stubby wings, and an antitorque rotor, in addition to the main rotor blades. The 2-man rotorcraft will be powered by General Electric's new T64-S4A gas-turbine engine generating 3,400 horsepower.

The Army plans to equip it with a variety of weapons, including machine guns, grenade launchers, rockets, and antitank missiles.

Lockheed's AAFSS is expected to be operational by the end of the decade. The Army is reportedly seeking an interim armed escort chopper with more speed and firepower than its present Bell UH-1Bs. Bell's HueyCobra, a modification of the UH-1B with slimmed-down fuselage and 180-mph (290 km/hr) speed, is a top candidate.

U.S. Army has awarded contract to Lockheed-California Company to build 10 prototypes of Advanced Aerial Fire Support System. Craft will be compound rotorcraft, design first tested by Lockheed in this XH-51A.

* * *

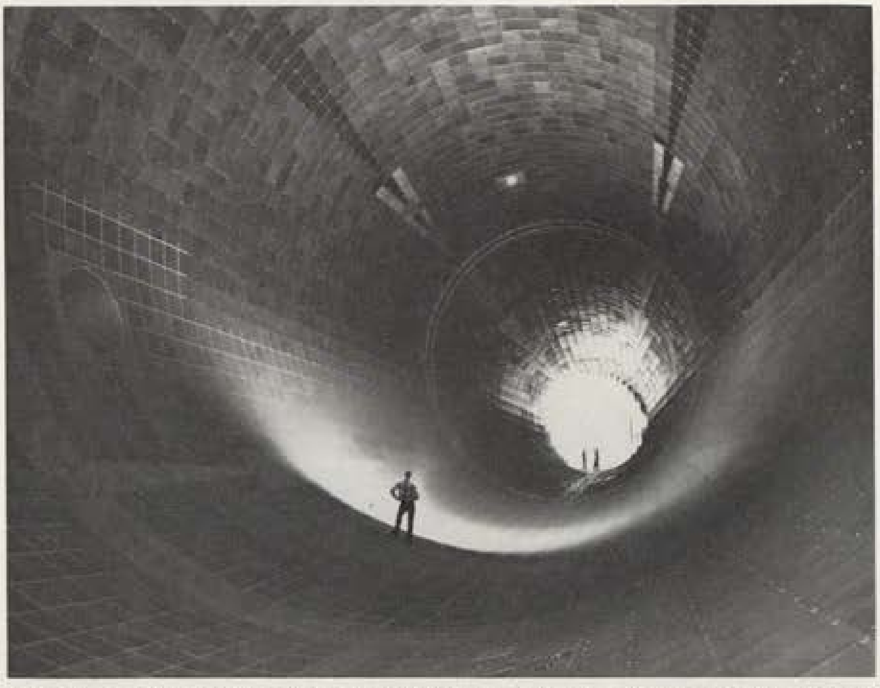
The United States and the Federal Republic of Germany have concluded an agreement to establish an air-defense training facility for the German Air Force to be located at the U.S. Army Air Defense Center, Fort Bliss, Texas.

The German training facility, Air Force Surface-to-Air Missile School, now located at Aachen, Germany, has a permanent staff and faculty of about 280. At Fort Bliss, the school will train about 1,200 German students annually, with the first class scheduled to begin in the spring.

The transfer of the school, proposed by the Federal Republic of Germany, is an extension of the U.S.-German cooperation which already exists in the training of German personnel at various facilities within the U.S. Training of military elements of allied forces of the Atlantic Alliance takes advantage of larger physical space available in the U.S. and thus assists NATO allies in carrying out joint alliance defensive tasks.

All costs of rehabilitation and construction of facilities at Fort Bliss as well as operational costs for the training are being paid for by Germany. Training costs are estimated at $1.7 million annually.

A German staff and faculty will administer their personnel, operate the school, and conduct instruction in accordance with German Air Force regu-



This supersonic wind tunnel can handle 650° F airflow required to simulate flight at velocities up to Mach 4 in its 16-foot (4.8 m) test section. The largest of its type in the world, the tunnel is located at the U.S. Air Force's Arnold Engineering Development Center in middle Tennessee. Above, technician checks the circuit's interior, lined with stainless steel insulated panels to handle the tremendous airflow at very high temperatures.

These Netherlands AF ground controllers guided U. S. Air Force pilots from Camp New Amsterdam in winning F-102 category at USAF worldwide weapons meet. It was first time foreign controllers had directed a USAF team to victory.

lations and regulations governing foreign nationals at U.S. installations.

* * *

A contract to investigate a wide variety of hydrogen-fueled hypersonic airplanes, assess their feasibility, and analyze some of the critical problems connected with hypersonic aircraft has been awarded the Convair Division of General Dynamics.

The 9-month study of the air-breathing aircraft is being made by Convair under a $200,000 contract from the National Aeronautics and Space Administration (NASA).

One of the variety of configurations under consideration for the hypersonic transport (HST) calls for an over-all length of more than 300 feet (90 m), a wing spread of more than 90 feet (27 m), with the tip of the tail towering more than 80 feet (24 m) in the air.

"First-look" studies indicate that any of the various designs under consideration will have a gross weight of more than 550,000 pounds (250,000 kg).

The hypersonic aircraft must also be capable of taking off in approximately 10,000 feet (3,000 m) and landing on an 8,000-foot (2,400 m) runway. Lift-off speed will be approximately 160 knots (300 km/hr) and landing speed about 135 knots (220 km/hr) permitting the use of conventional airfields.

Scientists at the Convair Division say that liquid hydrogen is advantageous as a fuel because of its high-energy content and its ability to absorb heat. They note, however, that advances in the present technology are required before a hydrogen-fueled aircraft can be achieved.

The outside temperatures of the aircraft will reach 2,000° F (1,085° C) during the cruise portion of flight and this will require new structural materials for the wings and body.

As envisioned by General Dynamics designers, the HST probably will not have windows. This may not be much of a drawback, since the plane will require only 2 hours on a trip from Los Angeles to London as compared with 12 hours for currently operating jet aircraft.

* * *

Two precedents were set by the U.S. Air Force's 32d Fighter Interceptor Squadron from Camp New Amsterdam, The Netherlands, as it captured first place in the Convair F-102 Delta Dagger category of USAF's 1965 worldwide fighter-interceptor meet at Tyndall Air Force Base, Florida.

For the first time in the meet's history, a team representing the U.S. Air Forces in Europe won first place in its category. It also marked the first time that foreign aircraft controllers directed a team to victory.

A team of 5 Royal Netherlands Air Force ground control intercept (GCI) personnel directed aircraft of the 32d to their targets in the 8-day event.

Members of the RNAF controller team were Captain Paul C. Bakker, First Lieutenant Johannes J. Damoiseaux, First Lieutenant Joop W. Arnold, Sergeant Wilhelmus A. Spitters, and Sergeant Karel H. Jager.

This was only the second time in the history of the competition that a U.S. Air Force participant utilized foreign controllers. A team of Japanese controllers supported the Pacific Air Force's entry in 1963.

The Netherlands controllers played a major role in helping the 32d FIS win the prized Richard I. Bong Trophy, the highest award at the meet. They were responsible for directing the pilots close enough to their targets to enable the aircraft's own radar to take over and make the final "kill."

* * *

Piper Aircraft Corporation of Lock Haven, Pennsylvania, and Vero Beach,

(Continued on following page)

Reaching skyward to a height of 60 feet (18.3 m), this Lift-A-Loft elevated work platform is being used primarily for vertical assembly on the Saturn booster. Built by Lift-A-Loft Corporation of Muncie, Indiana, the self-propelled work platform can handle 500 pounds (227 kg) and provides a 20-foot (6 m) reach at the top.

Florida, which has built more airplanes than any other company in the world, has received President Johnson's "E" award for outstanding contributions to U.S. export trade.**

The award was presented by U.S. Secretary of Commerce John T. Connor to William T. Piper, 84-year-old founder and current chairman of the board and president of the company.

Piper Aircraft Corporation entered the export market in a modest way in 1934 with the sale of 4 Cubs to Brazil. Since then it has sold nearly 9,000 aircraft overseas.

In the year ending September 30, Piper showed sales of 906 aircraft in 91 countries. This year it expects to sell 1,100 aircraft, and its 1970 goal is 1,750 aircraft costing $32,500,000. Export sales currently represent 20 to 25 percent of Piper's total production.

The company is currently producing and exporting 12 models, ranging from the Pawnee agricultural aircraft to the 6-place executive twin-engine Aztec. Early in 1966 it will put into production a heavier 6- to 8-place turbocharged twin-engine aircraft, the Navajo, with a top speed of 260 mph (418 km/hr) and a ceiling of more than 30,000 feet (9,100 m).

While Piper production is primarily for commercial use, its off-the-shelf models are being used by many governments for military training, general liaison, supply missions, and patrol work.

* * *

Belgium, The Netherlands, and West Germany have jointly contracted with the Hughes Aircraft Company for establishment of a new air-defense system programming and training center.

Announcement of the $2.5 million contract award by the 3 nations was made by Clarence A. Shoop, Hughes vice president and group executive of Hughes International.

The new center, to be located in Belgium, will be used in conjunction with the proposed NADGE (NATO Air Defense Ground Environment) air-defense system to be operated by NATO in Europe.

Shoop said that the center will train operators, maintenance personnel, and programmers in the use of computers, data-display equipment, data-processing units, and communications equipment. It will contain a high-speed general-purpose computer, nucleus of the 3 countries' modular air-defense system, and a variety of electronic data-display units.

In addition to providing training facilities, the center will enable each country to test new techniques in its air-defense system's computer programming, without interrupting operation of its command centers.

Many roles can be played by this new U.S. Army armored vehicle, the Commando. Being produced under a multimillion-dollar contract by Cadillac-Gage Company of Warren, Michigan, the car is especially suited for limited warfare and has unique capabilities for guerrilla operations. It also can be a versatile civil-defense vehicle, an airport crash truck, or an amphibious off-the-road fire engine. Commando travels through water as well as on land, can negotiate a 60 percent grade and knock down obstructions, and carries its own winch.

Equipment for the center will be manufactured by Hughes Aircraft Company at Fullerton, California.

* * *

A new armored military vehicle being produced for the U.S. Army under a multimillion-dollar contract has many talents in addition to those required in a combat role.

Called the Commando by its developer, the Cadillac-Gage Company of Warren, Michigan, it can also be a versatile civil-defense vehicle, an airport crash truck, or an amphibious off-the-road fire engine.

Representing the first significant procurement by the Army of wheeled armored fighting vehicles since World War II, the Commando has unique capabilities for guerrilla operations.

It can carry 11 fully equipped personnel and is equipped with a turret that can mount weapons ranging from twin .30-caliber or .50-caliber machine guns to a 90-mm cannon firing a shaped charge that can penetrate any tank now in existence.

Powered by a 210-horsepower V-8 engine, the Commando will attain speeds up to 65 mph (105 km/hr) on land and can travel through water. It is capable of negotiating a 60-percent grade, knocking down obstructions in its path, and carries winch equipment to extricate itself from difficult spots.

Two other recent developments in

wheeled vehicles for U.S. Army use are a pneumatic all-terrain amphibian (PATA) designed by the Firestone Tire and Rubber Company and a 5-ton (4.5 mt) cargo truck being built by the Ford Motor Company.

Firestone's PATA is a cargo-carrying vehicle that is supported and propelled by rotating cushions of air, making it capable of traveling over normal roadways, swamps and marshlands, tundras, and even water. It is essentially a rubber-tracked vehicle with cargo-carrying hold supported by rotating cushions of air. Attached to each of its 2 oval treads are air cells inflated to a pressure of only 1.5 pounds per square inch (.105 kg per cm²). On hard terrain, the cleated cells bear directly on the surface; on water or semiliquid surfaces the cells float.

PATA can carry 10 fully equipped combat troops or 1.25 tons (1.13 mt) of cargo.

The 5-ton truck being produced by Ford under a $3.4 million contract is designated the XM656. Most notable features, compared with the Army's present 5-ton trucks, are improved mobility, ease of ride, increased range, ability to swim, and greater reliability and durability. It is designed to operate 20,000 miles (32,000 km) without replacement of major assemblies.

Powerplant is a 210-hp 6-cylinder Continental engine which will burn diesel oil or gasoline. Highway cruising range is about 400 miles (640 km) at a top speed of 50 mph (80 km/hr). The engine is linked to a 6-speed automatic transmission with hydraulic torque converter and planetary gear system. Hydraulic power is also employed to steer all 4 front wheels. Tires are 10 ply, low pressure, and wide-based to offer excellent riding and antishock characteristics.

The PATA (pneumatic all-terrain amphibian), wheeled vehicle developed for the U.S. Army by Firestone Tire and Rubber Company, makes use of rotating cushions of air for support and propulsion. It is a rubber-tracked vehicle with 1.25 tons (1.13 mt) capacity. Attached to its 2 oval treads are air cells enabling it to travel over land or water.

* * *

Whittaker Corporation of Los Angeles, California, has completed a licensing agreement involving air-traffic control radar systems with Telefunken of West Germany.

Another new Army vehicle is this 5-ton (4.5 mt) truck, the XM656, which can climb hillsides, swim streams, or be airborne to remote battle areas. It is lighter by 2 tons (1.8 mt), more durable, and requires much less maintenance than the present Army 5-ton cargo truck. Designed and built by Ford Motor Company, it can operate 20,000 miles (32,000 km) without replacement of major parts. Top speed is 50 mph (80 km/hr).

The agreement enables Telefunken to manufacture Whittaker-designed Secondary Surveillance Radar systems (SSR) at its Electronics Engineering Division in Ulm, West Germany. It also provides for the German firm to market the SSR equipment in several European countries including Austria, Belgium, Czechoslovakia, Denmark, Finland, Federal Republic of Germany, Hungary, Luxembourg, Romania, Poland, and the International Eurocontrol Organization at Brussels.

Vital elements in air-traffic control functions, the systems are used in conjunction with primary radar to identify and locate aircraft operating within 200 miles (320 km) of ground stations. The system is said to be the most advanced real-time automatic data link between aircraft and controllers to be available for the next several years.

All of the secondary surveillance radar equipments now in use by the Federal Aviation Agency are manufactured by Whittaker. They number more than 150 ground-station systems. Similar equipment is also in use by the governments of Holland and Switzerland.

Telefunken, a major German producer of radar equipment since the 1930s, developed advanced antenna systems featuring side-lobe suppression for use with the SSR systems.

* * *

U.S. engineers at the National Radio Astronomy Observatory at Green Bank, West Virginia, are pivoting 2,600

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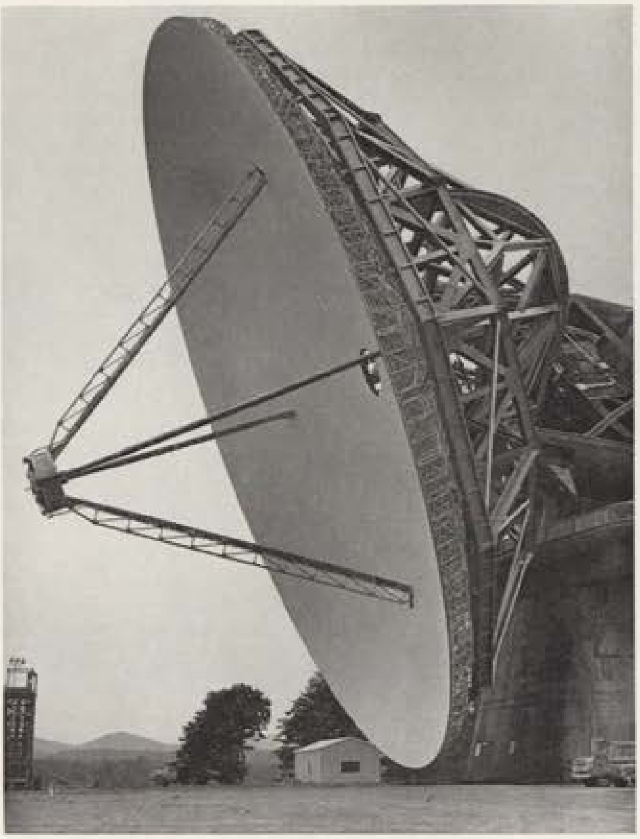


Huge radio telescope at U. S. National Radio Astronomy Observatory, Green Bank, West Virginia, measures 140 feet (42.7 m) in diameter and weighs 2,600 tons (2,360 mt). Shaft and bearing, which rotate the dish, float on film of oil just 0.005 inch (.127 mm) thick. Brakes exerting more than 1,260,000 pounds (570,000 kg) of pressure assure aiming accuracy and will lock the telescope safely in winds up to 140 mph (225 km/hr).

tons (2,360 mt) of metal on a film of oil as thin as a hair's breadth.

The tons of steel and aluminum make up the 140-foot (42.67 m) dish and supporting components of a new $13 million radio telescope being used by Associated Universities, Inc., of New York, which operates the observatory for the National Science Foundation, an independent agency of the Federal Government.

Shouldering the weight of the radio telescope's massive yoke and aluminum dish are a 210-ton (190 mt) shaft and 167-ton (151.5 mt) mirror-finished bearing manufactured at the East Pittsburgh, Pennsylvania, plant of Westinghouse Electric Corporation. Both components literally float on a film of oil just 0.005 of an inch (.127 mm) thick. The oil enables the shaft and bearing—and thus the telescope dish—to slip delicately into position without "stiction," an engineering term for stick friction.

To achieve the close tolerance demanded of the spherical bearing casting, Westinghouse machinists meticulously machined, ground, and polished the mammoth chunk of steel for 5 months. When the machinists were finished, the surface—17.5 feet (5.33 m) in diameter—approached plate glass in smoothness and came within 0.003 of an inch (.076 mm) of being a perfect sphere.

Specially developed industrial brakes, believed to be the largest of their kind in the world, play a key role in the extreme accuracy of the observatory's new radio telescope.

The huge brakes were custom-designed by Goodyear's Aviation Products Division to keep the movable portion of the telescope pointed in any desired direction with precise accuracy. They grip the 2 ring gears that rotate the 140-foot (42.67 m) antenna with such force that directional variation is less than .003 of a degree.

The 6 brakes together exert more than 1,260,000 pounds (570,000 kg) of braking force, according to Goodyear engineers. This is enough, they say, not only to assure the aiming accuracy of the telescope in winds of up to 16 mph (25.6 km/hr) but sufficient to lock the telescope in a safe stow position in winds of up to 140 mph (225 km/hr).

The radio telescope is designed to be one of the most stable and precise in the world, permitting highly accurate determination of the position of radio sources out in space; tracking with very great accuracy over long periods of time; use at very short wave lengths when weather permits; and stability and accuracy throughout a long life.

* * *

REVIMA, the Société pour la Revision et l'Entretien du Matériel Aéronautique in France, has been named the first European distributor for United Aircraft of Canada's PT6 engines.

The agreement, signed by Dominique Boyer, president of REVIMA, and George Estes, vice president of United Aircraft International, a subsidiary of United Aircraft Corporation, East Hartford, Connecticut, provides that REVIMA shall undertake the distribution of PT6 gas-turbine spare engines and spare parts with inventories located in France.

REVIMA will also establish and maintain a facility for the overhaul and repair of these engines at its existing plant at Caudebec-en-Caux, Seine Maritime, France. Through these arrangements, operators of PT6 engines throughout Europe will be able to obtain quick delivery of spare parts and prompt attention to their overhaul and repair requirements.

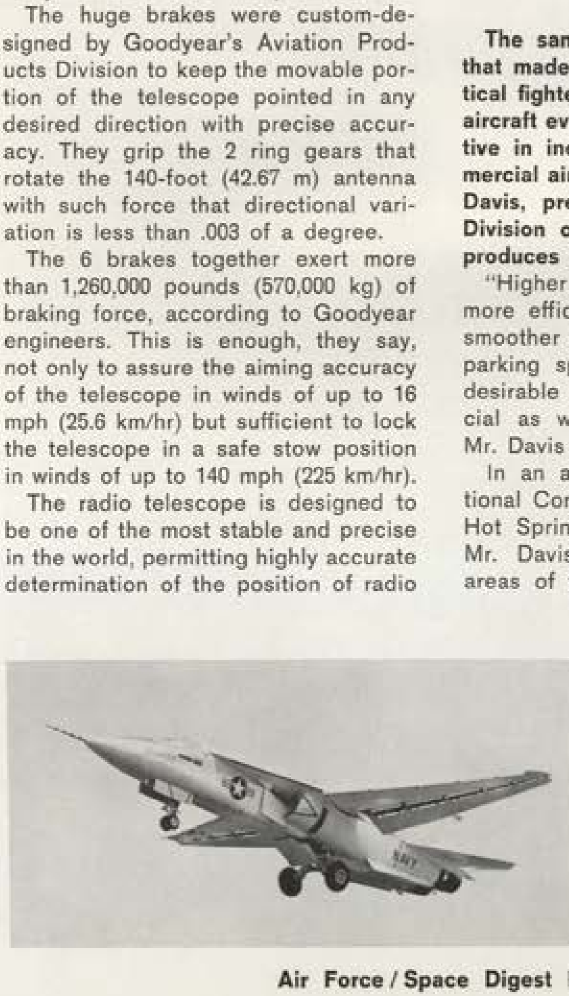
The service department of Pratt & Whitney Aircraft will provide technical assistance to REVIMA, including specialized PT6 training in its service school.

* * *

The same new flight advancements that made the sweep-wing F-111 tactical fighter the most versatile military aircraft ever built will be equally effective in increasing the utility of commercial aircraft, according to Frank W. Davis, president of the Fort Worth Division of General Dynamics, which produces the USAF/Navy F-111.

"Higher speed, quicker climb-out, more efficient loiter, slower landings, smoother ride in rough air, and smaller parking space are all important and desirable characteristics in commercial as well as in military aircraft," Mr. Davis said.

In an address at the first International Congress on Air Technology in Hot Springs, Arkansas, in November, Mr. Davis commented briefly on 2 areas of the F-111 development pro-



Weight and powerplant problems in U. S. Navy's F-111B variable-sweep-wing fighter are being overcome, according to Frank W. Davis, President of General Dynamics' Fort Worth division.

gram which have attracted attention —weight and engine compressor stalls —pointing out that problems of this kind are not at all unusual in a development program.

"Although the development program has indicated the necessity of some weight increases," said Mr. Davis, "approximately 5,210 pounds (2,363 kg) of excess weight (in the Navy production design) have been avoided by a vigorous weight-control program. The forecast weight has remained essentially unchanged since January 1964.

"In addition, an aerodynamic improvement program was started to increase the maximum lift that the wing could provide. Its results have been spectacularly successful. Flight-test results now indicate that sufficient improvement has been achieved in lift to offset the adverse effects on carrier takeoffs and landings occasioned by all the weight increases—initiated by both contractor and Government—since the General Dynamics proposal was first submitted in 1962."

He pointed out that engine stall is a difficult problem to diagnose, but that "modest changes" in the airframe duct system and in the powerplant itself have apparently corrected the problem.

"As a matter of fact," said Mr. Davis, "I am extremely pleased to have found so few problems of significant magnitude. It has already been possible to fly the airplane at Mach 2 and above 50,000 feet [15,200 m] without yet having incorporated the changes we now know to be desirable."

* * *

Air navigation aids costing an estimated $2.4 million will be purchased by the Federal Aviation Agency for the Brazilian Government.

FAA also will assist the Brazilian Government in installing the facilities at 5 airports with technical guidance provided by FAA's Civil Aviation Assistance Group office in Rio de Janeiro.

Funds for the project were provided by a $2.7 million U.S. Alliance for Progress loan. Delivery of the equipment to Brazil is expected to begin by June 1966.

The equipment, all designed to improve air safety and expedite traffic control, consists of 4 high-intensity airport approach light systems with sequenced flashing lights (ALS/SFL), 2 airport surveillance radars (ASR), and 3 instrument landing systems (ILS).

The ILS, to be installed at airports in Belem, Recife, and Campinas, will be among the first operational low-cost systems developed by the FAA. The ILS provides horizontal and vertical guidance along a prescribed descent angle to the runway, and 2 checkpoints that mark the distance from the end of the runway.

The 4 ALS/SFLs to be installed at airports in Brasilia, Belem, Recife, and Campinas will be essentially the same as the high-intensity approach lights used at major U.S. airports. These lighting systems, used in conjunction with the ILS, are one of the essential links in providing safe approaches for landing under adverse weather conditions. They assist the pilot in making the transition from instrument to visual approach for touchdown.

The 2 Airport Surveillance Radars to be established at Brasilia and Porto Alegre will be essentially the same as current radars being procured for installation at U.S. airports. The system provides airport traffic controllers with the radar display showing aircraft flying within a 60-mile (95 km) radius at altitudes up to approximately 30,000 feet (9,150 m).

* * *

A malfunction monitor, which can check on the condition and performance of thousands of individual components in an airplane and report its findings within minutes or even seconds, has been developed by the Lockheed-Marietta Company, Marietta, Georgia.

It can be used before takeoff to check on the engines, landing gear, hydraulic system, auxiliary power units, and flight control, electrical, and fuel systems. It can make similar checkups during flight. The information is displayed instantaneously on a screen on the flight engineer's console in the cabin.

With the help of a built-in computer, the system senses, locates, and identi-

(Continued on following page)

First live test of a zero-altitude, zero-airspeed ejection seat was successfully made recently by U. S. Air Force Reservist Major James C. Hall at Edwards Air Force Base, California. The seat was developed by Weber Aircraft Company of Burbank, California, to recover a pilot whose aircraft is disabled on the ground. The pilot is ejected and boosted to 400 feet (122 m), where device separates him from seat and and opens chute.

fies malfunctions, recommends what units need replacing, what tools are required, and how replacements should be made. On the basis of these instructions, the flight crew can make in-flight repairs or radio ahead to the next ground station for specific parts and tools.

In addition to this visual information, the system makes a permanent tape record of the same information for use by the maintenance crew after landing. The system also gives warning of gradually declining performances of components so that preventive maintenance can be performed.

Most of these examinations of the plane are done automatically and continuously at a rate of 30 times each second. The malfunction monitor was developed by Lockheed after 10 years of research. The firm's scientists say similar monitors can be designed for ships and for manufacturing plants to keep tab on the condition of complex machinery.

* * *

After tests with numerous chemicals, a mixture of 75 percent tripotassium phosphate and 25 percent formamide has been selected for removing snow, ice, and slush from U.S. airport runways in temperatures down to minus 10 degrees F (minus 23° C).

The mixture, which can be manufactured at reasonable cost, causes less corrosion and less damage to runway surfaces than salt and sand mixtures currently in use. In pellet form, the mixture is spread at the same rate and with the same equipment as sand and salt.

Tests were conducted by the Monsanto Research Corporation, Dayton, Ohio. Additional tests for storability and effect on grass and rubber will be conducted at the U.S. Federal Aviation Agency's National Aviation Facilities Experimental Center, Atlantic City, New Jersey.

The 8 largest U.S. airports spend an estimated $1 million each year for removal of snow, ice, and slush from runways, taxiways, and ramps.

* * *

Retrieval of downed aircraft, airlift of bulldozers to mountaintops, and carrying a detachable personnel pod for use as a command headquarters are among the initial functions performed by U.S. Army Skycrane helicopters in Vietnam.

The Sikorsky CH-54As, 4 in number, are flown by the 478th Transportation Company (Heavy Lift) in support of the Army's First Cavalry (Airmobile) Division. Thus far, the big Skycranes have retrieved more than 2 dozen aircraft of various types. A highlight was the recovery of a twin-engine Boeing-Vertol CH-47 Chinook helicopter that had suffered landing damage. The Chinook, with its engines and rotor blades removed, weighed 14,000 pounds (6,350 kg). It was carried on a 4-point nylon sling, with a drag chute attached to stabilize the load.

In one day's lift, 2 Marine Corps CH-34 helicopters were recovered and returned to their base about 30 miles (48 km) away. One was lowered gently and accurately onto sandbags, as part of its landing gear had been broken off.

Among the loads carried were 600 cases of C-rations weighing 15,000 pounds (6,800 kg) in one sling load; 4 fuel bags in one sling; a signal van weighing 17,000 pounds (7,700 kg); a 17,000-pound (7,700 kg) bulldozer to the tops of several mountains; 12,000 pounds (5,440 kg) of wire lowered into an area accessible to no other vehicle but the Skycrane; and 3 Army "conex" general-purpose containers weighing a total of 17,000 pounds (7,700 kg).

Use of the hydraulic hoist predominated, but the cargo and personnel vans (or pods) received some use. One commander used a pod in the field as a command post in a highly successful operation against the Viet Cong. Another pod was transformed into a mobile hospital operating room.

During their first few weeks in Vietnam the CH-54As logged about 100 flight hours, flew more than 2,000 miles (3,200 km), carried about 850 passengers, and airlifted more than 360 tons (325 mt) of cargo.

Demonstrating its recovery ability, Sikorsky CH-54A Skycrane rescues twin-engine Boeing-Vertol CH-47 Chinook helicopter that had suffered landing damage in Vietnam. Chinook airframe, weighing 14,000 pounds (6,350 kg), was carried on 4-point nylon sling, with drag chute stabilizing the load. Four Skycranes are flown by 478th Transportation Company with U.S. Army's First Cavalry (Airmobile) Division in Vietnam.

* * *

Four J85-13A turbojet engines for the Italian Air Ministry's G.91Y close-support aircraft prototypes have been shipped by the General Electric Company to the Fiat Company in Turin, Italy.

Two additional engines will be shipped in 1966 for the G.91Y to complete the initial Fiat order to G.E. The G.91 single-engine fighter of modified design will be refitted with twin J85-13A engines to almost double its takeoff thrust, improve its rate of climb, increase its takeoff payload of bombs and rockets, and improve its short takeoff capability.

The Italian Air Force will soon begin flight tests of the G.91Y which could result in volume production of the aircraft.

In volume production for the Northrop supersonic F-5 Freedom Fighter, the J85-13 produces 4,080 pounds (1,850 kg) of thrust, yet weighs only 587 pounds (266 kg) for a thrust-to-weight ratio of nearly 7:1, the highest ratio of any afterburning engine in production in the Free World. The J85-13A for the Fiat aircraft differs from the J85-13 only in minor external details.

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A licensing agreement between Cessna Aircraft Company and Argentina's DINFIA aircraft manufacturing firm has been approved by the Government of Argentina.

The agreement is with Direccion Na-

cional de Fabricaciones e Investigaciones Aeronauticas (DINFIA), the government-owned aviation investigation and production agency.

Under terms of the 5-year agreement, DINFIA will build Cessna Model 182 aircraft which will be repurchased by Cessna for sale through its regular distributor-dealer sales channels in Latin America. The aircraft will be assembled at DINFIA's plant in Cordoba, a large industrial city 400 miles (640 km) northwest of Buenos Aires.

The Cordoba plant employs 8,000 people. It is presently building panel trucks, motorcycles, an agricultural airplane, and a twin-engine turboprop executive aircraft, the IA 50 Guarani II.

Approximately 500 aircraft are involved in the 3-phase agreement. First phase calls for assembly by DINFIA of 80 aircraft from major assemblies to be provided by Cessna in Wichita, Kansas.

Second phase involves assembly of 100 aircraft from detailed parts from Cessna, while the third phase involves an estimated 320 aircraft for which DINFIA will manufacture and acquire in Argentina as many parts of the aircraft as possible.

DINFIA will send representatives to Cessna in the near future for training and study in production and tooling techniques, while Cessna will send representatives to DINFIA to supervise inspection and quality control during production.

* * *

The feasibility of transporting copper by air from the mines of landlocked Zambia to East African ports was to be demonstrated by a Lockheed Hercules commercial airfreighter during a 25,000-mile (40,000 km) tour of eight African nations in December.

Other countries in which the new propjet air cargo transport was to be shown were Angola, Tanzania, Ethiopia, Sudan, Libya, and Nigeria.

In the Zambia test, financed jointly by 2 Zambian copper companies and Lockheed, the Hercules was to carry 25 tons (22.7 mt) of copper from N'Dola in the Zambian copper belt to the coast of East Africa and return with a similar payload of typical heavy commercial cargo.

For some time, the Zambian copper producers, the Roan Selection Trust Group and the Anglo-American Corporation, have been studying alternatives to the existing routes out of Zambia to world markets. At present, the copper is transported by rail 1,500 miles (2,400 km) to the ports of Beira and Lourenço Marques in Mozambique.

Lockheed has indicated that a total of 20,000 tons (18,140 mt) can be carried per year in each direction by a single Hercules aircraft.

C-130E Hercules, in markings of Royal Saudi Air Force, is test-flown near Lockheed's Marietta, Georgia, plant. Four Hercules transports have been ordered by Saudi Arabia, and will be flown home by Saudi and Lockheed crews. Meanwhile, another C-130E was engaged in a series of demonstrations in Africa in December, including flying copper ore mined in land-locked Zambia to Mozambique channel ports on the east coast of Africa.

The Hercules is already proven as a rugged and dependable cargo aircraft by nearly 1,000 planes throughout the world now transporting military supplies. Its notable features include the ability to accommodate outsize cargo in a 10-foot-wide, 9-foot-high, and 40-foot-long (3 x 2.75 x 12.2 m) cargo hold. Straight-in, truckbed-height loading eliminates specialized loading equipment and provides ease and speed of on-load and off-load handling. Short takeoff and landing capabilities make it especially suitable for remote or limited facility areas.

* * *

An armed version of the U.S. Army CH-47A Chinook helicopter was recently demonstrated for U.S. Department of Defense officials at the Boeing Company's Vertol Division at Philadelphia International Airport, Pennsylvania.

The aircraft carries an M5 automatic grenade launcher mounted on the nose; pylons on both sides of the aircraft, equipped with a 20-mm gun and either a 19-round 2.75-inch (70 mm) rocket pod, or a 7.62 mm high-rate-of-fire machine gun; and 5 7.62 mm or 50-caliber machine guns mounted on the sides and rear.

The first official flight of the armed Chinook included a demonstration of various maneuvers during which weapon use was simulated.

Boeing's Vertol Division is currently assembling a quantity of armed Chinooks to be evaluated by the U.S. Army at Aberdeen Proving Grounds.

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Displaying a variety of weapons, the first armed version of U.S. Army CH-47A Chinook helicopter was demonstrated for U.S. Department of Defense officials recently at Philadelphia International Airport, Pennsylvania. The Boeing Company's Vertol Division is currently assembling a number of Chinooks armed with M5 automatic grenade launchers, pylons equipped with 20-mm gun and rocket pod, and machine guns on side and rear.

Transport versions of the Chinook helicopter are currently in operation in Vietnam with the First Cavalry Division (Airmobile) to transport troops, supplies, fuel, ammunition, and to retrieve downed aircraft and carry refugees. Its gross weight is 33,000 pounds (15,000 kg).

* * *

U.S. scientists are experimenting with a liquid that will disclose material defects when applied to a surface and heated. The solution is known as a liquid crystal because it displays many of the properties of solid optical crystals. The Boeing Company developed the liquid-crystal mixture from derivatives of cholesterol, a fatty substance banned from the diets of people with heart trouble.

The mixture is painted on a metal part to be tested, the surface warmed and then air-cooled to 86 degrees F (30° C). The metal surface immediately begins to blossom into color. If the part is well bonded and free of faults, the color is uniform. Trouble spots show up by turning a different color than the rest of the surface as the temperature is lowered gradually.

Boeing explains the phenomenon as the reflecting of light from the surface of a part in a series of planes. These planes change their spacing instantaneously as the temperature of the part rises and falls in fractional degrees. Such temperature-triggered reflections are viewed as hues of color, from red at 84 degrees (28.9° C) to purple at 86 degrees (30° C). Perfect parts cool consistently, changing from purple to green to red. But flaws cool either faster or slower than any other areas, and show up as contrasting color spots.

By reversing the technique, poor thermal insulation can be detected. The coating used on rivets in aluminum wing skins to prevent corrosion can be checked with the new technique. A properly insulated rivet, when painted with the liquid crystal, will reach a uniform blue color, but an improperly coated rivet in contact with the wing skin will take much longer to turn blue.

* * *

Successful tests of a nuclear rocket engine turbopump exposed to extremely high temperatures have been conducted at a newly activated test facility of Aerojet-General Corporation at Sacramento, California. Reactor operating temperatures were simulated by heating hydrogen before it reached the turbopump.

The Nerva (Nuclear Rocket for Vehicle Application) engine uses liquid hydrogen (–423 degrees F., –253 degrees C.) which is heated to thousands of degrees in a nuclear reactor, expanded, and exhausted as gas through a nozzle to provide rocket propulsion.

The Nerva engine system, which can make possible manned missions to Mars and the planets beyond, is being developed under the direction of the Space Nuclear Propulsion Office (SNPO) by Aerojet-General in Sacramento. Westinghouse Astronuclear Laboratory is the principal subcontractor with reactor development responsibility.

The Nerva turbopump, while only the size of the average automobile engine, was tested up to 6,500 shaft horsepower. Pressure developed by this pump was so great that it could have sent a column of water 6 miles (9.7 km) skyward.

Critical components of the turbopump also have been tested in a radiation environment. All nuclear power testing of Nerva components are conducted at SNPO's nuclear rocket development station in Nevada. Later this year, the full Nerva engine system will be tested there.

* * *

The Royal Australian Navy has awarded a $100,000 contract for ground-control approach radar equipment and associated electronics to ITT Gilfillan, Inc., Los Angeles, California, a subsidiary of International Telephone & Telegraph Corporation.

Known as Quadradar, the system is a complete 4-in-1 terminal area air-traffic-control system providing surveillance, final approach, height finding, and air-traffic taxi information. The system may be operated by one man who may easily select any one of these 4 functions.

Lightweight Quadradars, weighing approximately 4,600 pounds (2,087 kg), have been purchased by 11 European countries and are used by all branches of the U.S. military services.

* * *

Members of Greek Air Force, led by Lieutenant General George N. Antonakas, third from right, are shown on visit to Arnold Engineering Development Center, Tullahoma, Tennessee, during recent tour of USAF installations. At left is Major Dimitrious Danopoulos; third and fourth from left are Colonel Athanasios Deligeorgis and Brigadier General Anastasios Marmaras. At right, Brig. Gen. Lee V. Gossick, AEDC Commander.

The French Government, through the Materiel French Military Mission in Washington, D. C., has awarded a contract to Airborne Instruments Laboratory (AIL), a division of Cutler-Hammer, Inc., for the lease of the AIL FlareScan all-weather landing system.

The system will be used under actual operating conditions at Aeropostale, the night-flying French airmail service. The system consists of a FlareScan ground station that will be installed at Orly Airport, Paris, and receiver/computers to be installed in 4 DC-4 aircraft that fly mail in and out of Paris every night.

FlareScan ground station antenna scans a broad, flat radio beam up and down into the airport approach zone; as it scans, it codes the beam (by changing the spacings between successive pulses) to indicate the angle the beam is making with the ground at each instant of the scan. Operating in conjunction with the standard ILS glide slope beam, FlareScan gives the pilot of a properly equipped approaching aircraft the angular guidance needed to perform the flareout maneuver that brings the aircraft through the final 200 to 300 feet (60 to 90 m) of descent to the runway.

Aeropostale, a source of French national pride for many years, has consistently made good the claim that any airmail letter posted in a major French city will be delivered the following day to its destination in any other major French city. Aeropostale's intrepid night-flying crews are internationally famous for their exploits in delivering the mail on schedule—even through weather that forces all other air flights to remain grounded. FlareScan equipment will enable the French mail pilots to safely extend their flying to conditions of near-zero visibility. ☆☆☆

*Based on the ability of the Phantom II to range over the globe in the conduct of air superiority operations, without air refueling, from existing suitable friendly land bases or carrier decks.