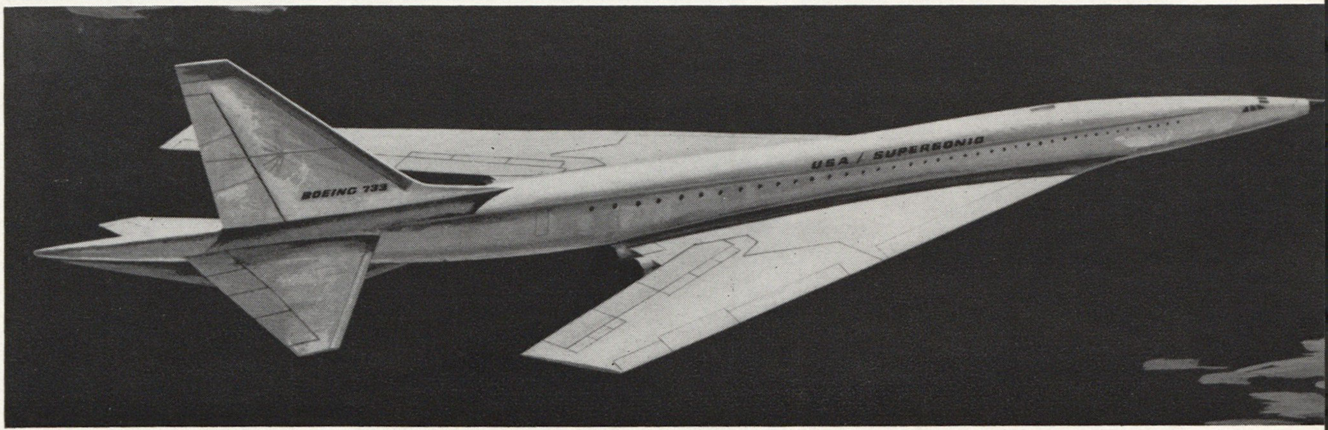
JULY 1966

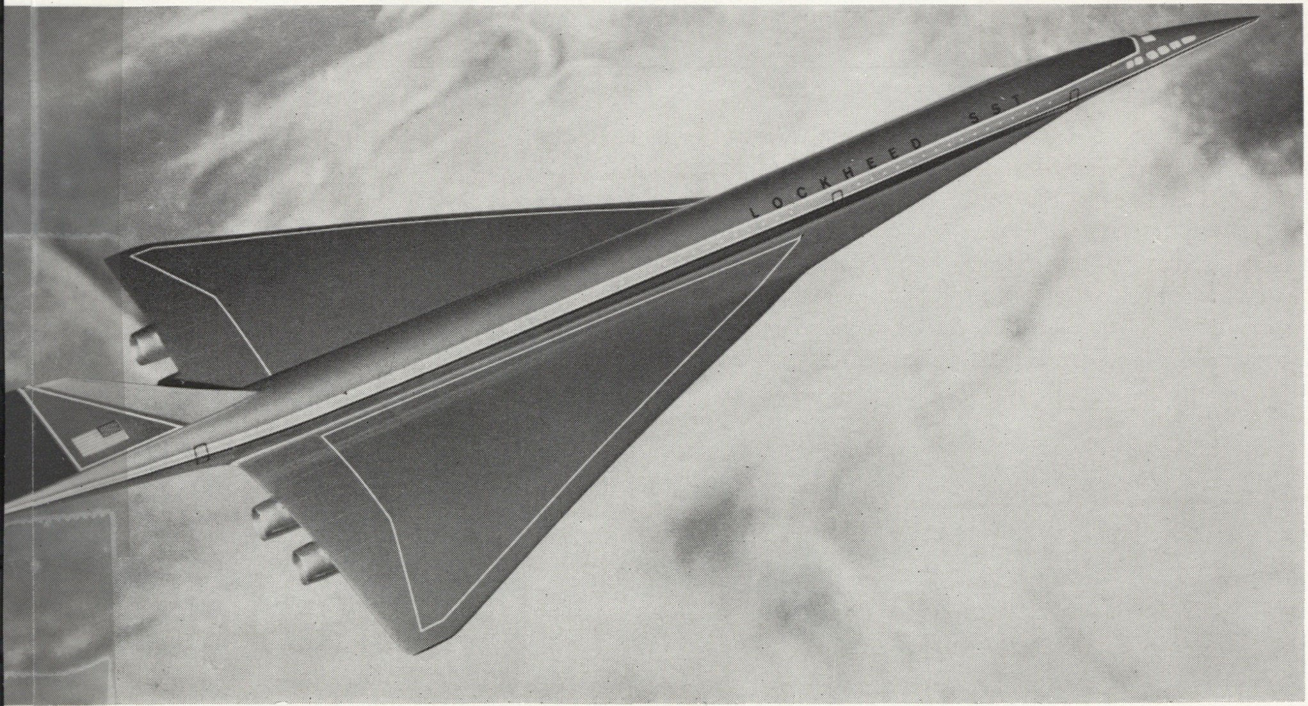
Air Force/Space Digest International

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

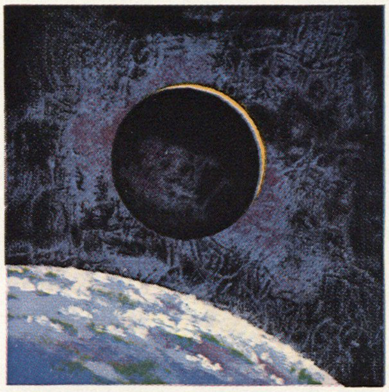
Boeing's Variable-Sweep 733

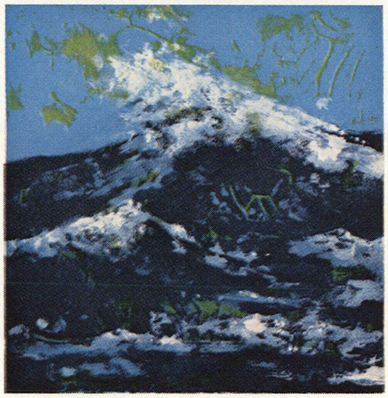


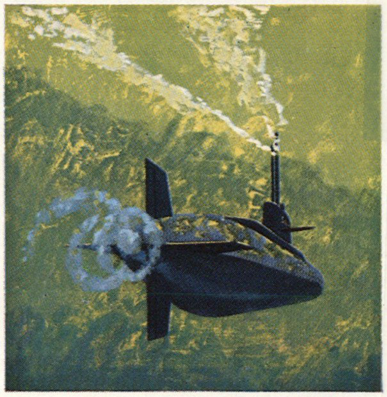
SST Which Design Will Be Chosen for the U.S. Supersonic Transport?



Lockheed's Double-Delta L-2000







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Air Force/Space Digest

International

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

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MEMORANDUM

TO: Readers of AF/SD INTERNATIONAL

FROM: John F. Loosbrock, Editor

The broad sweep of aerospace technology is well illustrated in this issue of AF/SD INTERNATIONAL. The article on the U.S. supersonic transport effort (see page 6) deals with commercial air transport. This is advanced technology applied to the rapid and efficient movement of people and goods between the continents of the world. The article on communications satellites (see page 28) likewise treats of highly advanced technology applied to the transmission of ideas and information. There is reason to hope that eventually the peoples of the world will become so interdependent, one upon another, that technology can be devoted exclusively to peaceful commercial and cultural interchange.

This time has not yet come. One needs only to read newspapers and listen to the wireless to know that armed conflict still scars the world. We find aerospace technology applied also to the solving of other kinds of problems, problems that are of interest and concern to all who have responsibilities in the area of military matters. And so we publish herewith (see page 22) an article on the new techniques of control of tactical airpower as exemplified in Vietnam.

We make no attempt, it must be noted, to judge the diplomatic and political issues involved in Vietnam. But an air war is being fought there, and there is legitimate professional interest in how it is being fought, the problems encountered, and how technology is being applied to solve them.

It is hard to say which of the 3 subjects here discussed is most important to the future shape of the world. Perhaps it is foolish to try to make a choice. Each has its impact, each in its own way.

In the case of the supersonic transport, for example, the impact will be primarily economic. By this is not meant the immediate and short-term benefits that will accrue to the nations and the industries involved. Here there is competition, to be sure. But all of the various supersonic transport programs now under way—the U.S. version, the builder of which is still undecided as between Boeing and Lockheed, the French/British Concorde, and the Russian TU-144—all 3 of these will see service on the world's airlines. The economic effects, however, will be felt by all of us, not only the future passengers, but literally all of us. One has only to look for proof at how the jet transport revolutionized the economic of today's transportation systems. The effect has gone far beyond the predictions of the most optimistic prophets of only a few years ago.

Likewise, the coming revolution in communications, in which the new communications satellites will play such an important role, will touch and shape the lives of millions of people. There is a classic case in U.S. history which is pertinent. The Battle of New Orleans in 1815, which made a national hero and future President of Andrew Jackson, was fought after a treaty of peace with Great Britain had been signed. But the slowness of communications had not brought the word to the troops involved. It is not too unbelievable to foresee future situations where wars will be averted precisely because speed-of-light communications have become available to governments. The free flow of ideas and information may do more than anything else to remove ultimately the frictions and misunderstandings from which conflicts often arise.

Nor, in this context, can one ignore the lessons that are being learned in Vietnam. Is it not even possible that out of that struggle may come better ways of settling future international problems of the kind that hitherto have been traditionally settled by force? Military technology can be put to work not merely to win such wars but to either avoid them altogether or settle them with a minimum of bloodshed.

AF/SD INTERNATIONAL believes that advanced technology is the key to human progress. We believe that technology can solve many more problems than it is currently being called upon to solve. We believe that technology can be the great equalizer among nations, becoming a resource that is more important than land, or minerals, or large populations. We further believe that aerospace technology, because of the strenuous and very exacting demands it places upon scientists and engineers, is the seedbed for future progress. New materials, new fuels, new propulsion systems, new communications, new manufacturing techniques, new management systems—all products of aerospace technology—are being applied with profit in areas far removed from the fields of aeronautics and spaceflight.

This is why, in these pages, we concentrate on aerospace technology. It is not just because we know it best. It is because we believe in it as the well from which most advanced technology ultimately flows.

We have noted before, but it bears repeating, that technology flies no flag. It knows no international boundaries. It works for all, and all can contribute to its advancement. Our aim is to contribute to greater international understanding of this basic and fundamental premise. ☆☆☆


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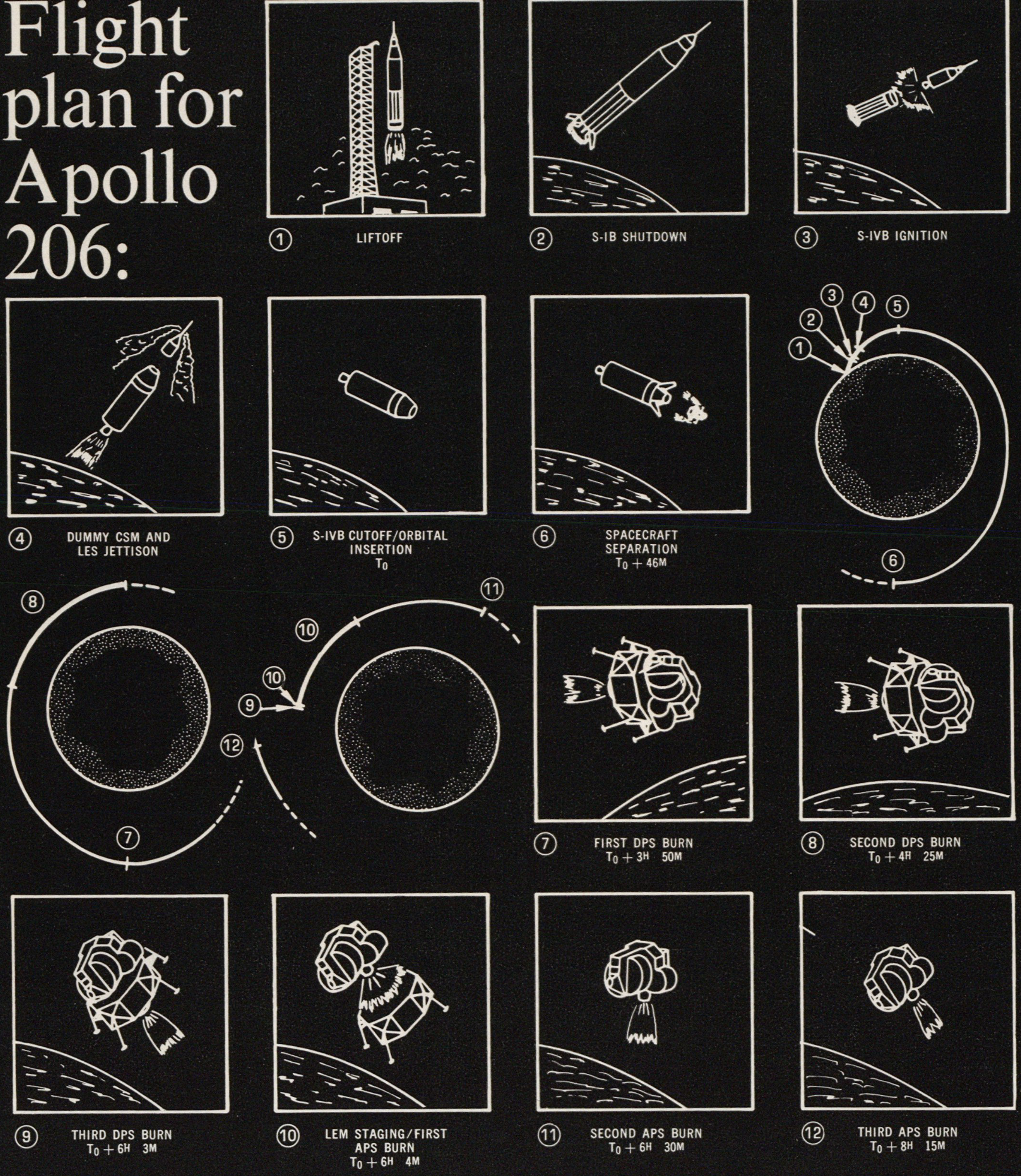
Flight plan for Apollo 206:



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Letters to AF/SD INTERNATIONAL

Gentlemen: Congratulations on your April issue which featured Seapower in the Space Age. This was a thorough coverage of several segments of our seapower forces. I am sure your readers will have a better insight on some of the Navy's problems and what we are doing about them.

Robert H. B. Baldwin
Undersecretary of the Navy
Washington, D. C.

Gentlemen: Your balanced and interesting presentation of Seapower in the Space Age in the April issue of AF/SD INTERNATIONAL in my opinion is deserving of special attention.

In order to meet the vastly complex challenges with which the United States is faced today, the highly developed skills and capabilities of each individual military service are needed. Further, these widely varied skills must be harmoniously blended together and operated in unison, each one complementing the others in order to achieve maximum efficiency and effectiveness.

The greater any military man's knowledge of the capabilities of his sister services, the better contribution he can make to our over-all defense effort, and the more easily is he able to work with his counterparts and colleagues.

The April issue of your magazine should serve the valuable function of increasing the understanding about one service for thousands of your readers, whose primary interest is quite naturally in another. More of the same type editorial effort could profitably be undertaken by many publications.

My compliments to Air Force/Space Digest INTERNATIONAL.

Admiral U. S. G. Sharp, USN
Commander in Chief Pacific
FPO, San Francisco, Calif.

Gentlemen: Having just finished reading your magazine's April issue, I wanted to drop you a short note to say how very much I enjoyed this issue and compliment you and your staff on an excellent and all-encompassing review of Seapower in the Space Age. The thoroughness given the antisubmarine warfare and research/technology programs of the U.S. Navy were particularly interesting.

The very fact that AF/SD INTERNATIONAL has recognized in such an outstanding and objective fashion the important operations of a sister service will in itself create a stronger bond of cooperation with our friends in the Air Force.

We in the Navy are delighted that you have decided to "go near the water," and we hope you don't quit! Again, hearty congratulations on a mighty fine issue.

Admiral J. S. Thach, USN
Commander in Chief
United States Naval Forces, Europe
FPO, New York, N. Y.

Gentlemen: Claude Witze has done it again. His article in the May issue of INTERNATIONAL ["How USAF Participates in International Cooperation"] shows the touch of a real professional.

. . . It is refreshing to read such a clear and objective presentation of a difficult subject.

His article will do much to clear the air on Air Force policy and role in the military sales program. My congratulations.

Lieutenant General T. P. Gerrity, USAF
DCS/Systems and Logistics
Hq. USAF
Washington, D. C.

Gentlemen: The April issue of the AF/SD INTERNATIONAL is being well read by the United States naval personnel assigned to this command.

Your presentation of the story of Seapower in the Space Age is very much appreciated by all of us. Well done!

Rear Admiral F. L. Ashworth, USN
Deputy Chief of Staff
Hq. U.S. European Command
APO, New York, N. Y.

Gentlemen: Some more technical data and charts, e.g., payload-range chart as was presented [in January 1966] for the A-4 Skyhawk ["Skyhawk: A Proud Past and a Promising Future," by J. S. Butz, Jr.], would be welcome.

Dr.-Ing. H. M. Dathe
Operations Research Gruppe
Munich, Germany

Gentlemen: . . . I read [your publication] with great interest, and I have found most thought-provoking articles on several aspects of technological development, defense policy, and military strategy.

During 1965, I had several occasions, as a military-political writer to cite your excellent articles (naturally always mentioning the source). I am regularly writing in the Review for the Swedish Officers Union ("Svenska Officersförbundsbladet") and the Journal for the Royal Academy of Military Sciences ("Kungl. Krigsvetenskapsakademiens handlingar och Tidskrift") in Stockholm. . . .

I am always eagerly looking forward to each copy of AF/SD INTERNATIONAL. I know it will supply most valuable information. . . .

Colonel N. Lund
Ystad, Sweden

Gentlemen: No other publication can provide so much actualized information about the most modern developments in air and space matters and their applications for Free World defense. This information is particularly useful for my airport-planning activities, including both military- and civilian-use airports. Both tangible and intangible data provided by editorial content and advertising material are essential elements to be applied in forecasting matters for the future and, of course, for better planning activities as its consequence. . . .

Jorge Nasim
Airport Planning Technician
Buenos Aires, Argentina

Gentlemen: I am very satisfied with coverage generally but would like to see more space given to USAF organizational structure, particularly as changes are made. . . . I would also like to see more on U.S. methods of research and development and procurement of military systems. . . .

Squadron Leader Ronald E. Davies, RAF
Malvern, Worcestershire, England

Gentlemen: AF/SD INTERNATIONAL contains . . . a good combination of technical, political, and military information. The issue on tactical air warfare in Vietnam [December 1965] was most interesting. It gave a good impression of the broad scale of problems, difficulties, and responsibilities the U.S. faces in Vietnam.

Uwe Voelckers
Braunschweig Technical University
Braunschweig, Germany

At least 19 foreign air carriers have joined U.S. airlines in awaiting results of the long-drawn-out U.S. SST competition. The first Mach 2.7 SST may not be flying until 1970, and more than 3,000 hours of flight tests will be required before it is certificated for commercial use. Yet its development is now going forward with all possible speed. Here is a detailed report on the competing designs, the philosophies behind them, and their economic implications . . .

AMERICA'S SST:
Matching Haste With Reason

BY EDGAR E. ULSAMER, Special Correspondent

The decision to be made this fall on the U.S. supersonic transport program is bound to have a significant effect on commercial aviation throughout the world. The implications of the competition between the U.S. program and the Anglo-French Concorde (which we will report on in an upcoming issue) are obvious. Some 22 airlines outside the U. S. have route structures that could economically support a supersonic transport. And, as is pointed out in this report, 19 of these 22 have indicated interest in an SST purchase.

The Advisory Board of aeronautical experts that will decide which companies will build the U.S. supersonic transport has indicated that the preferences of foreign carriers will be considered. And both of the airframe competitors have stated that they will consider using engines designed abroad on those aircraft purchased by foreign airlines.

These points and many more, we feel, make the following article of interest to AF/SD INTERNATIONAL readers.—THE EDITORS

This fall top U.S. aviation experts will have to make a decision that may well determine the future of U.S. commercial aviation for years to come.

At issue is the U.S. supersonic transport (SST), the most ambitious and expensive aeronautical development program in the history of commercial aviation.

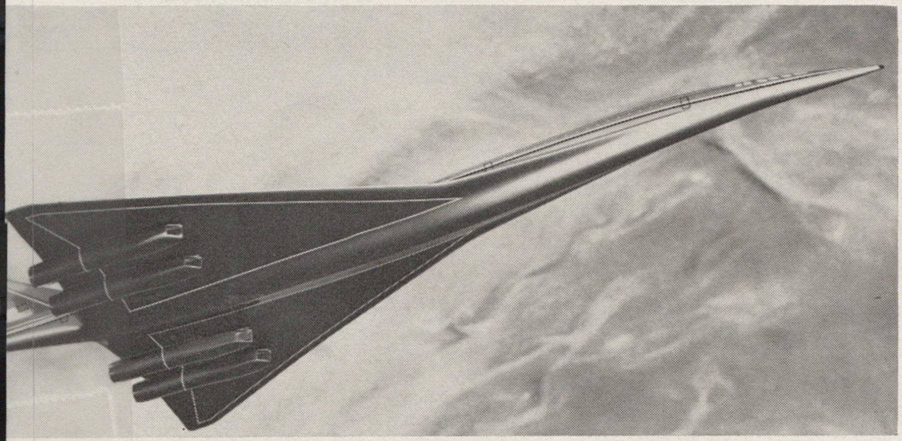
Because the cost of developing an SST strains the financial resources of the aerospace industry, the U.S. Government will finance the major share of the undertaking on a cost-sharing basis, to be repaid out of profits when the transport gets into the air. The formula on which this cost sharing is based is one of the better guarded U.S. secrets. Officials will only admit that the Government's contribution will range somewhere between 75 and 90 percent of the total cost and that the net worth of the participating industry is somehow involved in the computation.

The job of deciding who will build the SST and what configuration it is to take will begin in earnest on September 6, the Federal Aviation Agency's (FAA) deadline for final specifications and bids. Lockheed Aircraft Corporation and the Boeing Company are competing for the airframe, and the General Electric Company and United Aircraft Corporation's Pratt & Whitney Division are in competition for the engines.

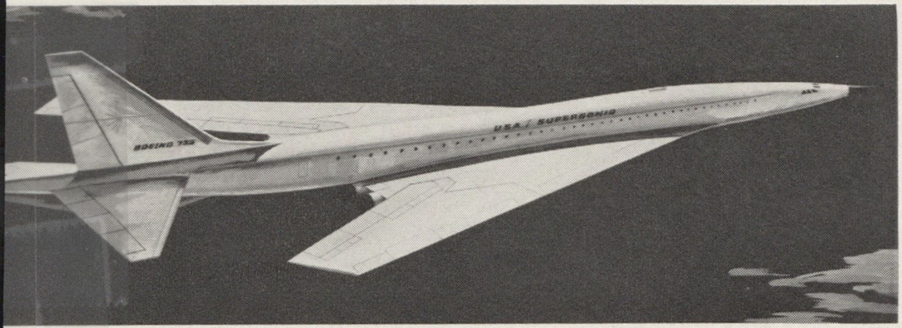
The work of evaluating the technical and economic aspects of the competing entries will be done by an Advisory Board to be named and convened by FAA. Informed sources predict that between 200 and 300 aeronautical experts from the U.S. Air Force and other Government agencies will make up this Board. Executive officers of U.S. airlines will participate in the decisions. The preferences of foreign carriers will be taken into account. A cabinet-level committee, answerable directly to the U.S. President, will review the Board's findings and make the final recommendations to the White House.

Despite a number of unknown factors, the selection process is expected to be rapid since Washington, as well as the industry, is keenly aware of the importance of maintaining the present timetable.

There now appears to be little chance of Lockheed and Boeing each building separate aircraft. Even the most stalwart spokesman for the 2-model approach, the Chairman of the Senate Aviation Subcommittee, Senator A. S. Mike Monroney, now concedes that time and money are running out, and he has, therefore, "reluctantly abandoned advocacy of 2 SSTs." As it is, he says, the SST program will have trouble in Congress. But he predicts that both Houses of Congress will eventually sanction and finance the complete program without major changes.



Lockheed's entry into the SST race is over 271 feet (83 m) long and has a wing span of 116 feet (35 m). Fully loaded, it will weigh in at about 550,000 pounds (249,480 kg). In maximum density configuration the aircraft will accommodate 266 passengers.



Boeing's SST model, the 733, is designed for Mach 3 speed but the first models will be held to Mach 2.7. Titanium will be the principal structural material used in the U.S. SST. Titanium's strength-to-weight ratio bests that of aluminum by some 12 percent.

Brigadier General Jewell C. Maxwell, SST Program Director, directed B-52 development and served in other important R&D posts during his 25-year military career.

SST Project Manager Robert A. Bailey has been with Lockheed since 1937. He was the Chief Spacecraft Engineer, 1960-64, and worked on a space transporter idea.

Brigadier General J. C. Maxwell, the FAA's SST Program Director, agrees, saying that only in the unlikely event of the airlines banding together and financing the second model could both SSTs be built.

Both Boeing and Lockheed officials would still like to see both aircraft types come into being. They cite 3 reasons for this: First, Lockheed's L-2000 has certain advantages over Boeing's 733 in certain circumstances, and vice versa, thereby automatically guaranteeing better U.S. market penetration if 2 models are available.

Secondly, the U.S. system is oriented toward competitive conditions. But now the U.S. Government, it is argued, creates a monopolistic situation by funding only one company to build what the Government considers the basic form of air transportation of the future.

And finally is the advantage of safety in numbers. Nobody holds any illusions about the difficulties of building an SST that will do exactly what the American SST is supposed to do. If 2 companies were designing and testing 2 different aircraft, using 2 different types of engines, U.S. aerospace industry could survive if one turned out to be a failure. As it is, they say, failure by the single American entry in the SST race to perform as expected might take the U.S. out of advanced commercial aircraft design for years to come.

The SST's prototype is to fly within 4 years. There is every indication that the plane will be in the air by 1970, or even earlier, since everybody involved realizes that every day lost means losses in sales to the French-British Concorde or to the Soviet TU-144.

Boeing and Lockheed officials stress that the national SST effort is moving along to their complete satisfaction. As the Boeing Company's SST Government Relations Manager, Heber J. Badger, puts it: "We are making haste with reason. I don't think you could speed things up any more and not run into trouble."

FAA's General Maxwell stresses the virtues of the orderly and evolutionary progression that has marked the aircraft's development so far: "I shudder when I reflect on the situation which would exist if the program had gone into prototype last July. The configuration changes and improvements that have evolved since then would dictate a completely new beginning."

Lockheed's SST General Manager

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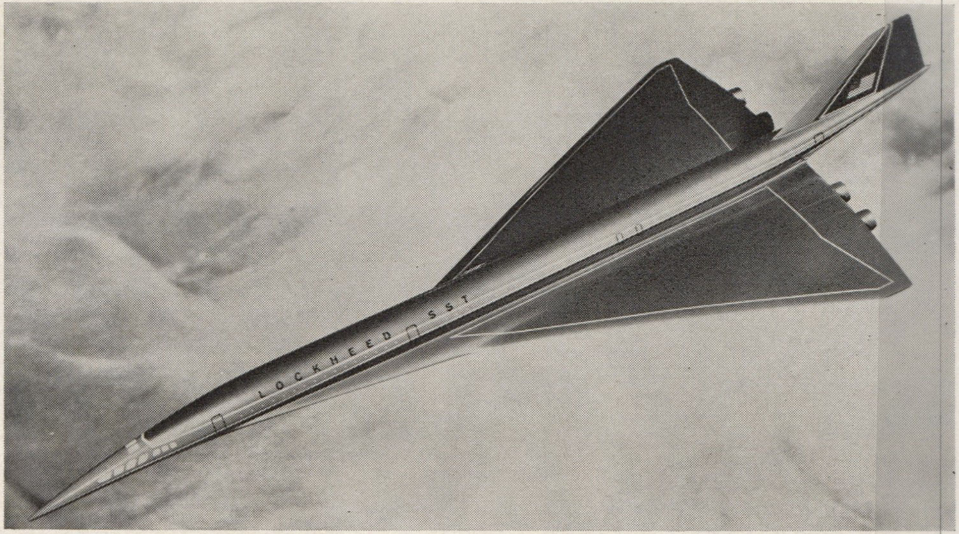


Lockheed's double-delta configuration is similar to that of the YF-12A and SR-71. Essentially, the small, forward delta becomes aerodynamically effective only during supersonic flight. The low wing loading of this design results in an extremely low stall speed and excellent cross-wind characteristics. Because the wing has no moving parts, safety and reliability are enhanced, according to Lockheed engineers.

Robert A. Bailey agrees, but adds that further delays at this time would not lead to any great advantage in the state of the art.

Yet both companies feel that the original slow pace of the SST program has caused an irretrievable time loss. The 2 companies and the FAA are of the opinion that, under the present schedule, between 125 and 175 Concordes will be sold to the world's airlines, "simply because that aircraft will be the first on the scene."

The risks inherent in building the SST at all are considerable, and the costs are staggering. General Maxwell recently estimated that the total investment in the SST program by the time the first airplane is delivered to the airlines in 1974 "may exceed $4,000,000,000."

In terms of the U.S. economy, the difference between a successful SST and the need to import one exceeds $15,000,000,000, according to conservative estimates based on the assumption that the useful life of the SST will run from 1975 to 1990. By then, incidentally, current studies indicate the Hypersonic Transport (HST) or an orbital transport will replace the SST.

What makes the SST's risks even more acute is the fact that this aircraft departs from the historic pattern in which military technology leads the way, with commercial aviation following in its footsteps as the beneficiary.

SST Design Criteria

The SST's design criteria are demanding. President Johnson, in March, told Congress:

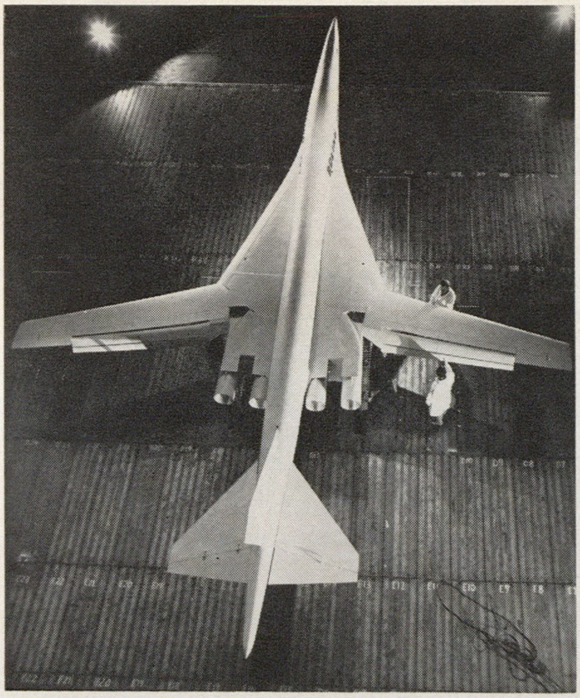
"Our supersonic transport must be reliable and safe for the passenger. It must be profitable for both the airlines and the manufacturers. Its operating performance must be superior to any comparable aircraft."

The question of the SST's speed, a subject of some conflict, appears to have been settled by a compromise. Originally conceived as a Mach 3 aircraft, the speed criterion of the SST was lowered last year by the 2 competing companies to Mach 2.7.

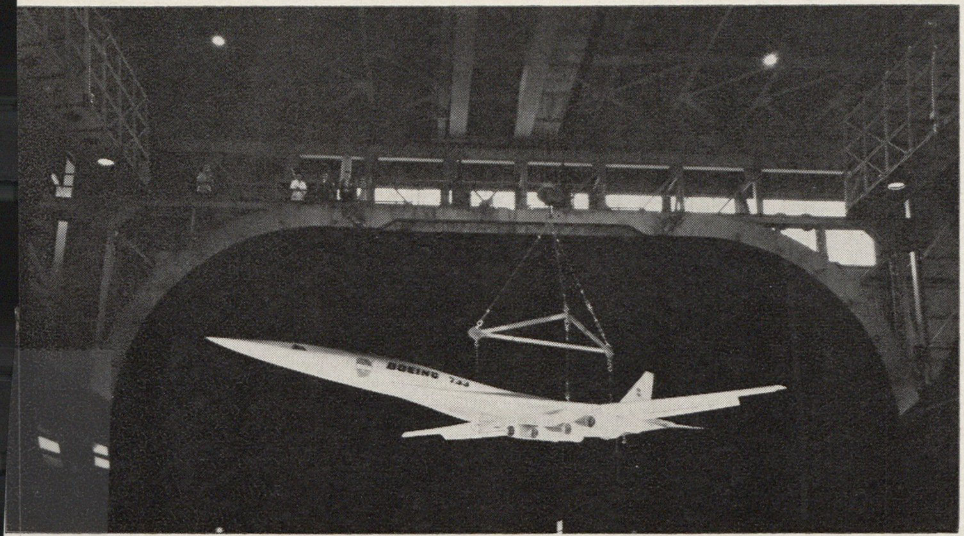
According to FAA officials at that time, this reduction aimed for a safe middle ground between temperature limitations and flight efficiency. This lowering of the cruising speed was significant beyond the prestige aspect of a round Mach number. Supersonic flight efficiency reaches a peak in the Mach 3 area, considerably above the level of Mach 2.7.

Both Boeing and Lockheed now say that their 2 entries, the variable-wing Boeing 733 and the double-delta Lockheed L-2000, are slated to go into production as Mach 2.7 aircraft. Lockheed says its model, if chosen by FAA, "would be built up to a Mach 3 speed gradually, in a step-by-step development program, and would eventually reach Mach 3.2."

Boeing's Heber Badger says that the 733 will be capable of Mach 3 cruise speed from the start so far as aerodynamics, structure, and materials are concerned. He adds, however, that the hydraulic system and other elements



With wings stretched out to the maximum reach, the Boeing model has a moderate swept-back configuration of only 20 degrees from perpendicular. In this trim condition, its aerodynamic characteristics test out in the wind tunnel almost identical to that of a Boeing 707. Its landing and takeoff characteristics, according to Boeing officials, exceed those of the 707 and are said to be as good as the Boeing 727 and the 737.



Fifth scale model of Boeing's 733, according to company scientists, proved in the wind tunnel that this configuration can operate profitably and for sustained periods at subsonic speeds. This eventuality has been taken into consideration by American designers in case supersonic overflight is prohibited by certain countries because of sonic-boom problems.

need to be "beefed up before we can gain Mach 3."

He predicted that this could be accomplished after the first few production models have been completed.

Market and Economics for the SST

In the critical area of economy, both companies and the FAA are convinced that the SST will not require the surcharge which may well be necessary for the Concorde.

The economics of the $30,000,000 SST on a long-term basis are staggering. FAA studies indicate that within slightly more than 2 decades, SSTs will fly about half the Free World's passenger seat-mile total and that this total will be about 2½ times the total of all seat-miles currently produced by all commercial aircraft. Lockheed studies to date show that 32 airlines (10 in the U.S. and 22 abroad) maintain route structures that could economically support SSTs. Incidentally, 19 out of the 22 foreign airlines have indicated interest in the SST and sent a total of 63 executives to attend Lockheed's SST briefings in California. As for the U.S. airlines, their executives have participated in 7 design meetings with Lockheed officials.

Lockheed's marketing experts forecast a market potential for 500 SSTs, 166 Concordes, and almost 2,500 subsonic jets by 1988. Other marketing men predict an even greater SST potential—800 or more aircraft. In terms of total cash flow, Lockheed experts say the SST may represent as much as $37,000,000,000 by the end of the 1980s and produce a worldwide average of 26 percent return on the investment.

Over what kind of routes will the SST be profitable? Without question, any flight over 1,100 miles (1,770 km), which is the "crossover point," theoretically ascertained by Boeing and Lockheed as the range where the SST, with normal occupancy, produces passenger seat-miles at direct operating costs equal to today's subsonic jets. Break-even load factor for transcontinental SST operation is 30 percent, according to Lockheed analysts.

On stage lengths exceeding 1,100 miles (1,770 km), the SST is predicted to produce lower-cost seat-miles. On short runs these costs would be slightly higher than those of today's 707 or DC-8.

Boeing's Heber Badger points out, however, that his company foresees "thoroughly profitable" ranges as short as 750 miles (1,207 km), "simply because there is evidence that the SST's appeal will produce higher occupancy rates than the subsonics."

Lockheed's marketing experts predict excellent SST productivity over long- and short-leg combination flights such as Los Angeles to Chicago to New York, or San Francisco to Detroit to New York. Also, they expect the SST to be competitive on such flights as Miami to New York and San Francisco to Denver. The 733 and the L-2000 designs, of course, reach optimum productivity only over the longer ranges for which they were designed. There they produce passenger seat-miles on a direct operating cost basis up to 20 percent lower than those of the present subsonic airliners, or roughly equal to those of the stretched-out DC-8-60 series, which had its first test flight this spring.

FAA's General Maxwell points out, however, that the SST's competitiveness with subsonic jets must be viewed with an eye toward future developments: "The proposed jumbo jets [C-5A derivatives, including the L-500 and the Boeing 747]," he says, "promise economies that an SST cannot match on a seat-mile basis; so it must offer better service [speed] at a slightly higher fare."

The Lockheed double-delta L-2000 as well as Boeing's variable-sweep-wing 733 are said to be thoroughly at home in the 3 speed regimes of a supersonic transport—subsonic, transonic, and supersonic. Lockheed achieves flight economy at the high, middle, and lower ranges of the speed spectrum through low wing loading while Boeing's variable-sweep-wing design, similar to that of the F-111, promises equal flexibility. The 733's subsonic economy would "equal that of the best subsonic jets," according to a Boeing official. Boeing's SST can maintain subsonic flight indefinitely, he said, adding that this feature could be of critical importance on transoceanic flights. In an emergency situation occurring at or close to the midway point during transoceanic flights, the 733's range can be extended by 50 percent simply by "shifting down to subsonic speed," he said.

Selecting the Materials

An issue of great significance is materials selection. The 2 airframe competitors have now decided on titanium 6-4 and titanium 8-1-1 as the primary metal for the SST. At $11 per pound, titanium 6-4 is a highly expensive raw material to be used to build a 500,000-pound (226,800 kg) aircraft, but the slightly cheaper titanium 8-1-1 alloy originally selected, using aluminum, molybdenum, and vanadium, was found to be vulnerable to salt water and, therefore, had to be dropped for certain applications. Eventually, it is hoped, the price of titanium 6-4 will

(Continued on following page)

come down appreciably as the demand for it increases. Titanium prices have already decreased by 51 percent since this metal was first used in quantity on such aircraft as the YF-12A (which is 98 percent titanium).

Thermal heating encountered by an SST will be immense, reaching 600 degrees Fahrenheit (316 degrees C.) at Mach 3. The side effects of these aerokinetic parameters are substantial: According to FAA figures, the SST will "grow 1 foot [.3 m] in length during the heating process on each supersonic flight, causing severe stresses to develop between the hot external and cool internal structure."

In the case of a hydraulic fluid line, 100 inches (254 cm) in length and made of stainless steel, the temperature changes between takeoff and supersonic cruise will stretch it by almost 4 inches (10 cm).

The design of the aircraft, even with the use of heat-resisting titanium, must allow for wrinkling or buckling of the structure without adverse aerodynamic results. The lessons learned from Lockheed's SR-71 supersonic reconnaissance aircraft's "controlled smoothness dimples" are proving of great importance, especially in designing the SST's wings, according to Lockheed designers.

While Boeing and Lockheed engineers readily admit that new advanced composite materials unquestionably hold great promise for ultimate use in supersonic flight, the need to produce the SST within a relatively short time and as a safe, well-tested aircraft has ruled out their use in the first-generation SST. But the use of "composites" in follow-on SSTs is being explored vigorously by both airframe competitors. So are rene 41, stainless steel, and even arcane columbium.

General Maxwell makes a good case for the application in future SSTs of new advanced materials, which are currently under development by the Air Force and other agencies.

Of all commercial aircraft, the SST, General Maxwell says, has to operate on the lowest payload fraction. The most likely remedy, he believes, would be the use of high-strength, low-weight materials, but he expects that these can be considered only for the second-generation SST or even later.

Boeing, Lockheed, and the FAA have examined, but have doubts about, the practicality of incorporating laminar-flow control (LFC) into a follow-on SST. Theoretically, LFC could improve the SST's payload by 20 percent (vs. more than 40 percent in the case of subsonic aircraft), or increase its cruise altitude by a similar percentage without increasing size or fuel consumption. According to officials of the Northrop Corporation, a pioneer in LFC research, this latter alternative might be used to combat the sonic-boom problem, which is largely a function of altitude.

Lockheed's L-2000 design, according to company officials, is economically competitive with current subsonic jets on stage lengths of 1,100 miles (1,770 km), and on any longer flights up to 3,800 miles (6,115 km) will produce seat-miles at costs below the contemporary level. The Lockheed entry can accommodate the maximum payload of 60,000 pounds (27,216 kg) on ranges up to 3,550 miles (5,713 km).

The manufacturing companies feel, however, that the complexity of the system does not warrant its consideration at the moment.

Safety and Reliability of the SST

Considerable ingenuity is required to protect the human cargo and sensitive instrumentation from the very high external temperatures of sustained supersonic flight. Intricate cooling devices combined with a special isothermal inner trim wall have been developed and have stood up well under realistic testing conditions.

The fuel tanks, inerted through the use of nitrogen to prevent spontaneous ignition at the prevailing 200° to 300° F. (93° to 149° C.), also serve as a heat sink, a technique first evolved by the Air Force for high-performance aircraft.

Equally critical is the design and absolute reliability of the pressurization systems, since any complete failure at the cruise altitude of 75,000 feet (22,860 m) or higher would automatically result in death for the passengers and the crew.

For the SST to be truly safe will require simplicity of operation well in line with the capability of the human pilot and his training. The need for backup systems and new safety features is obvious. At cruise speed, the SST will travel more than half a mile in the proverbial blinking of an eye—2,934 ft./sec. (894 m/sec). The pilots of 2 SSTs closing in on each other from 10 miles (16 km) apart would be totally helpless in avoiding collision since the "grace period" of 10 seconds is too short for evasive action. By way of illustration, at Mach 2.7, an SST going into a 30-degree bank will have a turn radius of more than 40 miles (64 km).

Nevertheless, the FAA and the 2 competing airframe manufacturers entertain no doubt that the SST will be one of the safest aircraft ever built. Flying it, says a Boeing executive, will be "as easy as flying the 727 and easier than the 707 or DC-8." For this he credits the "excellent low-speed characteristics resulting from the variable-sweep wing." He rejects any suggestions that the variable-sweep wing and the high-lift devices to be employed by the 733 complicate its operation to the detriment of the aircraft.

"Complexity is a sin," he says, "only when it leads to unreliability. It becomes a virtue when it increases performance and safety." He claims that high-lift devices on hundreds of Boeing's subsonic airliners have not detracted from their outstanding dispatch capability. As for the variable-sweep wing, he predicts that this device reduces the need to shift the fuel weight through pumping to achieve a balance between center of gravity and center of lift. U.S. aeronautical experts, incidentally, think that the French-British Concorde is "fully dependent on fuel pumping and, should it fail, could not land without crashing."

Lockheed spokesmen are equally convinced of the reliability and sim-

Boeing's variable-sweep wing, which moves back from 20 degrees on takeoff to 72 degrees at supersonic cruise, permits the pilot to aerodynamically "tailor" the aircraft to the speed he is flying at a given time. While, according to Boeing engineers, it is possible to land the aircraft with the wings folded back, this would be a critical maneuver. Every care is being taken, therefore, to make the pivot bearings and other moving devices as fail-safe as possible under true flight-test conditions.

Daniel J. Haughton, Lockheed's President, headed Lockheed-Georgia during development of the C-130 Hercules and then served as Executive Vice President until 1961.

plicity of their entry, claiming that trimming the aircraft is held to a minimum by virtue of the double delta (the smaller leading delta becomes aerodynamically effective only at supersonic speed), and that all it takes to land is a change in attitude of about 1 degree because of the L-2000's high ground effect, rather than the 4- or 5-degree adjustment needed by currently operative subsonic jet airliners. Boeing claims a similar advantage for the 733.

It is perhaps ironic that the Boeing variable-sweep-wing design has its roots in work done by Lockheed's brilliant designer, C. L. "Kelly" Johnson, who plays a prominent role in the design of the fixed-wing L-2000. Boeing is quick to point out that no royalty payments need be made to the Lockheed designer.

Lockheed officials are prone to dwell on this point. They say their company rejected the variable-sweep wing in spite of its "kinship to this design" after lengthy design evaluation studies dating back to 1956. As the world's only designer of Mach 3, or faster, production aircraft, Lockheed engineers, working with Mr. Johnson, discarded the variable-sweep-wing concept as a "20,000-pound millstone." Says Lockheed's SST General Manager Bailey: "The double delta, by virtue of the peculiar aerodynamic phenomena encountered at subsonic and supersonic speeds, becomes in effect a variable-geometry device—without as much as moving a wing."

He claims that Lockheed's wind-tunnel tests not only give the L-2000 double delta "a phenomenal safety margin because of low stall speed, but indicate low-speed characteristics better than current subsonic aircraft."

This, he says, results from the "favorable vortex pattern which makes the entire delta wing, all the way back to the trailing edge, generate lift through a pumping action."

He adds that the pumping action prevents boundary-layer thickening and leads to high lift forces without causing turbulence, wing stall, or drag. These benefits, the Lockheed officials maintain, are increased further over sweptwing designs during takeoff and landing because of the ground cushion effect.

The SST's Pilot Requirement

How do the pilots themselves feel about the SST? Captain George T. Henderson, United Air Lines Flight Operations Manager, who also acts as his company's liaison man on the SST project, liked what he saw after several exercises on supersonic simulators and flying specially adapted supersonic military aircraft. Instead of encountering a number of problems he had expected, the actual ease of supersonic flight "makes me, as a pilot, look forward to the SST with much anticipation instead of trepidation," he said.

An element of considerable importance to the ease-of-mind of prospective SST pilots is the variable-geometry nose, or "droop snoot," pioneered by Lockheed but now also adapted by Boeing. In the 733, according to Mr. Badger, this feature was used more for the sake of improving the aircraft's aerodynamic efficiency, than for upgrading the already adequate visibility to a level equaling that of subsonic

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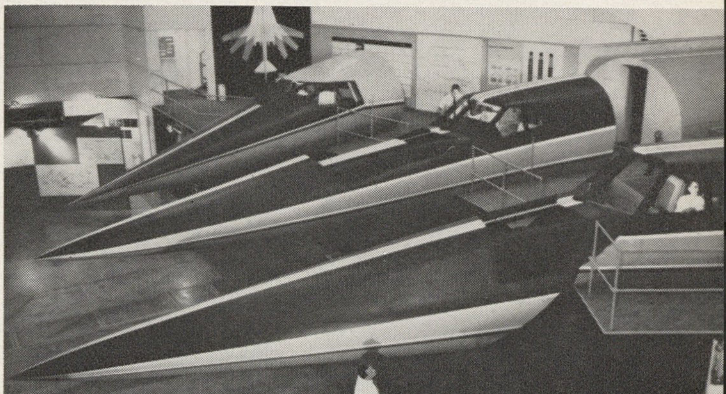
Lockheed first, and Boeing later, made a variable-geometry nose part of their designs. Purpose of this "droop snoot" is twofold: By adjusting the nose to the speed of the aircraft, the aerodynamic efficiency of the SST is increased. At the same time, the pilot's field of vision is greatly enhanced at the time of landing and takeoff.



Undersecretary of Commerce for Transportation Alan S. Boyd, left, the former Chairman of the Civil Aeronautics Board, and Boeing's SST Project Pilot James R. Gannet make themselves at home in Boeing's cockpit mockup. Airline pilots given simulator training in flying the SST have said that operating the supersonic craft should not be more difficult than flying large subsonic jetliners.

airliners. "The fact that the droop snoot did bring this about is, of course, a byproduct that we are most happy with," he says.

In cruise, the SST's pilot vision is, of course, more restricted than in present aircraft. Elaborate programs employing spaceflight simulators, computer-controlled television, and other electronic devices are being used extensively to establish the visibility limits necessary to maneuver the aircraft safely during cruise and to be able to land even if the droop snoot is inoperative.

Lockheed spokesmen have dubbed the L-2000's variable-geometry device a "weather-vision" nose, which can be lowered during subsonic flight by 15 degrees, thereby furnishing better pilot vision during takeoff, approach, holding, and landing "than is available in the best of today's subsonic jets."

General Maxwell states that on a preliminary basis his agency, FAA, will insist on a minimum total flight time of 3,400 hours before certificating the SST. While this may seem excessive, he points out that the SST will operate in a "thoroughly hostile environment which so far has only been penetrated by a limited number of U.S. Air Force and NASA aircraft."

Lockheed's Bailey agrees that the American SST "will be the most tested new commercial aircraft ever to enter airline service." Part of its safety will result from unparalleled "redundancy" in all communications and instrument flight information. This provision for backup systems, according to Lockheed, will link the SST to high-frequency (HF) and very-high-frequency (VHF) ground stations and communications satellites in a near fail-safe fashion. Inertial navigation, pioneered by the U.S. Air Force, will be used to give the SST bad-weather capabilities beyond that of contemporary jets, according to FAA spokesmen.

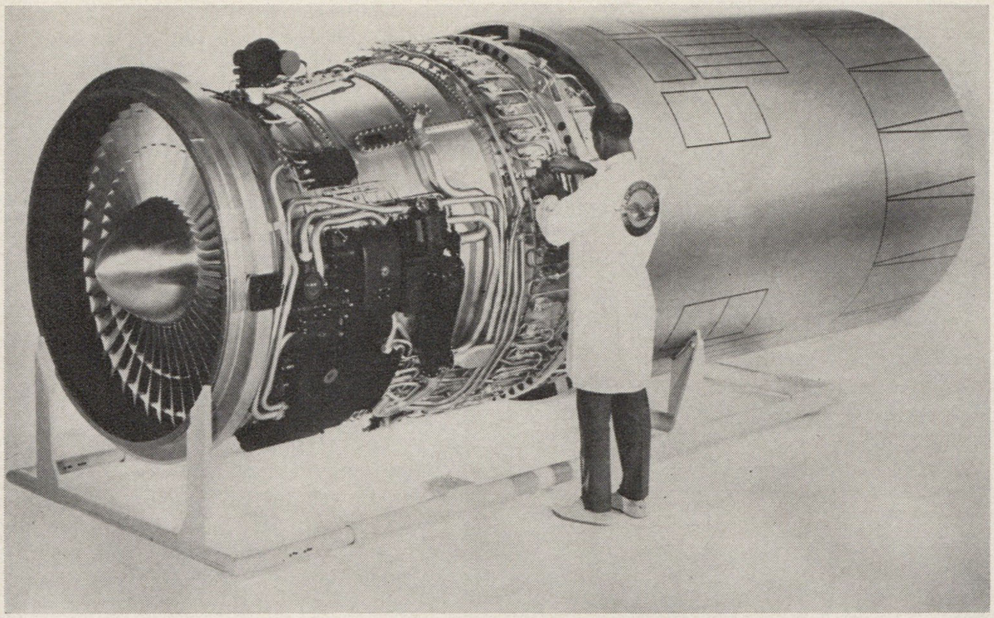
Advanced antenna systems, flush-mounted on the structural design of the fuselage and empennage and installed in duplicate or triplicate for full reliability, are being developed by Lockheed and said to be radically advanced over present equipment.

Whoever wins the airframe contract, according to FAA, will have the job of initial pilot training.

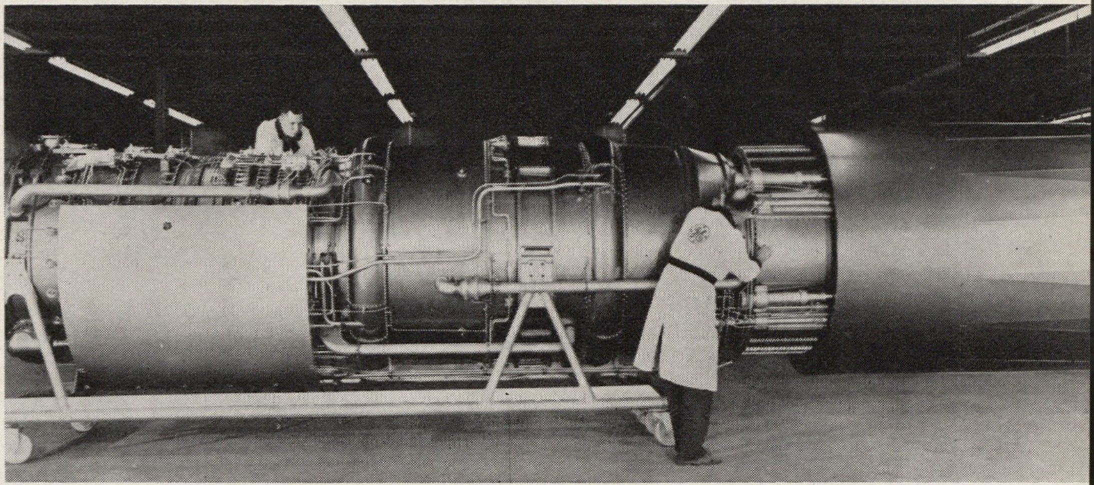
How difficult will it be to check out an SST pilot? Lockheed officials say it takes 35 hours to check out a pilot on the YF-12A and claim they can't see any reason why it should take any longer for an SST pilot. Boeing spokesmen are equally optimistic.

But this kind of cheery optimism is not necessarily the belief of FAA officials.

FAA's General Maxwell, for instance, points out that, in training pilots for the vastly simpler subsonic aircraft of the B-47 bomber variety, the Air Force required 40 hours of flight time, pre-



The Pratt & Whitney JTF17A represents a novel approach to supersonic propulsion. In place of the traditional afterburner, it employs fan-duct burning. The result is a shorter, stubbier configuration and, it is claimed, better specific fuel consumption in the subsonic regime. This engine, as is the General Electric entry, is in the 60,000-pound (27,216 kg) thrust class.



General Electric's bid for the SST's propulsion system is the GE4/J5, said to produce over 60,000 pounds (27,216 kg) thrust. It employs a conventional afterburner and is almost 30 feet (9.15 m) long. Both the GE and the P&W engine had to be beefed up from an original 50,000-pound (22,680 kg) thrust because the airframe manufacturers increased the takeoff weight of their SST entries to above 500,000 pounds (226,800 kg).

ceded by weeks in ground school "before the officer became a copilot, a phase in his training when he really began to learn how to fly the aircraft."

General Maxwell makes it abundantly clear that the Federal Aviation Agency will insist on "thoroughly adequate pilot training" as a vital prerequisite for safe SST operation.

The SST Engines

The propulsion system, of course, is of overriding importance to the SST's reliability, performance, and economy.

The SST's engines, according to General Maxwell, will "be twice as powerful as the largest military aircraft engine and will have a higher mass flow, run hotter, and be more efficient." Engine thrust ratings, according to Mr. Bailey of Lockheed, will be 60,000 pounds (27,220 kg). With an overall output of 240,000 pounds (108,860 kg) of thrust by its 4 engines, the SST easily tops the present "power champion," the 180,000 pounds (81,650 kg) of thrust produced by the 6 engines of the USAF XB-70.

At cruising speed, the SST engine will operate about twice as efficiently as the best reciprocating airplane engine ever built and at least 1½ times as efficiently as the best fanjet engine that can be predicted for future subsonic aircraft, according to Boeing's SST Program Manager, Maynard L. Pennell. It will produce about 50 times the cruise power of the largest piston engine, yet weighs only 1½ times as much.

The SST enjoys 2 special advantages: In its natural habitat the aircraft weighs 2,000 pounds (907 kg) less than on the ground. Centrifugal force in the form of Mach 2.7 speed cuts the SST's weight by more than 1,200 pounds (544 kg), and in addition the more than 65,000 feet (19,810 m) of altitude reduces gravitational pull by almost 800 pounds (363 kg). Considering the SST's payload of 40,000 pounds (18,144 kg), these 2 factors are not insignificant.

But this benefit of supersonic propulsion is not without indirect penalties which, for the moment, can be alleviated but not entirely eliminated. For a subsonic jetliner, the fuel needed to gain cruising speed and altitude amounts to roughly 3 percent of the gross takeoff weight. This value increases to almost 10 percent in the case of the SST, which burns up fuel at this stage at the rate of 200,000 pounds (90,720 kg) per hour. Unfortunately, only a fraction of the energy represented by this speed and altitude can be converted into distance during descent and deceleration for landing, detracting, thereby, from the SST's productivity.

The propulsion system program for the SST is well along toward the hardware stage. The 2 competitors, General

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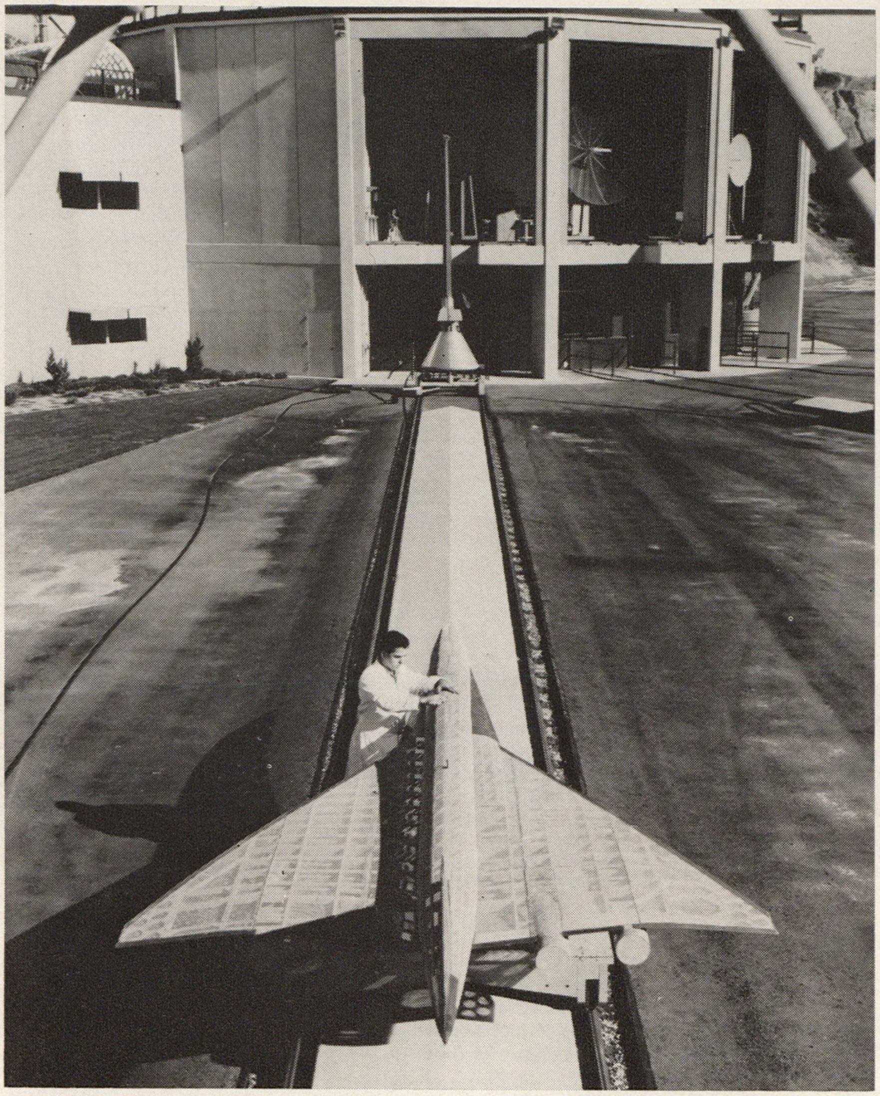


The SST will be provided with the most reliable communications systems ever put into a commercial aircraft. Lockheed experts have tested this special 1/10-scale model with 28 flush-mounted antennas for navigation, communications, and "blind" landings.

Electric and Pratt & Whitney, under their current contracts with the Government, will build 3 flight-weight engines each and will obtain test-stand running times of at least 100 hours on each engine to prove both performance and weight before the end of the year. Thus, whichever engine will be selected should be available in hardware state well before the prototype is ready to undergo its first test flight.

The differences between the General Electric and Pratt & Whitney engines are sizable, literally and figuratively. As a matter of fact, their only common denominator is the output—about 60,000 pounds (27,220 kg) of thrust—and the fact that it takes a starting unit of about 1,000 horsepower to set either in motion.

General Electric has come up with a thrust-augmented turbojet, while Pratt & Whitney followed the concept of a twin-spool turbofan engine with fan-duct burning augmentation for subsonic and transonic transition.

Pratt & Whitney claims a number of advantages for the augmentor/ram-induction burner principle. First, the augmentor operates in the fan duct, an environment some 900° F. cooler than the turbine exhaust, where the afterburner is normally located. This, according to Pratt & Whitney designers, permits metal temperatures at or below 1,600° F. (871° C.), thereby enhancing the engine's durability substantially above that of one employing an afterburner.

In addition, they maintain, turbofan engines furnish improved payload/range characteristics and generate less engine noise. Subsonic fuel consumption of a turbofan is 15 percent better than that of a comparable turbojet. It is hypothesized, therefore, that this feature makes it safe to operate an SST with smaller fuel reserves since no special penalty is attached to subsonic operation necessitated by engine malfunction or other emergency conditions.

General Electric's reasons for staying with the more orthodox afterburner are simplicity, the fact that its excellent supersonic and subsonic characteristics are well understood, and that the Free World's "flight-time total, at Mach 2.7 or above, of a few hundred hours" furnishes full confirmation of this design.

The General Electric engine will be almost half the length of a DC-3 and its thrust about twice the weight of a fully loaded DC-3. The Pratt & Whitney entry is considerably shorter and fatter than the General Electric SST engine.

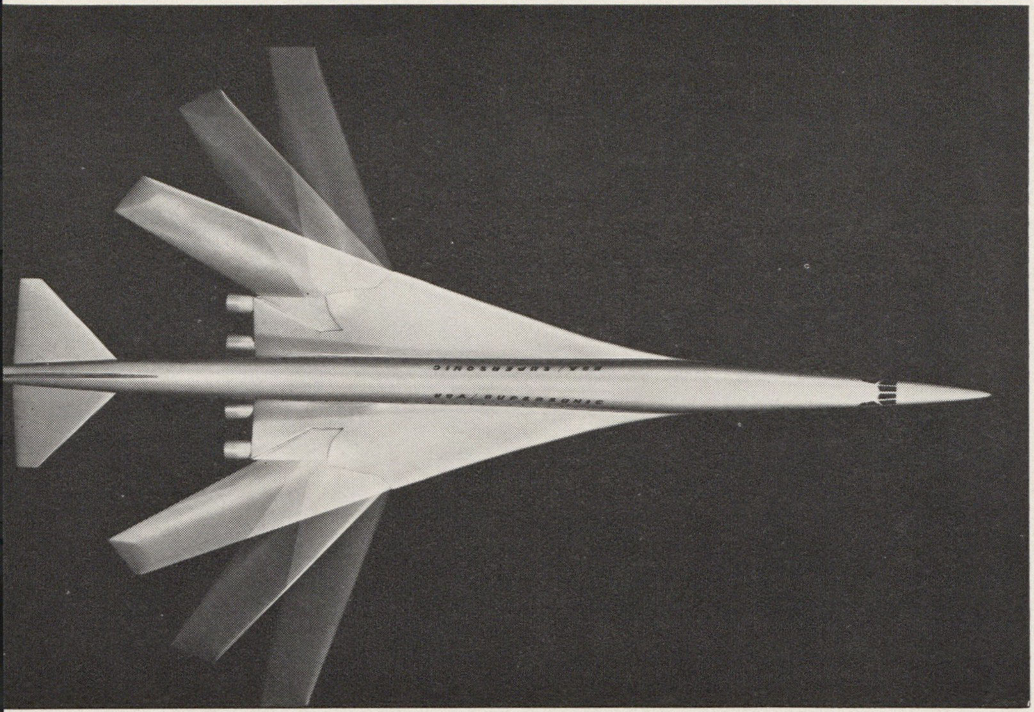
Lockheed officials, incidentally, claim that their company nearly was eliminated from the SST competition by the FAA over a year ago. Reason for this was in part Lockheed's unilateral commitment to the Pratt & Whitney engine, which at that time cost $1,000,000 more than the General Electric engine. As a result, Lockheed relinquished its preference. Since then, they say, the Pratt & Whitney engine has come down in price while the General Electric engine has gone up. Nevertheless, the General Electric engine still maintains a substantial price advantage over the Pratt & Whitney JTF17, they report.

Both Lockheed and Boeing are expected to state a specific engine preference in their final specifications, but will retain sufficient flexibility to be able to incorporate either engine if the Government so rules. For the moment these preferences are a well-kept secret. Both companies indicate that in the case of foreign airlines, they would consider use of engines designed overseas, if and when such compatible propulsion systems are developed there.

Either engine will run at extremely high temperatures throughout the SST's speed envelope, exceeding 2,300° F. (1,260° C.) for takeoff and 2,200° F. (1,204° C.) for supersonic cruise. The exact temperatures are classified for the moment, indicating the military parentage of the technology.

Thermal efficiency, of course, is the key to high thrust output of any jet engine, regardless of whether it is operated subsonically or supersonically. General Electric's Flight Propulsion Division General Manager Gerhard Neumann says the General Electric 4 SST engine has a 40 percent thermal efficiency—twice as good as today's best subsonic engine—and that this would increase as the engine progresses from Mach 2.7 to Mach 3 cruise speed.

The critical factor is the amount of compression that can be achieved without exceeding the temperature limits set by the materials in the hottest sections of the engine. Here the



Both Boeing and Lockheed configurations stem from spade work done years ago by NASA aerodynamicists and research by the U. S. Air Force. Boeing, after 25,000 hours of wind-tunnel testing, has decided on the swing-wing, and categorically denies the recurring rumor that it will submit 2 entries, a sweep-wing and a fixed-wing design, to the FAA. Boeing officials point with pride to the flawless performance of the variable-sweep wing in the F-111.

supersonic engine faces a problem that is less pronounced for the high bypass ratio subsonic engine, for at cruise speed the SST's engine must live with an inlet temperature of about 500° F. (260° C.) above that of the subsonic variety. This "overage" is carried backward into the propulsion system, resulting in a combustor inlet temperature of more than 1,000° F. (538° C.) or, roughly, twice that of a subsonic engine.

To offset this curtailment of the power-generating potential, the SST engine needs to raise the temperature tolerances through the use of heat-resisting alloys and titanium to be able to run hotter, and to operate at close to maximum temperatures throughout its flight regime—peaking, of course, at takeoff when the turbine inlet temperatures will be considerably above 2,000° F. (1,093° C.). Conversely, a commercial subsonic jetliner's engine operates at maximum temperatures only for 1 percent of the operating time.

The need for heat-resisting materials and advanced turbine-cooling techniques is self-evident. Directionally solidified turbine blade casting, which eliminates grain boundaries that lie perpendicular to the principal stress axis in nickel-base alloys, improves the life cycle of the SST high-temperature turbine. This technique is already proving itself in the Pratt & Whitney engine.

A still more sophisticated process is under study by Pratt & Whitney and results in superior materials known as "Monocrystaloys"—alloy crystals that survive high thermal shock cycles and retain high strength, stiffness, and hardness under high temperatures.

General Electric in its GE4 engine combines metallurgical and metal-processing breakthroughs with turbine bucket cooling, which, according to Mr. Neumann, reduce metal temperatures to maximum levels "no greater than in today's commercial jet engines —while at the same time reaping the performance benefits of higher turbine gas temperatures."

Vital to the efficiency of both the General Electric and Pratt & Whitney engines are complex variable-geometry inlet and exhaust systems, which are almost as critical to the aircraft's performance as the engines themselves. They must function at maximum efficiency at any given speed regime to maintain the SST's payload and range requirements. The so-called capture areas must be wide open at low speed and narrow at supersonic cruise. Only computerized analyses can furnish the precise values, without which the SST would lead to physical and economic disaster. For instance, a one percent change in exhaust nozzle thrust coefficient on an SST increases the specific fuel consumption by almost 4 percent—meaning 4,600 pounds (2,086 kg) less payload or 115 miles (185 km) shorter range.

The Loser

Boeing and Lockheed both have invested many millions of dollars of their own funds in SST research. What will happen to the loser? Under the rules of the game, there need not be a loser in the usual sense. For, if the design not chosen meets fundamental criteria, that company will be reimbursed, at least in part, by the Government for its work. Beyond that it would appear likely that substantial subcontracts on the SST will go to the loser, not as an automatic privilege but simply because of the complementary nature of his expertise.

Finally, it is a foregone conclusion that the "loser" will waste little time going to work on preliminary studies of the Hypersonic Transport, a vehicle which, in General Maxwell's opinion, will constitute a great challenge. "The SST's technology was pioneered by the Air Force and NASA. We are now harvesting from their seed beds. The HST builders won't be quite as fortunate. Research in the higher Mach regions is lagging," he said.

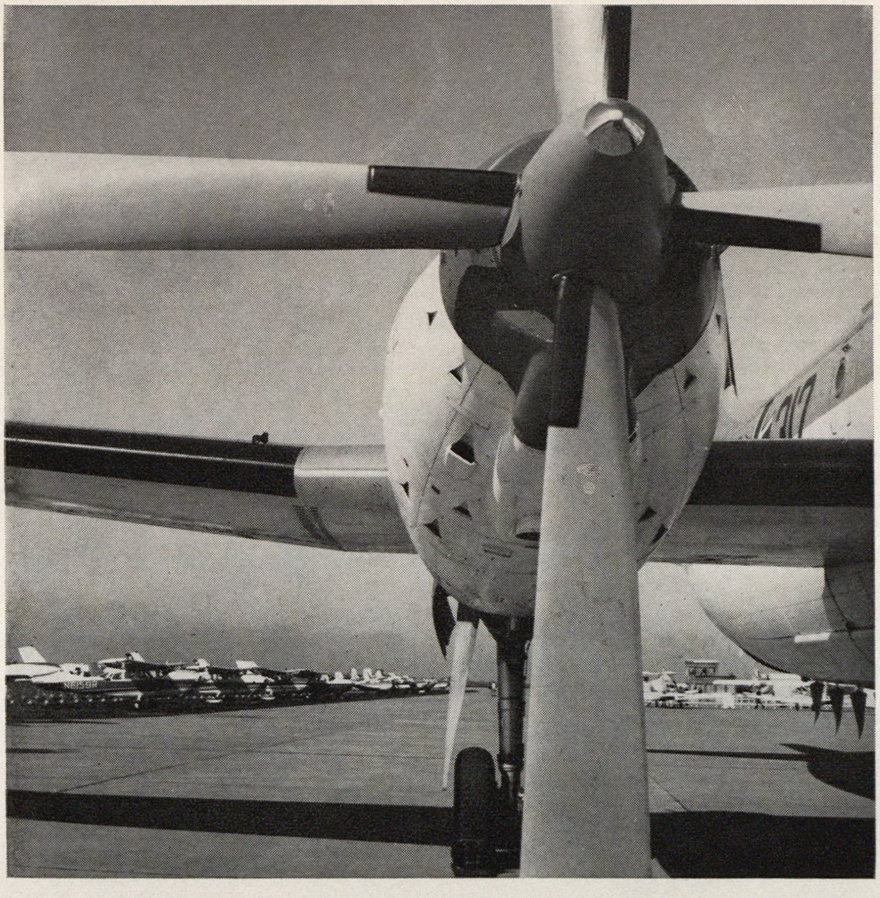
But men like U.S. Senator Monroney, who fight the "folly of shortchanging aeronautics for the sake of astronautics," may yet have their way and bring about a deeper national commitment to the exploitation of technologically advanced flight within the earth's atmosphere.

And Lockheed's Corporate President D. J. Haughton added this comment: "Technology is like a cup. If all you do is drain it, everything dries up. What you take out, you have got to replace. As a company we try to live by this creed. But as a nation we don't always apply this lesson." ☆☆☆

In its biggest presentation since it was founded in 1958, the Hanover Air Fair drew 307 exhibitors and 200,000 spectators. Executive jets and turboprops dominated the scene, along with a representative crosssection of military aircraft, highlighted by Britain's P.1127 Kestrel V/STOL fighter. Although major commercial airliners were missing from hardware displays, their representatives were very much on hand . . .

The Hanover Air Fair: 1966

BY STEFAN GEISENHEYNER, Editor for Europe



Aircraft exhibited at the Hanover Air Fair came from most nations of Western Europe, the U.S., and Canada, some of the satellite countries, and as far away as Japan. The fair drew more than 200,000 spectators in the biggest showing of its 8-year history.

The first Hanover Air Fair took place in 1958 with a total of 65 firms participating. Since that date the German show has experienced such a phenomenal growth rate that, since 1960, as it began to rival the Paris Air Show in size and scope, it has alternated every other year with the Paris show. In 1966 at Hanover a total of 307 exhibitors participated, of whom only 114 were German companies. After Germany, the country most heavily represented was the U.S. with 74 firms, followed by France with 62, and Great Britain with 27 individual exhibitors. One of the British stands, however, represented 50 companies from the United Kingdom.

Also represented were Switzerland with 6, Sweden and Italy with 5 companies each, Belgium with 4, and Canada with 3 participants.

From The Netherlands and Austria came 2 companies each; Japan, Poland, and Czechoslovakia sent single exhibits. The hoped-for Russian exhibit did not materialize. Several Russian visitors in uniform were seen during the show, however, scrutinizing, in particular, the electronics exhibits.

The Hanover Air Fair started out as a light utility aircraft fair. And it has still not overcome this reputation. Compared to the past Paris shows, the amount of the military hardware

(Continued on page 18)

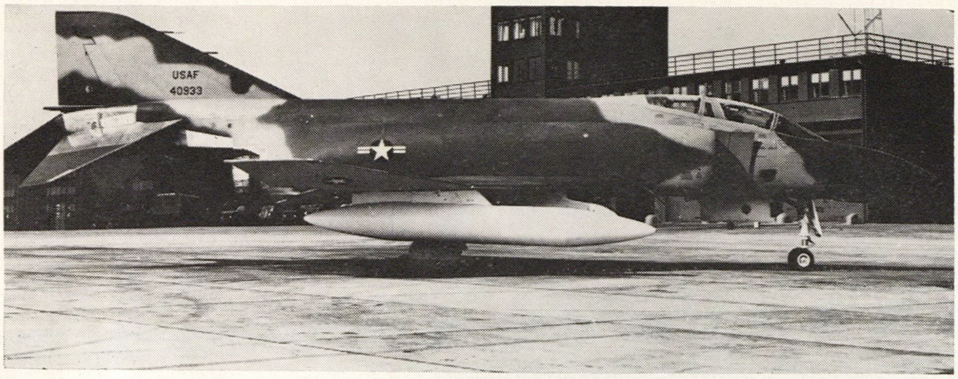
Panoramic view of the Hanover Airport shows some of the huge crowds attending this year's air fair. This photo was taken from almost the same angle as the map published in the May issue of AF/SD INTERNATIONAL (pp. 18-19). In center is Hall B, which housed most U.S. exhibits. Above it is smaller Hall A. To left of exhibit halls are arrayed the many types of military and civilian aircraft assembled for fair-goers.

and aircraft displayed this year was negligible. Thus, the static display area was dominated by a Republic F-105 and a McDonnell F-4C Phantom, both from USAF units stationed in Europe. Landing and parking fees were paid by the respective manufacturers.

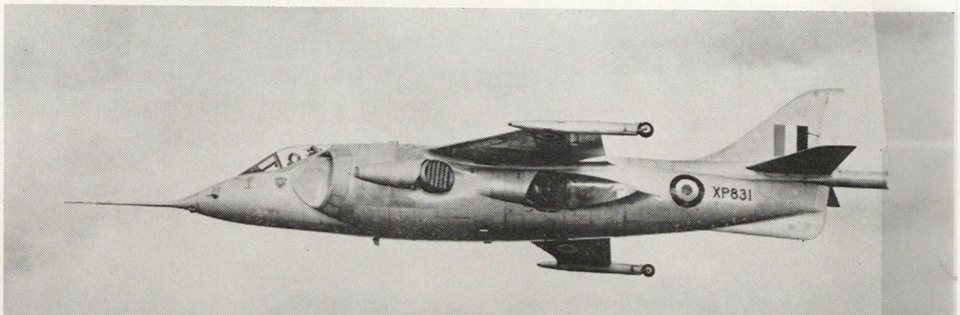
A British Aircraft Corporation Lightning interceptor of the RAF was flown to Hanover at a special request of the British Embassy in Germany, with BAC footing the bill. Also on display was a C.160 Transall, a heavy military transport built jointly by France and Germany, in French colors. The main attraction of the military side of the show was a Hawker Siddeley P.1127 Kestrel vertical/short-takeoff-and-landing (V/STOL) fighter prototype, which was demonstrated brilliantly on several occasions. Two aircraft of the Greek Air Force—a Northrop-built F-5A and an F-5B—were flown regularly during the show, demonstrating the excellent maneuverability of the aircraft.

Aerial Displays

Aerial displays of aircraft included some aerobatics by a Lightning team



Among U.S. Air Force aircraft featured at Hanover was the McDonnell F-4C Phantom II strike fighter. It attracted considerable interest, both because it is relatively new to the European scene and because it will soon enter service with the British RAF.



Britain's soon-to-be operational V/STOL fighter, the Hawker Siddeley P.1127 Kestrel, proved the main attraction among military aircraft. It made several flights, brilliantly demonstrating its unusual capabilities.

of the RAF, the demonstration of a Hawker Siddeley Andover military transport, and some RAF Canberra bombers.

The USAF did not take part in the flying demonstrations, since, due to a communications error, the minimum flying altitude was originally stated by the show management to be 2,500 feet (762 m), far too high even for a fly-by. As it turned out later, lower flight levels could be requested and were granted prior to the demonstrations.

Civilian Exhibits

In the civilian sector, the scene was dominated by the executive jet aircraft. All of the light twin-engine business jets were present at Hanover. The Hawker Siddeley DH-125, the Jet Commander, the HFB Hansa 320, the Mystère 20, and the Lear Jet were demonstrated frequently and reportedly drew some prospective customers who came over from the Hanover Industrial Fair on the other side of town—a fair which overshadows the air fair in size and importance by a wide margin.

The Italian twin-engine executive jet Piaggio-Douglas 808 made its debut in Germany. It is expected to receive its airworthiness certification during the month of August. The Italian Air Force is showing interest in this aircraft and may order it in quantity.

A completely new concept in executive jet aircraft was offered by the Swedish company, SAAB, which showed a model of its SAAB 105 twin-turbofan military trainer with a 5-seat cabin. No decision has been made as yet by the company to go ahead and build the aircraft. If, however, public reaction is favorable, a prototype may be built. A selling price of $450,000 per fully equipped aircraft was mentioned. This would be extremely low if compared to the $650,000 to $1,000,000 prices for the other executive jets.

A real sensation was the first official showing in Europe of 2 Mitsubishi MU-2 twin-turboprop light short-take-off-and-landing (STOL) aircraft, with German markings. They were the first Japanese-built aircraft to come to Europe since the end of the war and most certainly made an excellent impression upon everybody.

The MU-2 seats 6 passengers and is ideally suited for use as a light executive transport. It features excellent STOL performance and soft-field capability. The standard price in Europe will be around $321,000. Since the Turbo Commander was not shown, the only rival in the twin-turboprop field that was shown was the well-known Beechcraft King Air.

Single- and twin-engine light propeller aircraft were the predominant feature of the Hanover Fair. However, not too much that is new was shown. The Italian firm Siai-Marchetti showed its new S.205 4-seater, and Aero Commander brought its series 100 and 200, 4- and 5-seaters, respectively, to Europe for the first time. Most of the other 30 types displayed in this category were old acquaintances, familiar aircraft in the skies over Europe.

Executive jet transports, like West Germany's HFB Hansa 320 shown here, dominated fair's civilian sector. Now being sold in Europe and U.S., the Hansa 320 carries 9 passengers plus 2-man crew at 500 mph (800 km/hr) over 1,000-mile (1,600 km) range.

In the feeder-liner category, 2 aircraft made their debuts during the air show. De Havilland of Canada brought its Twin Otter to Europe, and Dornier showed its twin piston-engine Skyservant to the public for the first time. The latter aircraft is a 12-seat, general-purpose design built for simplicity of maintenance and stability. It should find its market in the underdeveloped areas of the world as a fast transport that can operate from rough strips. The aircraft shown, the first prototype, had logged only 12 hours of flight time. Dornier hopes to begin deliveries in December of this year.

The price for this aircraft is extremely low. Fully equipped, it will cost about $150,000.

De Havilland's Twin Otter is equipped with 2 turboprop engines, seats 15 to 19 passengers, and features a remarkable STOL performance.

Much has been said about the alleged competition between the Skyservant and the Twin Otter. But after seeing them both in operation it becomes obvious that they are basically

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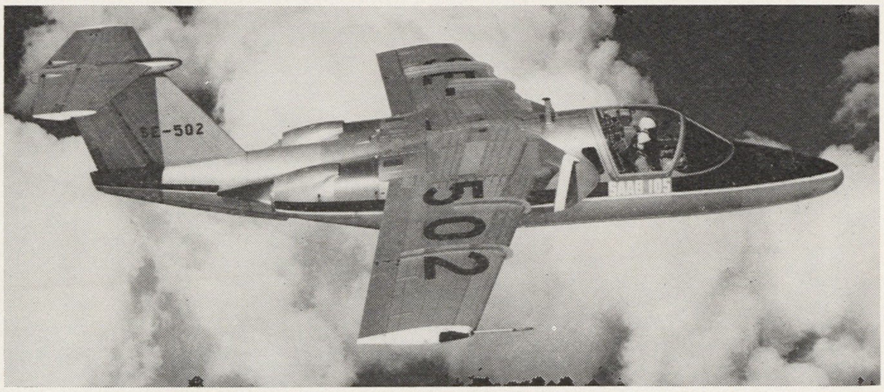
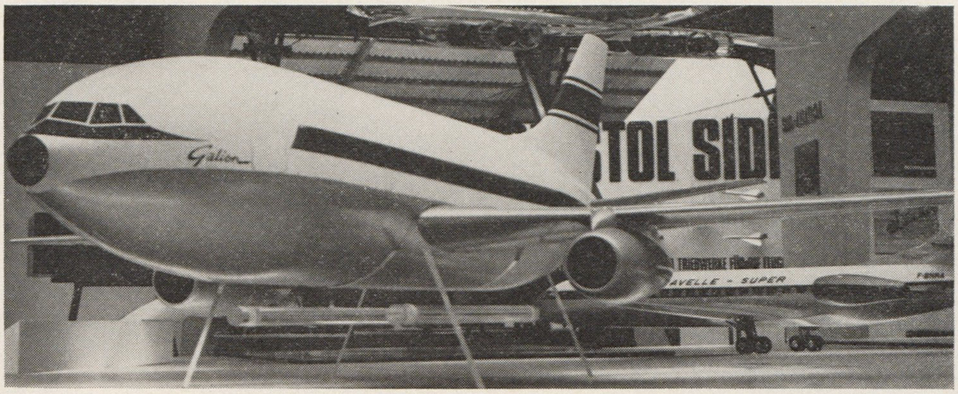


Sweden is bidding for the executive jet market with a commercial version of its SAAB 105 military trainer. A 5-passenger model displayed at Hanover would sell for about $450,000. SAAB is surveying customer reaction before proceeding with its development.



France's Sud Aviation displayed this scale model of the Galion, one of several designs submitted in the European airbus project. The Galion would be powered by 2 Pratt & Whitney or Rolls-Royce engines. West German designers prefer a 4-engine airbus for added safety.

different and will not be competitive at all. The Skyservant is tailored for straightforward bush flying, whereas the Twin Otter will excel as a feeder liner and for certain military purposes.

The Airbus Project

The manufacturers of major transport aircraft have long since come to the conclusion that air shows do not further their sales effort. Therefore, there was not a single big transport on display at Hanover. Company representatives were only too happy, however, to discuss future plans.

One item of considerable interest is the European airbus project. The airbus, a possible British-French-German venture, would be designed to provide mass air transportation in the 1970s. Each aircraft would seat between 250 and 300 persons. The airbus fleet is supposed to operate from specially prepared terminals linked to city centers by modern transit systems.

The idea is undoubtedly not new and will run into the same problem faced by similar proposals: Nobody knows who will finance the new terminal setup.

Further difficulties arise from the different design philosophies of the participating countries. The Germans are proposing a 300-seat, 4-engine aircraft, whereas the French and British have designed a 2-engine, 250-seater. The French-British consortium, consisting of Hawker Siddeley, Breguet, and Nord Aviation, showed at Hanover for the first time their HBN.100 twin-turbofan airbus design in model form. Sud Aviation of France exhibited its model of a similar design, named Galion. Both aircraft can be adapted to use the Pratt & Whitney JT9D or the Rolls-Royce RB.178 powerplants. Each engine delivers about 40,000 to 44,000 pounds (18,100 to 20,000 kg) of thrust.

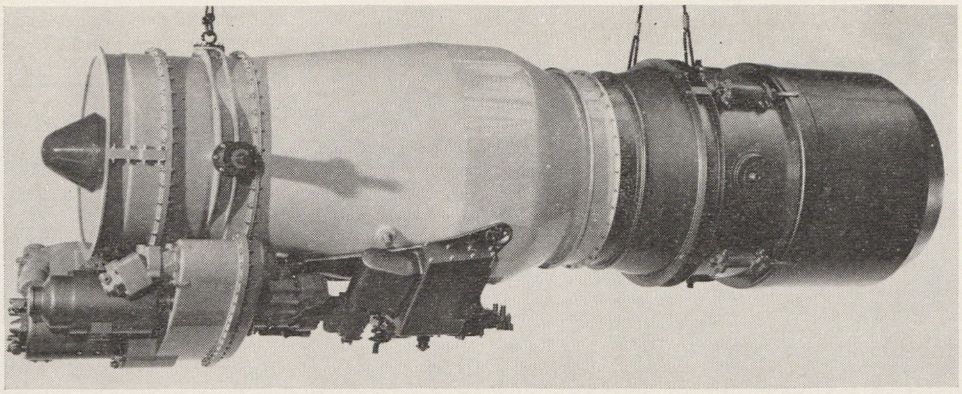
On May 6, a semiofficial meeting among governmental officials from France, Germany, and Britain took place to discuss the future of the airbus plans. The airbus scheme is one of the last chances for a joint European venture. If this opportunity slips by, European aircraft manufacturers may as well bow out of the international transport market and leave it to the 2 giants: the U.S. and the U.S.S.R.

Another project the German aviation manufacturers pin their hopes on, as demonstrated by the life-size fuselage mockup shown at the fair, is the VFW 614. It is a relatively small, twin-jet, short-range transport which was specifically designed to replace the DC-3s still in service. The aircraft can seat up to 40 persons and is also suited to take palletized freight. Its best payload range lies around the 500-mile (153 km) mark.

The design is frozen, and a partnership between Fokker and VFW to manufacture the aircraft is about to be concluded. VFW will get financial support from the German Government, and Fokker is expecting money from the Dutch Government. The engine will be the M45, a Franco-British design by Bristol Siddeley and SNECMA. Since the M45 was designed as a military powerplant, it will be necessary to convert certain assemblies for civilian use. This conversion is being paid for by the German Government and the 2 engine manufacturers.

The prototype of this aircraft is expected to fly in the summer of 1969, and it is hoped that first deliveries can take place in late 1970. It is understood, however, at VFW and Fokker

Developed as a successor to the Douglas C-47 Skytrain is the VFW 614, shown here in an artist's sketch. A partnership is being arranged between VFW in Germany and Fokker in The Netherlands to produce the aircraft. The relatively small twin-jet plane, seating up to 40 passengers, will be powered by 2 Mars M45 engines jointly developed by Bristol Siddeley and SNECMA.



This is a mockup of the Rolls-Royce/Turbomeca turbofan engine which will power the BAC/Breguet Jaguar trainer/strike aircraft. Designated the RB.172/T.260, its thrust rate of 4,200 pounds (1,905 kg) will be increased to 6,300 pounds (2,857 kg) with addition of an afterburner.

that time is critical and utmost speed in designing and building the aircraft is necessary to forestall any moves by potential competitors. The hopes that this aircraft will materialize as the biggest postwar aviation venture of German industry are well founded, since, for the first time, definite governmental interest for a purely civilian project is in evidence.

Powerplant Exhibits

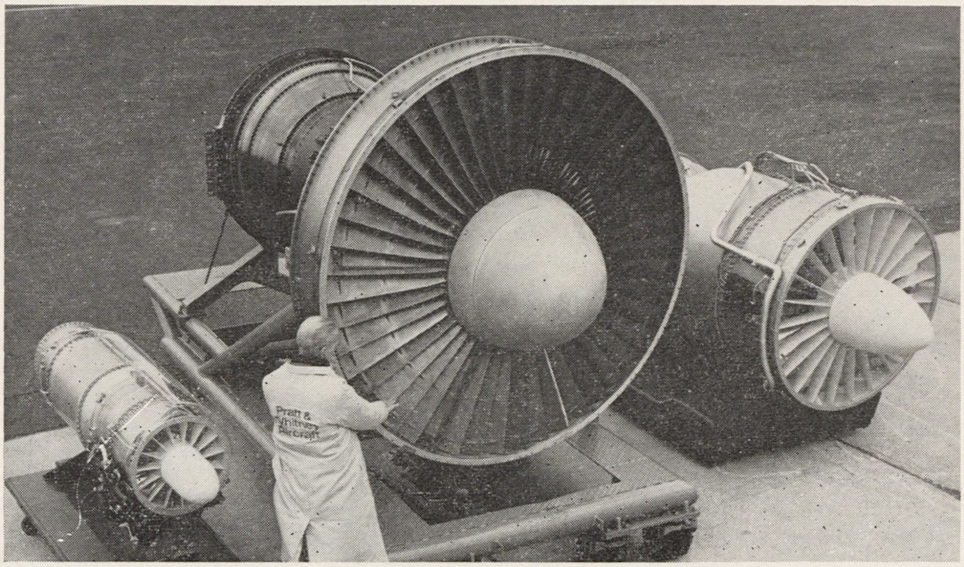
Much discussed in the jet-engine sector was Pratt & Whitney's new JT-9D-1 turbofan, which will power the Boeing 747 and possibly a European airbus design. The thrust of the engine is presently rated at 41,000 pounds (18,600 kg), but an output of about 44,000 pounds (20,000 kg) is expected of the production models. The JT9D features a twin-spool, 2-bearing arrangement and a bypass ratio of 5:1. A novel building-block concept has been employed, which will greatly facilitate maintenance and overhaul, thus making the engine highly attractive to the user.

A competitor of this powerplant on the world market is the Rolls-Royce RB.178, which is in the same thrust class. This design, however, uses a highly complex 3-spool arrangement and a 2-position exhaust nozzle. The RB.178 was constructed for high efficiency at the cost of extreme mechanical sophistication. Though Rolls-Royce engines are held in high regard for their reliability, it remains to be seen whether the airline user is willing to sacrifice valuable maintenance time for high efficiency.

Several important military jet powerplants were on display at Hanover. The most interesting design seen was the Bristol Siddeley/SNECMA M45-G turbofan engine, which is destined for the Anglo-French variable-geometry aircraft. The M45 is rated at 7,000 pounds (3,175 kg) thrust dry, and 12,000 pounds (5,443 kg) with afterburner. The bypass ratio is set presently at 3:1—a figure which may be changed as developmental testing continues. Further noteworthy features are an infinitely adjustable afterburner system and the reported use of internally cooled turbine blades. A civilian version of this powerplant is being developed for the German short-haul liner project VFW 614.

Also shown was a mockup of the Anglo-French Rolls-Royce/Turbomeca RB.172/T.260, a turbofan engine which will power the BAC/Breguet Jaguar supersonic strike aircraft. The design thrust of this new engine is 4,200 pounds (1,905 kg), rising to 6,300 pounds (2,857 kg) with afterburner. The basic powerplant should be suitable for further development into a commercial version, which could be used in executive aircraft, medium-sized airliners, and possibly other military aircraft.

The smallest jet engine on display was the Bristol Siddeley BS.347, weighing only 30 pounds (14 kg) dry, including accessories and electrical equipment. Constructed as a classical centrifugal turbojet, it has a maximum continuous power rating of 140 pounds (63 kg) thrust. The engine is very simple, with only a single-stage compressor and a single-stage turbine. Firm data was not available on fuel consumption or price. The powerplant seems to be ideally suited for light target or surveillance drones. Should the engine be suitable for cheap mass production, it would most definitely find a very good market as an auxiliary engine for gliders and sailplanes.☆☆☆



Powerplant for Boeing's huge new 747 transport is Pratt & Whitney's big JT9D-1 turbofan, shown here flanked by the JT12, left, and JT3D. With a dry weight of 7,800 pounds (3,538 kg) and bypass ratio of 5:1, the JT9D's thrust is rated at 41,000 pounds (18,600 kg) but is expected to reach 44,000 pounds (20,000 kg) in the production version. Inlet diameter is 8 feet (2.44 m).

Forward Air Controllers in Vietnam

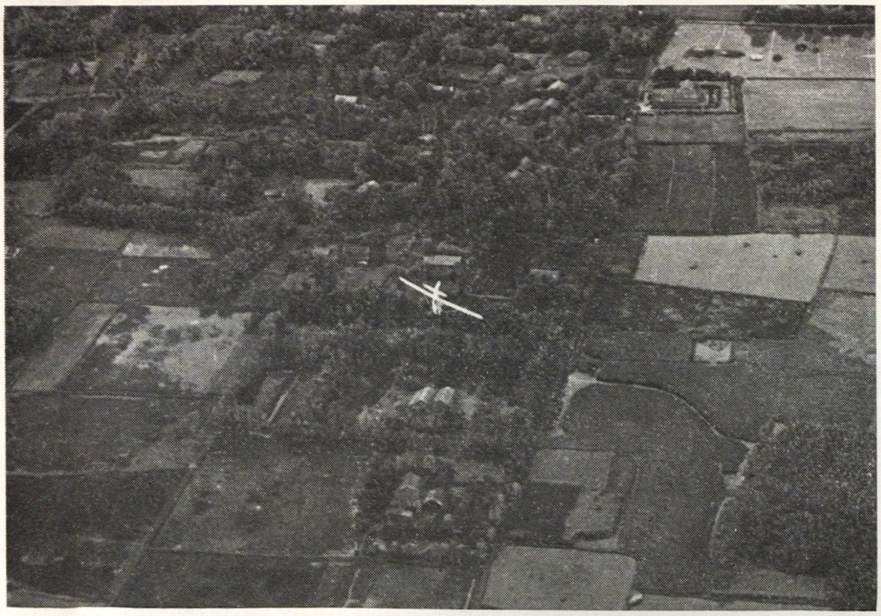
Tactical air operations in South Vietnam are by far the most closely controlled in history. The key to this control is the Forward Air Controller (FAC) in his tiny Cessna O-1 Bird Dog. Highly competent, deeply motivated, the FACs do a big, difficult, and dangerous job extremely well. Airpower in Vietnam is hitting the targets assigned to it—and only those targets. A large share of the credit for this accuracy must go to the U.S. Air Force FACs . . .

They Pinpoint the Targets

BY J. S. BUTZ, JR., Technical Editor

Tactical air operations in South Vietnam are by far the most closely controlled in history. The U.S. has a tactical air control system in operation in South Vietnam which must be considered one of the major achievements of the war.

Understanding how this control system works is essential to understanding what airpower is doing in South Vietnam. Those critics who equate U.S. use of airpower in South Vietnam with the bombing of defenseless cities in the Spanish Civil War, or with Luftwaffe attacks on refugee columns during the blitzkrieg of 1940, or even the massed, high-speed sweeps of Allied fighters over Germany during 1944 and 1945, just don't know what they are talking about. They are arguing from ignorance.



Forward Air Controllers perform an invaluable service by flying over the countryside each morning to see what damage the Viet Cong did during the night. Roads are often cut several times and rendered impassable by the Viet Cong in just one night's work.

Nothing of this sort is going on in Vietnam, nor could it under the current control procedures. No pilot in South Vietnam is free to drop a bomb or launch a rocket or fire a machine gun on his own. There are checks and double checks on all pilot actions. These checks are welcomed by the fighter pilots, for it is virtually impossible, whether in high-performance jets or propeller-driven attack aircraft, to enter an unfamiliar area, locate proper targets, and strike them accurately without help. Without assistance and double checking, someone is sure to make a mistake.

In simple terms, the control system for South Vietnam is an outgrowth of the Forward Air Controller (FAC) system, which has been used in various forms since the beginning of World War II to positively identify enemy targets and protect friendly troops during tactical air strikes on the battlefield. The big difference now is that it is being used to protect civilians as well as friendly troops.

Under the basic FAC plan no target is attacked without obtaining the permission of the Vietnamese province chief involved, as well as the U.S. and Vietnamese military authorities at corps level. Assistance for the strike pilots and checking of their perfor-

Airpower in South Vietnam is in the hands of the chiefs of the nation's 43 provinces. No ordnance can be discharged from an aircraft and no artillery round can be fired in a province without the permission of the province chief. Lt. Col. Le Huu Duc, center, chief of An Xuyen province, confers with Captain George Getchell, USAF, right, one of the province FACs, and an interpreter. Colonel Duc credits airpower with vastly strengthening the government's position in An Xuyen during 1965.

mance is provided by the Forward Air Controller—an Air Force pilot who flies low and slow over targets in a Cessna O-1 Bird Dog aircraft. No target is attacked unless a FAC has verified it as legitimate. And the FAC must guide the fighters into the target area, verbally describe the target or mark it with a smoke rocket, observe the strikes, and report the accuracy with which the ordnance was delivered.

During a 2½-month visit to South Vietnam in the first quarter of this year, I observed this system in both main types of operations conducted by U.S. and South Vietnamese forces. One was in support of sweeps by major ground units searching for the Viet Cong main force. The other was in small actions by South Vietnamese local forces attempting to stop VC harassments, such as mining roads, blocking canals, collecting taxes, and drafting and recruiting soldiers for the Viet Cong.

Today there are more than 250 FACs in South Vietnam. About 100 of them are spread out through the provinces, serving as the "eyes" of the province chiefs. The others are assigned to U.S. and Vietnamese Army units. The Vietnamese Air Force (VNAF) is speeding up the training of its own FAC corps, and in the next year or so it probably will provide all the support for the Vietnamese Army.

Slightly more than 150 O-1 aircraft are available to the FACs. So there is about one FAC airplane for every 4 strike fighters in South Vietnam, a good indication of the close control that exists.

After flying with 8 FACs and talking at length with many more, I find that they have 3 characteristics in common. First, they all have an abundance of what Dr. Harold Brown, Secretary of the Air Force, has described as "political sophistication."

Second, the FACs I knew were all highly competent professional pilots with a thorough background in strike fighter tactics, ordnance, ordnance-delivery techniques, etc.

Third, all had an intense desire to do their job properly. All were keenly aware of their responsibility for having the last word as to which targets were to be bombed and which were not. Everyone had an intense desire to ensure that innocent people were not harmed.

Each Forward Air Controller pilot spends a lot of time in the air. One hundred hours a month is the maximum flying time officially allowed. Many reach this figure on the nose

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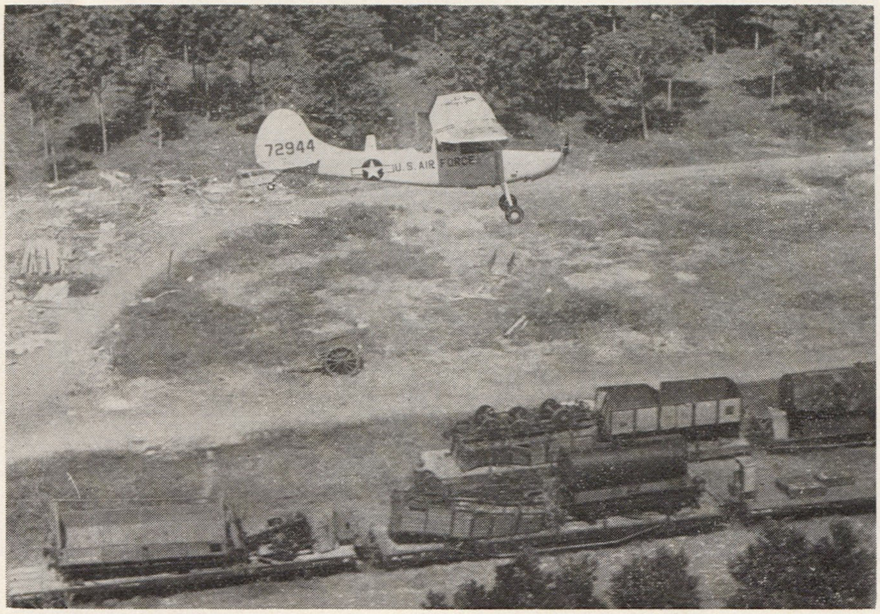
Capt. Lawrence L. Reed, a Forward Air Controller, right, and Capt. La Ba Do, a Vietnamese observer who accompanies Captain Reed on many flights, are shown here checking a map prior to a flight from Song Ba Special Forces Camp.



An O-1F aircraft with a USAF pilot and Vietnamese observer flies over a section of the Saigon-Hue railroad as a wrecking train prepares to remove freight cars damaged by a VC mine. Air surveillance has virtually eliminated daylight attacks on trains.

every month, and the pressure of combat has pushed most of them over the limit at least once.

A Forward Air Controller flight usually lasts more than 3 hours, right up to the endurance of his Bird Dog, which is around 4 hours, if the pilot is carrying no passengers. Normally, the bulk of the flight time is spent on visual reconnaissance (VR), just looking at what is going on in the countryside below. A VR mission takes you over villages, roads, rice paddies, canals, forests, and jungles. Literally the entire nation is covered. A small part of the time the FAC is flying over "safe" territory, held strongly by government forces. The majority of the time, however, he is over "contested" territory where the Viet Cong roam. And the FACs regularly inspect the coastal forests and remote valleys where no one but the Viet Cong has been in 15 years.

The main objective of visual reconnaissance, obviously, is to locate the enemy—to find targets. This is easier to talk about than to do. Many a FAC serves his whole year's tour in Vietnam without ever participating in a major battle. An average FAC might see clearly identifiable Viet Cong troops only 3 or 4 times in a year. Very rarely does a FAC sight more than one such group in a given month.

The best way to get an idea of the difficulty of visual reconnaissance, especially over a crowded rural area, is to go along on a mission. The first question you would ask is, "How can you possibly tell the Viet Cong from the friendlies?" The FACs give dozens of answers to this one, but the best one I heard was, "We can't. Look for yourself. It's about like flying over New York City at 1,000 feet and trying to pick out all the Italians."

No FAC tries to pick out the VC just by looking at them, because he cannot. No part of the air operation in South Vietnam depends for target selection on just looking at people, either at 1,000 to 1,500 feet (300 to 450 m), where the FAC usually flies, or on the ground.

A FAC gathers information primarily in 2 ways. One is by people shooting at him. These are presumed to be unfriendly. The other method is by spotting evidence that the Viet Cong are in the vicinity or have been there recently. The third method is to actually catch the VC at work, but this rarely happens.

In some sections of the country, sporadic ground fire is quite common. The IV Corps area, in the flat, delta region south of Saigon, is considered the worst area in this regard, both for the FACs and the psychological-warfare aircraft, which also come in low, dropping leaflets and broadcasting over airborne loudspeakers.

One or 2 isolated shots at a FAC aircraft will not bring in an air strike. The VC would be happy if they could get a village bombed merely by firing a few shots at a FAC. They could, and would, hold up such an incident to the local people as an "American atrocity."

Normally, the FAC leaves open both back windows of his O-1. At 1,000 feet (300 m) or so he can hear shots fired at him from the ground. If he does, and it is rifle fire, he usually circles and tries to find out where it came from by spotting the muzzle flashes from additional rounds. If the shots are not coming from a village, and if they continue, the FAC may call in artillery, or he may launch one of his rockets to see if that will stop the fire. Most often he will simply report the incident to the province chief and the intelligence officers. Rifle fire must be quite intense before there is any thought of an air strike, and intense rifle fire often indicates some sort of unusual ground activity.

Automatic weapons are another matter entirely. It is difficult to hit an O-1 with a .30-caliber rifle even though the aircraft cruises slowly at about 90 knots and flies low (around 1,000 feet [300 m]). The probability of scoring hits goes up considerably when a .30-caliber machine gun is used. And a good gunner with a .50-caliber machine gun almost certainly will bring down an O-1 if he holds his fire until the plane is just about straight overhead. The O-1 just doesn't have the speed to get out of the area quickly, and the .50-caliber gun is effective to 3,500 feet (1,100 m) altitude and out to oblique ranges of more than one mile (1.6 km).

Consequently, the FAC takes a dim view of being fired on by automatic weapons. Such fire is usually an indication that the VC are present in large numbers and are on an important mission. In such a situation the FAC tries to stay out of effective range of the automatic weapons but he stays in the area. He takes evasive action, flies erratically, never makes the same turn twice. This is the first rule of everyone who fights the VC, on the ground or in the air: Never follow a set pattern. A large percentage of U.S. losses have occurred when an operation was performed 3 or more times in the same manner. The rule applies to field commanders making their weekly visit to higher headquarters, to transport planes supplying remote outposts, to infantry units sending out patrols, to FACs making their morning visual-reconnaissance rounds, and to just about everyone in Vietnam. The wise ones don't pass the same spot at the same time of day or on the same day of the week 3 times in a row.

In the relatively rare case when a FAC comes under automatic-weapon fire, he tries to stay out of range, set up an erratic flight pattern, and locate the gun positions. So far, few .50-caliber machine guns have been used in South Vietnam except in the major battles, but their incidence is increasing. When they are used in small actions, it usually has been against strike fighters. Most often they are fired from the edge of a forest or some other place that provides a ready escape route. The heavy-caliber guns are very valuable to the VC, and they don't risk them in "contested" areas except as support for major attacks. If they are fired at FAC aircraft from positions in Viet Cong strongholds, then air strikes definitely are called in. The larger the ground weapons, the larger the air strike.

In any event, all information on weapons being fired at FACs is fed into the intelligence system, and often it is useful in tracing the movements of major VC units.

Looking for evidence that VC are in the vicinity or have been in the vicinity is the more common FAC activity. One indication is any change in the pattern of ground traffic. If VC units are around, the number of people on village streets and country roads usually decreases and sampans often disappear from the canals. Changing patterns on the scum that forms on small canals and streams usually means the VC have been in the area. Every morning on his visual-reconnaissance rounds, the FAC looks for new trenches dug during the night and watches for additions to old trenches. The Viet Cong have made it a practice to draft villagers to dig fighting trenches and bunkers. In many areas the FAC is never out of sight of these trenches. Sometimes the trenches begin several miles from a fortified village, and weeks are spent digging to within a half or quarter of a mile (.8 to .4 km) of the walls. Weeks later, at some opportune time, an assault is launched. Sometimes the defenders of the town spend many nervous weeks and the attack is never made. Often the VC trenches lie idle for months and finally are used in an ambush of government forces. Sometimes visual reconnaissance reveals new buildings in the VC stronghold areas. Most often this kind of reconnaissance is accomplished by painstakingly flying back and forth over the forest areas around noon when the sun is directly overhead and casts no long shadows.

Much valuable information is gathered on visual-reconnaissance flights, but most FACs think the effectiveness of this operation has been exaggerated. It is often reported that, since they usually operate in one province, the FACs get to know the countryside and its activities "like the back of their hand." This just isn't possible. The job is too big. The best source of intelligence information is from the Army's Special Forces and from agents

Smoke rockets used to mark targets for strike fighter pilots are adjusted by Captain Lawrence L. Reed before takeoff in his O-1F Bird Dog. Captain Lawrence, an experienced FAC, operates out of a small jungle strip in support of U.S. and Vietnamese troops.

on the ground. With such leads, the FACs are able to look over a suspected area quite thoroughly. If they stay long enough, or fly over an area and circle back in 15 minutes or so, taking full advantage of cover, they are often able to catch VC in the open, and sometimes able to provoke them into firing.

Through all of this activity, a FAC tells the province chief and the US and Vietnamese military commanders at the district air support center (DASC) at corps headquarters exactly what he is doing. If he wants to call in artillery, he needs permission from the province chief; for air strikes, he must get permission from both the province chief and the DASC. No single office or headquarters has the authority to order the bombing of a village. If the VC are using a village as a headquarters, storage point, staging area for local raids, or for similar activities, any plans to bomb it must be approved at the province, corps, and national command levels. The villagers are warned in advance by leaflets and by loudspeaker planes. The FAC is on hand to guide the strike aircraft onto the proper target.

The question of judgment comes up more frequently in emergency situations when U.S. or Vietnamese Government forces are actually engaging the Viet Cong and running into trouble. Last year about 20 percent of the air strikes were expended in emergencies. They usually occur during VC ambushes of convoys or surprise attacks on fortified outposts. Here, unless the VC has overrun the friendly troops, it is easy for the FAC to direct air strikes. The friendly forces mark their lines, and tell the FAC the area from which they are receiving fire. The FAC guides the strike aircraft there. When such attacks come from heavy cover, it is assumed that anyone near the battle is a combatant.

During search-and-destroy operations by forces of brigade or division strength, the ground commander usually is granted a Tactical Area of Responsibility (TAOR). This means that requests for close air support can bypass the province chief to keep response time to a minimum. The FAC, however, must continue to validate each target and direct the strike fighters.

Even though many of these sweeps have not located any Viet Cong, most U.S. units have been strongly opposed at one time or another. The VC strike suddenly from hills, in groves of trees, behind dikes, and in villages. Sometimes a sweep may go through a village and then the VC pop out of tunnels in its rear. The fighting often is tough and full of surprises. Villagers and farmers are apt to suffer severely if caught in such fighting, just as they would in a full-scale war.

U.S. battalion commanders I talked with say that the opposition must become severe before they call in air strikes on a village. They point out that the VC would have us completely stymied if the ground forces pulled back and called for air support every time they received a few rounds of sniper fire. Ground commanders say

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they depend heavily upon the FAC above their unit to tell them what is ahead—civilians as well as men with guns, trenches, and so on. The FACs say that even during heavy fighting there is time to inspect targets closely and to avoid hitting civilians.

As fighting airmen, the FACs in Vietnam have earned the kind of praise from their contemporaries that comes to few men. The fighting units of the U.S. Army are unanimous in praising the close air support that the Air Force has provided for them in battle. In some battalions, no one can remember a single instance in which they could have registered a complaint. Relations between the Army and the Air Force have never been as good as they are in close air support in Vietnam.

Army people give the FACs and the USAF Air Liaison Officers (the FACs' bosses at Army division level) most af the credit. As one battalion commander put it, "The Air Force sent some very competent young officers to our division. They came in here and sold airpower, and made it work. They didn't stop until they gave us exactly what we needed, which sometimes wasn't what we thought we wanted."

A similarly high reputation is enjoyed by the FACs attached to the commanders of the 4 South Vietnamese corps, by the 43 province chiefs, and by the various Vietnamese Army units.

FACs first began this type of duty in 1962. They operate from airstrips scattered across the entire area of South Vietnam. At least one of them is close to every possible trouble spot. Until the big airpower buildup began last year, a FAC often was the only "air force" that could reach remote areas and stay for hours in an emergency. Even today, a FAC can often beat a flare ship or fighters to a beleaguered outpost by 30 minutes. In bad weather, the light, slow O-1 still may be the only aircraft that can get over troops in trouble.

The U.S. Army Special Forces and Vietnamese troops and their U.S. advisers operating in remote areas have a special regard for their FACs. It is normal for FACs to make night flights to an outpost as soon as it is attacked, to drop 2 flares and shoot the 4 rockets they can carry on the O-1, to stay in the area regardless of the ground fire, and to give both the defenders and the attackers the idea that airpower is on its way. Many a FAC at one time or another has flown low over the target, firing his automatic rifle out of the window with one hand and flying the aircraft with the other. FACs have directed air strikes from above virtually every battle, large and small, for nearly 4 years.

Despite their fine showing to date, FAC pilots see many possible trouble spots for the immediate future in equipment, management, and doctrine. If these problem spots are not properly solved, the FAC loss rate could go up, the efficiency of the tactical air control system go down, and the excellent relationship now existing between the Army and Air Force could be seriously affected.

The first and most serious need is for a new airplane. The O-1 has done a good job, but all of the pilots believe it has outlived its usefulness. Ground fire is getting to be more of a problem, and the VC are bringing in more .50-caliber machine guns. Six FACs were lost during the first 3 months of this year, compared to 12 lost in all of 1965.

A much more powerful aircraft with an initial rate of climb on the order of 3,000 feet (900 m) per minute is now needed to reduce the vulnerability to ground fire. This kind of aircraft would be in a class with the P-51 Mustang of World War II. With it, the FAC would be able to cruise at 2,500 feet (760 m) at about 90 miles an hour (145 km/hr), dive down to 1,500 feet (460 m) to take a closer look, reach an airspeed of about 150 knots during the dive, and have enough momentum to climb back up to 2,500 feet (760 m) with the addition of just a little power. Such maneuvering could be kept up for long periods without excessive fuel consumption.

Two engines are considered indispensable, even though they would raise the cost of the aircraft and increase the maintenance problems. But the pilots believe 2 engines will save many aircraft and be the most economical design in the long run. And even more important is what the second engine would contribute to the safety of future FACs.

The twin-engine OV-10A COIN (counterinsurgency) aircraft being developed by North American Aviation, Inc., meets these basic requirements, and most FACs are anxiously awaiting it. However, the first of the 150 OV-10As that the Air Force has on order are not due to reach Vietnam until the middle of 1967. Many FACs strongly believe that if some World War II fighters could have been designed and built in 90 days or so under high-priority programs, then the same sort of priority and effort should have been put into the OV-10A project. Under any circumstances they believe the 19-month-old project should be speeded up now and the aircraft brought into action in the next several months.

Other items on the FAC shopping list include: A liberal amount of lightweight armor around the pilot; full gyro instrumentation so they can fly weather properly; 8 smoke rockets for marking targets instead of the 4 carried by the O-1; provisions for carrying at least 8 flares, making the FAC more useful over troops at night; a 7.62-mm Minigun pod to strafe targets of opportunity too small to warrant calling in fighters; an IFF transmitter to allow radar stations to keep positive control on the location of the FAC; and 4 radios—2 FM, 1 VHF, and 1 UHF, which is 1 more FM set than the O-1 carries today, and would allow better communication with the 2 Army sets. All of the FACs rate P-51-type acceleration and climb performance at the top of the list.

There is not so much agreement on

FACs in Vietnam are eagerly awaiting the arrival of the North American OV-10A in mid-1967 to replace the Cessna O-1s now in use. The twin-engine reliability and very fine rate of climb of the OV-10A, which rivals that of the World War II P-51 Mustang, are high on the list of priorities for FAC pilots in combating Viet Cong antiaircraft fire.

Air Force FAC, 1st Lieutenant Ted Kyte (right foreground), confers with Lt. Col. Steve Phillips, Commander of the 1st Battalion, 2d Infantry Regiment, at command post situated in an old Viet Cong base camp in Zone D. They are communicating with aircraft over PRC-25 backpack radio maintained by Airman Second Class Daryl N. Laws (center foreground). The Army personnel at left are manning the battalion's tactical operations center in a "hooch" roofed by the Viet Cong with U.S.-made beer cans.

other requirements. Some FACs want to carry bombs up to 1,500 pounds (680 kg). Others don't want them. Some want armor around the engines. Others think this would reduce performance too much.

Some attempts are being made to improve the O-1s so that they will be more acceptable until the OV-10As arrive. The first such move the FACs regard as a failure. This was to camouflage all FAC O-1s with a mottled brown on top and a light blue on the bottom. It is very good camouflage. It worked for the Germans in World War II, and it works for us in Vietnam on strike fighters. It is so good, in fact, the strike fighters can't see the FAC when they come over a target at 15,000 feet (4,600 m) or so. When the O-1s are painted silver, sighting the FAC is no problem.

To correct this, the camouflaged O-1s were recalled to the paint shops again, and a big strip of high-visibility Day-Glo paint was put on top of the wings. But strike fighter pilots say that the silver O-1 is still the easiest to see from above. And anyone who has seen a mottled brown, blue-bottomed O-1 go over at 1,500 feet (460 m) knows you can't conceal any aircraft at that low altitude.

FAC operations now vary widely in the 4 corps areas and in the various Army units. Some of the differences are dictated by the terrain or peculiar conditions of a locality. Others are due simply to the preference of the Army commanders. Even though the differences in techniques are substantial, all of the FAC operations are going well. Most FACs expect trouble if any attempt is made to force conformity.

There is much debate as to the value of an airborne FAC compared to a FAC on the ground with the troops. Most Army people feel that the FAC in an airplane is absolutely essential and certainly more valuable in Vietnam than the ground controller. As long as the high ground is not secure and the ground FAC must stay with the troops, the airborne controller is going to be able to see much more. The ground FAC would come into his own if antiaircraft fire became intense or if the U.S. were to lose control of the air.

Questions of close-air-support control and the proper methods of FAC operation are at the heart of all military discussions today. No one operation will be adequate for any given war. However, U.S. experience in Vietnam, to date, indicates that the airborne FAC is far more valuable than the ground FAC.

Still, some Army divisions do not want to give up the ground FAC. The 1st Cavalry Division (Airmobile), for instance, wants the FAC assigned to each battalion, working with that battalion on the ground during all field operations. A pool of FACs from battalions not in the field is formed to act as airborne controllers. In this case, the ground FAC serves essentially as an Air Liaison Officer for the battalion commander, handling all his requests for air support, much as the battalion artillery officer handles the artillery request chore.

In the 1st Infantry Division, the situation is completely different. Only one battalion commander really wants a ground FAC with him in the field. So this is the only battalion that gets one.

Many different flight techniques are used. In the flat delta, in the southern part of the country, most FACs stay at 1,200 feet (365 m) or higher. They reason that if they get very low, the open fields of fire give the VC too much time to shoot at them.

In the rubber plantation and jungle terrain north of Saigon, the FACs often fly right on the tops of the trees. Here a man on the ground has only one chance to hit a FAC, and he must fire straight up into the air. Chances of scoring a hit are small. The FAC, in turn, has only one chance to spot buildings or men under the trees and that is to look straight down.

In the mountainous country of I Corps, in the north, FACs usually travel in pairs, with one O-1 down about 300 feet (91 m) above the trees most of the time and the other well over 1,000 feet (305 m) above the terrain. Back in the deep valleys that must be covered by visual reconnaissance in this area, the FACs cannot be tracked by radar and their radios often are ineffective. If one goes down in one of these valleys, his only link with friendly forces and his only chance of rescue would lie with his fellow FAC above.

All in all, the FACs in the field are exceedingly competent individuals who perform with a minimum of direction. This was proven during the rapid airpower buildup last year when the 2d Air Division (now redesignated Seventh Air Force) gave the FACs their head. The FACs certainly aren't self-sufficient, however. They need help if they are to continue to play an outstanding role in Vietnam.

But the kind of help they need is in terms of equipment—a better airplane, night reconnaissance aids, improved target-marking devices. No one needs to tell the FACs how to find and fight the Viet Cong. They are doing very well with what they have. They only want to do better. ☆☆☆

Technology is overtaking policy in the communications-satellite field. While there is no doubt that the International Telecommunications Satellite Consortium (INTELSAT) will deploy a truly global system before the end of the decade, there are numerous knotty questions concerning frequency allocation, national interest, cooperation or competition with the Communist world, impact of the emerging nations, and sharing of the industrial market for components. The U.S. has its own set of special domestic problems centering around ownership of earth stations, cables vs. comsats, and whether its COMSAT Corporation should be the sole operator of space communications systems . . .

Communications Satellites: Prospects and Problems

BY WILLIAM LEAVITT
Senior Editor/Science and Education

Of all the technologies to emerge from the space age, communications satellites show the greatest promise of quickly transforming man and his works in the years ahead. Already the relays-in-the-sky have made possible truly international television. They have provided instantaneous military communications from places as far apart as Washington, D. C., and Saigon when conventional radiotelephonic methods were inadequate. They have significantly enlarged transatlantic telephonic communications capabilities.

This is only the beginning. Tomorrow's comsats, as communications satellites are popularly termed, will allow rapid relay of business data (linking the computer to the satellite). They will enable diplomats to communicate via "hot lines" that will make today's Washington-Moscow emergency links seem primitive. And, through direct-broadcast abilities that are already foreseeable, they could serve as all-encompassing "schools in the sky" for the millions of illiterate and deprived peoples of underdeveloped nations. This latter prospect was described in some detail on these pages in the February 1966 issue (see "Spaceborne Video and the Revolution of Rising Expectations").

Comsats, linking the world's peoples more tightly together than ever before, will complement the coming revolution in aeronautics that will enable businessmen, travelers, and government officials to move supersonically, and someday, hypersonically, from continent to continent at incredible speeds. It is not an exaggeration to suggest that the arrival of communications satellites presages the development of a kind of "world culture."

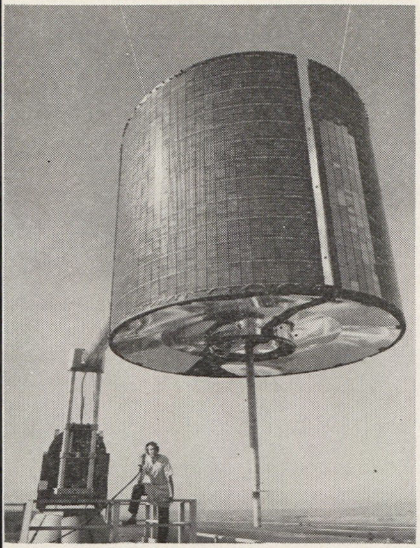
All this amazes even the imaginative Englishman, Arthur C. Clarke, who, only 21 years ago, suggested in the magazine "Wireless World" that 3 communications satellites, placed at equidistant synchronous altitudes of some 22,500 miles (36,200 km) above the earth, could serve the entire globe. Happily, Mr. Clarke, who was a British radar development officer during World War II, has lived to see his prediction begin to come true. Now one of the world's most celebrated science writers, he good-naturedly wrote recently of how he lost a billion dollars by not patenting and cashing in on his idea. But, of course, the world was not ready for such miracles of the space age back in 1945.

There is no doubt that the technology is available, or nearly so, to achieve most of the purposes outlined above, both in the Free World and in the Soviet Union. The Soviets have already inaugurated domestic satellite communications service with their Molniya vehicles, which have relayed not only telephony but also Russian television broadcasts.

Toward a Global System

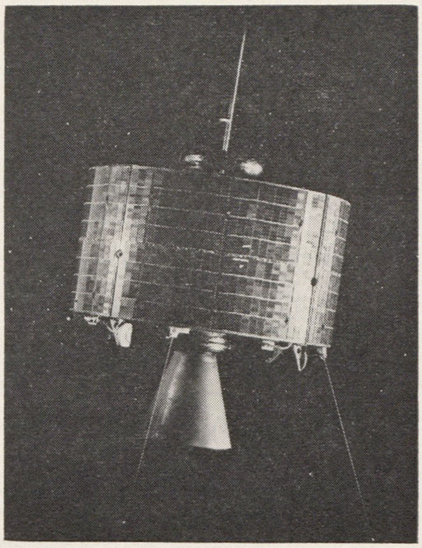
In the non-Communist World, 51 nations, including countries which are virtually at war with each other, have joined in the International Telecommunications Satellite Consortium (INTELSAT), with the purpose of creating a global synchronous satellite network. The United States, by dint of its role as one of the 2 present major space powers, has been designated manager of the INTELSAT system, and the job of management has been delegated to the U.S. Communications Satellite Corporation, which is becoming known throughout the U.S. as COMSAT.

COMSAT is a unique corporation in that it was specifically created in 1962 by the U.S. Congress as a semiprivate organization in which shares are held by individual American citizens and by the major American communications carriers. At the same time, COMSAT's operations are subject to the control of and jurisdiction of the U.S. Federal Communications Commission, a Presidentially appointed regulatory body. In addition, a number of members of COMSAT's board of directors are appointed by the President of the United States. COMSAT's unusual character was the result of a compromise reached in the American Congress after a bitter debate between the proponents of a purely private corporation and total public ownership.



Early Bird, at left, built by Hughes and deployed for COMSAT Corporation over the Atlantic, is an advanced version of the Syncom system and is providing telephone and television service between Europe and America. A Pacific Early Bird will soon provide a similar service in that area.

Feasibility of synchronous communications satellites was demonstrated by the Hughes-built Syncom, at right, originally developed for NASA and now transferred to the Defense Department, which is using them for military communications. Synchronous orbits have best earth coverage; 3 or 4 can serve entire globe.



Like all political creatures, COMSAT, in its short life, has had its troubles. They revolve around such legal questions, still being adjudicated within the FCC, as whether or not Congress intended COMSAT to be the sole U.S. communications-satellite operator and whether or not COMSAT should own and operate the ground stations that are the indispensable earth segments of satellite-communications technology. There is a large and lucrative market in earth-station ownership, and the communications carriers want a share of it.

At present COMSAT is operating under interim authority from the FCC that gives the Corporation these prerogatives, but the questions are still not finally settled. Another particularly interesting dilemma, which may someday vex other nations, is whether or not private companies ought to be allowed the right to launch and operate their own satellite communications systems.

The American Broadcasting Company (ABC)—one of the three major radio-television networks in the U.S.—has raised the question by asking for the right to operate its own television-relay satellite system. This may well be a uniquely American problem, but it is illustrative of the kinds of questions that make policy a more difficult problem than the complex technology of space communications itself. At this writing, COMSAT is attempting to design a U.S. domestic system that will satisfy both the carriers and radio-TV networks.

But these are American domestic questions. They have not stood in the way of the rapid advance of a global system. COMSAT, as manager of INTELSAT, is pressing ahead, under interim agreements that will be renegotiated in 1969, with the development of a global comsat network.

The global system will proceed in the face of the many complex international political questions that in a sense are worldwide projections of some of the U.S. domestic policy problems described above.

As James McCormack, a retired Air Force major general and former Vice President of the Massachusetts Institute of Technology, who is now Chairman of the Board of COMSAT, says:

"Beyond a shadow of a doubt, there will be a single global communications-satellite system. The funds are already committed, and the agreements made."

The General was referring to the planned launch in 1968 of 4 synchronous satellites, to be designed and built by TRW Systems of California. This system, an INTELSAT venture managed by COMSAT, will handle a minimum of 1,200 2-way telephone conversations simultaneously or 4 television channels. The system will also serve the U.S. Apollo moon-landing project's communications needs. (For a further report on the new synchronous satellite system see "Aerospace Review," page 38.)

Even before that, the current "experimental" Early Bird system over the Atlantic will be replaced by a new Hughes Aircraft Company-built advanced version. Another new Early Bird will be placed in orbit over the Pacific to provide comsat service over that vast area similar to the service that exists now over the Atlantic. Hughes deserves much credit for its pioneering development of the first successful synchronous-satellite-communications system—Syncom. Syncom is now being used by the U.S. Defense Department after being transferred from the aegis of the National Aeronautics and Space Administration. Hughes has questioned the need for the TRW system. But from all indications, COMSAT, acting for and in agreement with INTELSAT, means to press ahead.

Military Systems

Meanwhile, the U.S. Defense Department is, at this writing, about to launch a series of near-synchronous comsats, built by Philco, into equatorial orbit. The launch vehicle will be the U.S. Air Force's powerful Titan III booster. These satellites will serve Defense on an interim basis until the development of an advanced system for the 1970s. Such purely military comsat systems are designed for maximum security. The decision to proceed with them was taken after a rather rancorous argument between Congress and the Defense Department at a time when the Defense Secretariat seemed to be considering buying most of its comsat service from the COMSAT Corp.

After the successful use by the military of the Hughes-built Syncom system—and in view of the international problems that might have arisen from military security requirements on an international commercial system in which the U.S. would be, after all, only one partner with many other nations—the U.S. Administration decided to plan a large-scale, purely military, comsat network for secure messages.

Worldwide military communications by satellite are by no means the only project of interest in this growing field. U.S. Defense officials are openly talking of tactical communications whereby military commanders could relay command-and-control battle information over even short distances more reliably via space than by conventional radio communications.

To return to commercial space communications, COMSAT Corporation, in its capacity as INTELSAT manager, is now asking for industrial proposals from around the world on the design of a multipurpose communications satellite. According to COMSAT, the multipurpose satellite would weigh as

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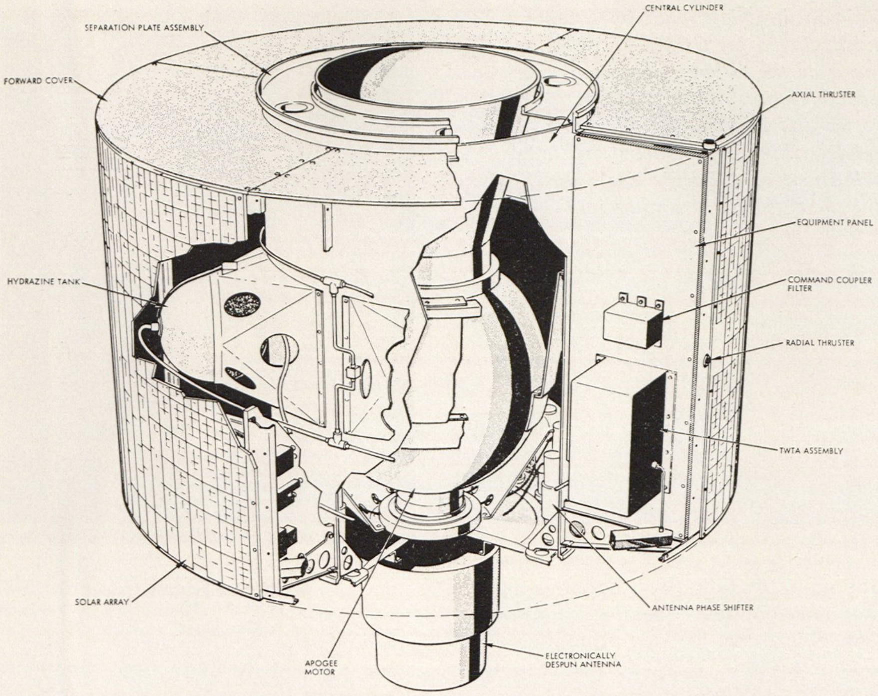

TRW SYSTEMS

GLOBAL COMMUNICATIONS SATELLITE

Physical Characteristics

System Reliability:	0.62 for 5 years
Structure:	Conventional sheetmetal construction, central cylinder with honeycomb equipment panels and solar substrates.
Size:	56 inch (142 cm) diameter; body height 37 inch (94 cm)
Weight:	234 lb (106 Kg) excluding apogee motor - including prorated separation assembly weight
Payload:	4 spacecraft per booster
Separation:	Vee-groove clamp assembly (Marman-type) with separation springs, ordnance actuated bolt cutters
Stabilization:	Spin (140-160 rpm)

This is a schematic of TRW System's Global Communications Satellite, scheduled for deployment by COMSAT Corporation for INTELSAT in 1968. Four will be launched into synchronous orbit, with 2 held in reserve. The system will be able to handle 1,200 2-way telephone conversations simultaneously. The expected reliable lifetime will be 5 years, a large step on the road to the 20-year lifetimes predicted for future systems.

James McCormack, retired Air Force major general, and Chairman of the Board of COMSAT Corporation, is confident of the future of global communications by satellite. But he acknowledges the lag between policy and burgeoning technology, symbolized by both the domestic legal questions COMSAT is facing and the various international questions ranging from frequency allocation to the impact of the new techniques on world politics and the emerging nations.

—Wide World Photos

much as 2,300 pounds (1,040 kg) and would provide many times the current total capacity of all international telecommunications means. It would also have a "truly large-scale" television-distribution capability. It would further have potential for airline traffic communications. The multipurpose vehicle, COMSAT says, would permit access to all these services from a practically unlimited number of earth stations.

In the field of airliner communications, COMSAT has already undertaken successful experiments on 2-way relays between earth stations and airliners via satellite. The tests have led to further studies by COMSAT, Pan American World Airways, and the U.S. Air Transport Association. COMSAT has proposed to the FCC that a satellite specifically for this purpose could be orbited by late 1967 over the Atlantic.

Earth stations are a crucial part of comsat technology. And there is great interest in showing U.S. industrial capabilities to participating countries for a market that may amount to hundreds of millions of dollars worth of complex hardware and technology. Consequently, in May, at a Washington meeting, delegates from 43 countries heard technical presentations from American industry. The foreign delegates exchanged technical ideas and heard what U.S. industry has to offer. Many also toured the facilities of such companies as Radio Corporation of America, Hughes Aircraft Company, Philco Corporation, Rohr Corporation, and North American Aviation, Inc. The market potential suggested by the prospect of 30 to 40 countries building earth stations, costing about $3,000,000 each, is formidable. The foreign visitors were afforded views of American capabilities not only in field trips but also by displays in the State Department hall that served as the site for the lengthy conference.

The commercial future of satellite communications is clear. It is equally clear that INTELSAT, presently spearheaded by the United States, is anxious to link as many nations as possible by 1969. At that time, the INTELSAT agreements are to be renegotiated into more permanent form. INTELSAT's invitation to all countries, east and west, still stands, and there have been reports that Yugoslavia may be interested in joining.

Policy Problems

The problems are not technical, but political.

Just some of the present dilemmas are:

- How rapidly can comsats be put to work to their full potential in the

The very large market for industry in the field of developing earth stations for use with the communications satellites has major international significance. In May, delegates from 43 countries around the world convened in Washington for a lengthy earth-station technology conference, heard presentations from U. S. industry, exchanged technical ideas, and many of them toured the facilities of U. S. aerospace and communications companies.

face of the enormous investment in conventional communications networks —on the ground and under the sea— that already exists in the advanced areas of the world?

- What are the best institutional arrangements for international cooperation, so vital to a workable global system? Will the Communist world join INTELSAT? In Vienna, in May, the Russians talked of entering the commercial market, and there are reports of her interest in direct-broadcast television from comsats to conventional receivers. Might China join Russia in such a venture?
- How can the political and economic purposes of such Western entities as the French community or the British Commonwealth be best served? Is it economically practical for them to develop separate systems over and above their adherence to the INTELSAT global network?
- How much of a share of the component market for the satellites will non-American technical companies have? There is certainly no enthusiasm in the advanced Western countries for U.S. comsat hegemony. There is already written into the INTELSAT agreements provision for such participation by other members of INTELSAT. Yet the intricacies of arranging an equitable industrial distribution of the potential market for the space and earth segments of comsat technology are formidable.
- What about the physical limitations of the electromagnetic spectrum? Should the frequency allocations problems be thoroughly reviewed by the International Telecommunications Union, the international body that disburses the frequencies?

On this point, both COMSAT's General McCormack and James O'Connell, the Director of Telecommunications for the White House, have both expressed concern. General McCormack points out that for the systems of the late-1960s the existing allocations of 500 megacycles "up and down" are sufficient but that for really advanced systems there could be interference with existing microwave ground networks. There is hope that current research into hitherto uncrowded areas of the frequency spectrum might provide technical solutions. But, in the end, the problem is political and will have to be solved by international agreements.

Mr. O'Connell put it this way recently to an audience of communications specialists in Washington: "We will run smack up against this situation unless we do a better job of planning utilization of the spectrum than we have in the past."

He contrasted conventional cables and communications satellites, and pointed out that cables have the one great advantage of making no demands on the radio spectrum. "We could pave the ocean floors with them to take care of the communications explosion," he said.

It is also true that cable technology, naturally, and under the pressure of the competition of comsats, is advancing. A crucial advance is the oncoming ability, using transistorized equipment which increases the number of voice channels, of cables to relay television. Until now, undersea cables have not had enough voice channels to relay video. American Telephone & Telegraph Company and International Telephone & Telegraph Corporation—both pioneers in comsats and shareholders in the COMSAT Corporation—are working on development of cables with 1,200- to 1,500-voice-channel capacity. This would be a major improvement over the 138-channel capacity of the newly laid transatlantic cable.

In addition, undersea cables currently have about 20 years of expected usefulness, while comsats are at this point working toward 5-year lifetimes. It is expected that eventually 20-year lifetimes will be possible for comsats too. There are those who have suggested that the key to such reliability and multipurpose diversity might well be the presence of onboard crews.

Manned Comsats?

Two experts who have advanced this idea are Hawker Siddeley's G.K.C. Pardoe, who with his colleague, L. W. Steines, declared in a recent paper:

"The reasons in the past for advocating separate satellites for [various communications functions] have stemmed from considerations of weight constraints and reliability. These objections can be overcome if a manned satellite is envisaged with the crew providing maintenance and operational capability. With the techniques of orbital rendezvous successfully demonstrated, there is no reason why such a large general-purpose spacecraft should not be assembled in orbit, and why in time several such craft should not form a comprehensive global network.

"Certainly such a network would be costly and fundamentally international in character, but the benefits would be equally great. . . . We are only on the threshold of an expanding, stimulating, and important era of world communications via satellites.

"We recognize the pattern as one of complex utilization against a background of international ownership, management, and development. Administrative, political, and legal questions will be as great or greater than the technical ones. Solutions to all of them must proceed hand in hand if we are to succeed, as indeed we must."

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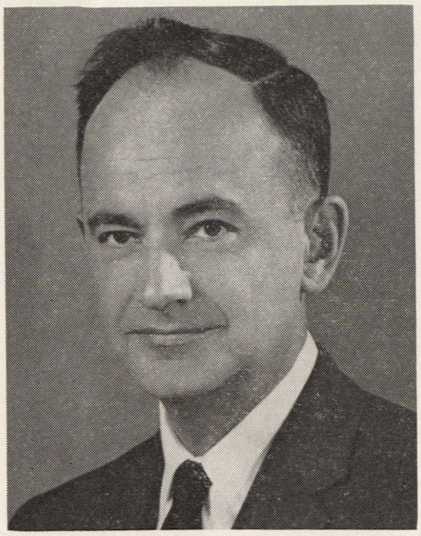


Dr. Joseph V. Charyk, President of COMSAT Corporation and former Air Force Undersecretary and Assistant Secretary for Research and Development, sees reliability and long life as the 2 technical keys to a comsat system's future technical and commercial success.

Again, on the subject of cables vs. comsats, it is a measure of the complexity of merely the domestic U.S. situation that COMSAT Corporation has publicly opposed AT&T's wish to lay a new 720-channel cable, with video-transmission capability (see above), in the Caribbean. AT&T is not only the major American communications carrier but is also a large shareowner in the COMSAT Corporation.

As General McCormack told the annual COMSAT shareowners' meeting in Washington: "All these [American] carriers are, by definition, 'authorized users' of COMSAT's service. They are also COMSAT's owners, up to 50 percent, as provided by law. At the same time, they are our competitors to the extent that COMSAT's services duplicate their services, existing or projected."

Anarchy or Evolution?

Are all these domestic and international political questions—questions that illustrate the lag between technology and policy that plagues every aspect of the modern era—going to lead to a kind of anarchy?

General McCormack thinks not. He sees a future development of a basic global network, supplemented by specific networks sponsored by nations or groups of nations for their own purposes. Among other possibilities there may be other purely military systems, such as those contemplated by the United States. There may even be a large-scale French-Soviet system serving Europe. But although there is British interest in a Commonwealth system, the General believes that the United Kingdom will probably stay with the INTELSAT global network.

As to the idea of a series of regional or other systems integrated into a global system, he considers that an idle prospect. He believes that the INTELSAT global system will prove commercially attractive enough for worldwide usage, and that any other systems will be put up for purely national reasons, if the money is available and the motivation strong enough.

What about the Russians? General McCormack considers that they certainly have the ability to put up their own systems—they already have done so. Indeed, if they choose to, they could probably offer to sell at cost or even give educational-television satellite systems to underdeveloped countries. Since the Soviets do not have to worry about such mundane questions as returns to shareowners, such policies might be much easier for them to execute than for the United States or the West generally.

Vis-à-vis conventional and cable communications, General McCormack foresees a gradual replacement, especially in the field of television, of existing systems by comsats. In the meantime, the existing conventional communications base will take up much of the other communications traffic. Finally, comsats will come into their full maturity as the microwave, sea cable, land wire, and other conventional systems begin to reach their full capacity. This would be a relatively orderly evolution.

The Emerging World

What about the underdeveloped countries, where there are no really large-scale existing microwave-relay ground systems to be interfered with, either physically, in terms of the spectrum, or commercially, in terms of existing financial investment? This question is crucial since direct-broadcast techniques now considered near at hand, once the onboard power systems are decided on (they would probably be nuclear), could perform such great tasks in education.

This is a special case. It would seem so easy technically but the political questions are enormous. Could America unilaterally offer such systems? Should the non-Communist advanced world combine to offer such systems? How are propaganda and educational materials to be differentiated? Who would do the programming? What about authoritarian societies? Do their leaders want their peoples to enter the 20th century? And who will pay the bill? Could the United Nations do the job?

For all these questions, there are presently few, if any, answers. But there are developing understandings of what the problems and prospects are.

It is recognized that the situation of the underdeveloped countries is different. Modern technology, particularly communications and transportation technology, can turn out to be the angel—or the devil—of their futures. As specialists never tire of warning us, the emerging countries stand at the brink of chaos unless they can quickly absorb, in styles suitable to their societies, the best of Western technology.

Their peoples are demanding a share of the good life of their former colonial masters, and unless some measure of their aspirations is provided there can be no peace. In an age of onrushing events, it may be that the only way for the emerging world to catch up with the advanced societies is by leap-frogging, skipping over developmental phases through which the West progressed in a more leisurely past.

Thus, in the view of many, there is no time for and little point in railroad building in parts of Africa where present transport is primitive. These areas should go now into air transport and even serve as the testbed for advanced aerial techniques such as vertical- and short-takeoff aircraft.

In the same vein, illiteracy, the bane of lands like India, can and must be overcome by the most advanced techniques available, such as direct-broadcast educational television to community receivers. In the end, it may be cheaper and more effective to bypass the conventional techniques which may never be able to meet the demands of the population. Why bother, in communications, with construction of expensive conventional ground-relay systems, when communications satellites can do the job over large areas at low cost and with vast coverage?

Against this backdrop of 2 divergent worlds sharing a single planet, the art and technology of global satellite communications is rapidly advancing, at a rate that has surprised technical planners, governments, and even the industry itself.

If there is one fact that has emerged from this rapid development, it is that technology is outracing policy. Thus, the best energies of government and industry must be devoted to the solutions of international and national problems of how to build the communications satellite systems and accompanying institutions that will ensure both public benefits and commercial utility from the new technology.

In view of the complexity of the problems, it is reassuring that a start has been made at all. ☆☆☆

Mockup of world's largest transport—the C-5A—unveiled . . .

First Step For a Giant Aircraft

The mockup of the 121-foot-long (36.9 m) C-5A cargo compartment looks like a huge tunnel in this photo, taken from the rear ramp. The compartment is longer than the Wright brothers' first flight at Kitty Hawk. A proposed commercial version of the C-5A, called the L-500 by Lockheed, would have 3 decks and carry some 900 passengers. Military version will carry 75 troops on top deck, in addition to cargo load.

A full-scale mockup version of the U.S. Air Force C-5A transport has been unveiled by Lockheed Aircraft Corporation at its Marietta, Georgia, plant.

The C-5 cargo deck is 121.1 feet (36.9 m) long. Two of the Army's biggest trucks can drive into the C-5 side by side. Three jeeps abreast have room to spare. The aircraft's cargo area, measuring 34,734 cubic feet (983.7 m^3), has more floor space than 3 good-sized houses.

Most types of equipment assigned to a normal Army combat division will fit into the aircraft.

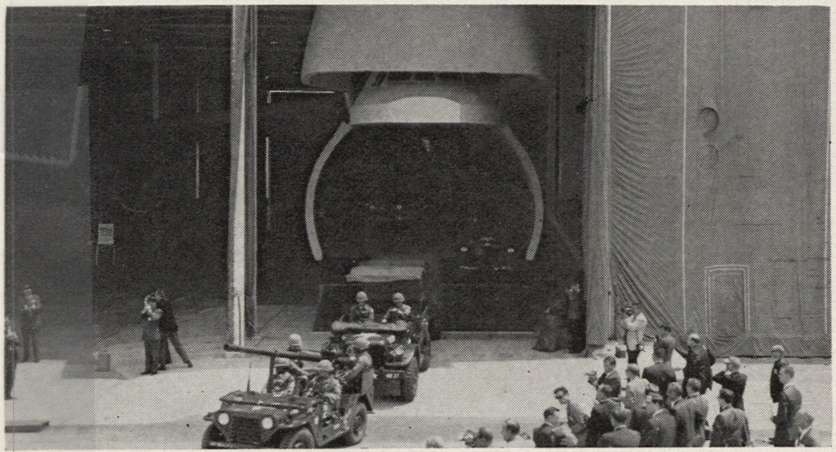
First of the huge cargo craft—said to be the world's largest—will be delivered to Military Airlift Command in less than 3 years.

The aircraft will fly 3,600 miles (5,800 km) with its 110 tons (99.7 mt) or will carry a 56-ton (50.8 mt) payload 6,300 miles (10,140 km). It will cruise at well over 500 mph (800 km/hr) and land on 4,000-foot (1,220 m) dirt runways no firmer than the average soccer field. Taking off empty, it can be airborne in 4,000 feet (1,220 m).

With cargo doors fore and aft, loading and unloading is rapid—a necessity when a transport aircraft is on the ground in a combat area. Although not planned for use as a troop carrier, it will carry about 75 troops in addition to cargo, enabling operators to move with their equipment.

Savings anticipated in the new airlifter are striking. The C-124 Globemaster requires 38 flying hours to reach Yokota Air Base, Japan, from Kelly Air Force Base, Texas. Cost per cargo ton is more than $800. The C-141 StarLifter can fly to Yokota in 14 hours 40 minutes at a cost of some $350 per cargo ton. The C-5 will deliver cargo for about $170 a ton over the same route. ☆☆☆

Robert H. Charles, Assistant Secretary of the Air Force for Installations and Logistics, who took part in unveiling ceremonies at Lockheed's Marietta, Georgia, plant, rides out of mockup in Army jeep.



One of the most important new capabilities offered by the C-5A will be its ability to carry the Army's largest field equipment, including tanks, helicopters, and missiles, as well as bulky construction equipment.
At left, during the mockup unveiling ceremony at Lockheed's Marietta, Georgia, plant, U. S. Army trucks and armored vehicles roll out of the main cargo compartment, after the nose visor of the mockup has been raised and ramp lowered.

Many aerospace planners are convinced that sooner or later an aerospace craft able to be flown through reentries to controlled landings on conventional airfields will have to be developed to serve orbital operations. It is doubtful that the present method of using large naval task forces to fish astronauts out of the ocean can continue indefinitely. The lifting-body principle may provide an answer to the problem. USAF and NASA are exploring its potential . . .

LIFTING BODIES:

Really Flying Home from Space

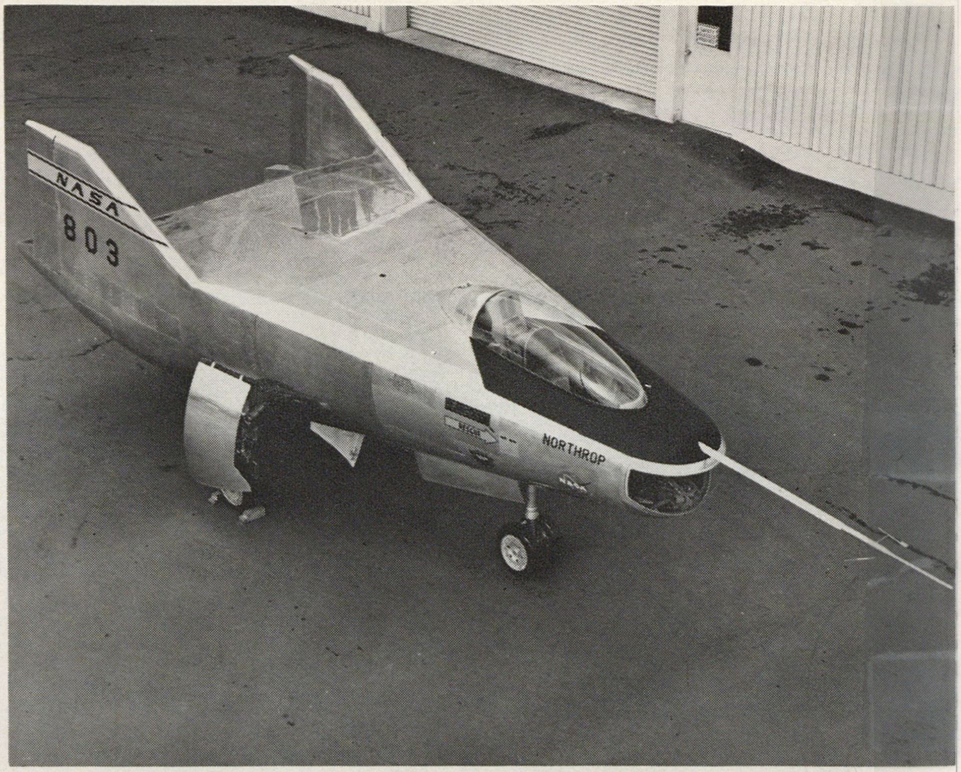
There will have to come a time, many aerospace planners believe, when spacecraft will roar in from orbit through the fiery heat of reentry and land in approximately the manner of present-day aircraft on conventional airfields.

The costs and complexities of Mercury- and Gemini-style landings at sea, with large naval forces required to fish pilots from the ocean, cannot be considered practical except for the early research-and-development phases of space operations.

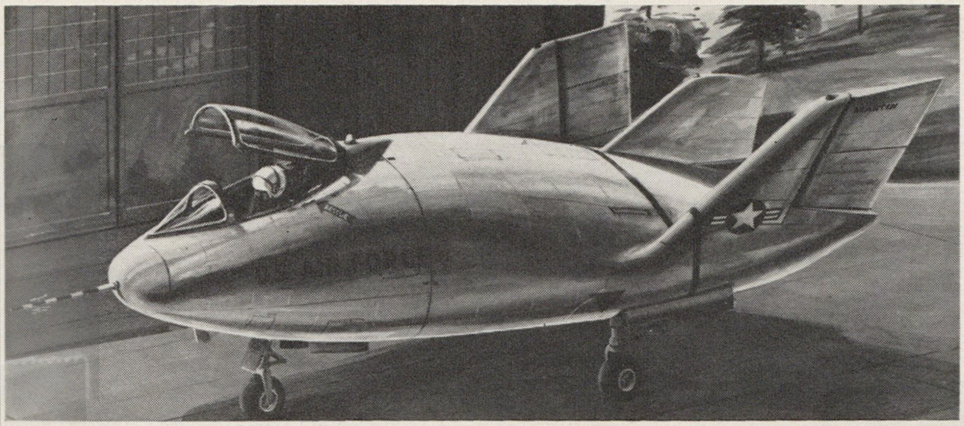
The fact that the Apollo mooncraft will end its homeward mission at sea is an indication of the relatively primitive state of technology of that vast project.

The lifting-body principle, whereby the entire body of the aerospace craft provides the lifting ordinarily created by the wings of aircraft, may supply an answer to the problem of really controlled reentry.

Both the U.S. Air Force and the National Aeronautics and Space Administration are working on wingless-spacecraft ideas that may lead to such a conventional-landing capability, using designs employing the lifting-body principle. The Air Force program is called ASSET, a 4-phase effort, the third phase of which will begin in 1967. It will use the manned vehicle (see photo) called PILOT, or SV-5P, which is some 24 feet (7.3 m) long and about 10 feet (3 m) across its tail fins. PILOT will be produced by the Martin Company and will be dropped from a B-52 from an altitude of 40,000 to 50,000 feet (12,190 to 15,240 m) to unpowered landings at arrival speeds of 120 to 150 miles per hour (193 to 241 km/hr). In later tests a B-52 will take



This is the M2-F2 lifting body, developed for the National Aeronautics and Space Administration by the Northrop Corporation. The craft is flat-topped, has 2 vertical tail fins, and is 22 feet (6.7 m) long. It will be flown to a conventional landing on an airfield after being dropped, much in the manner of the U.S. Air Force-NASA X-15 rocket airplane, from under the wing of a B-52 bomber. The M2-F2 is one of 2 vehicles—the other, the HL-10, is being developed for such research by Northrop for NASA.



This is an artist's conception of the Martin Company's SV-5P PILOT manned lifting body, the U. S. Air Force's entry in the lifting-body research effort. Fitted with onboard rocket power, it will be carried aloft by a B-52, rocket itself to altitudes of 100,000 feet (30,480 m), and be flown to an airfield landing.

the PILOT craft to altitude from which it will be released and rocket-boosted to some 100,000 feet (30,480 m) and then be flown to earth at cruise speeds of more than 1,000 miles per hour (1,609 km/hr).

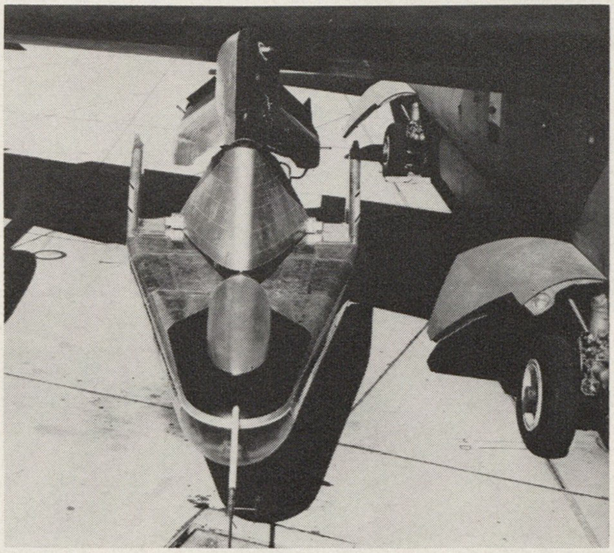
PILOT is a manned follow-on to earlier Martin-USAF efforts. These include the already-completed ASSET project in which the structural problems of high-speed maneuvers of lifting bodies were studied, and the Martin-USAF PRIME effort, in which a lifting body called SV-5D will be boosted to suborbital altitude and hypersonic speed, then be guided into a reentry path. At about Mach 2 speed, the recovery sequence will start, and the PRIME SV-5D will be slowed for its landing by a parachute system.

NASA's entries in the lifting-body program are the Northrop-built M2-F2 (see photo), a manned craft which is scheduled soon for launching from a B-52 mother craft at 45,000 feet (72,450 m) to be glided to earth by NASA test pilot Milton O. Thompson, and the HL-10, a similar craft, also built by Northrop. The HL-10 is half-conical in shape, has a flat bottom, 3 vertical fins, and is 5.5 feet (1.7 m) wider across the tail than the M2-F2. Both are 22 feet (6.7 m) long. The M2-F2 is flat-topped and has 2 vertical fin-tails. At present, neither has rocket-boost engines aboard, but it is likely that as the programs proceed, they will be added to increase performance by allowing the craft to reach higher altitudes after release from the mother aircraft and develop higher cruise glide and landing speeds.

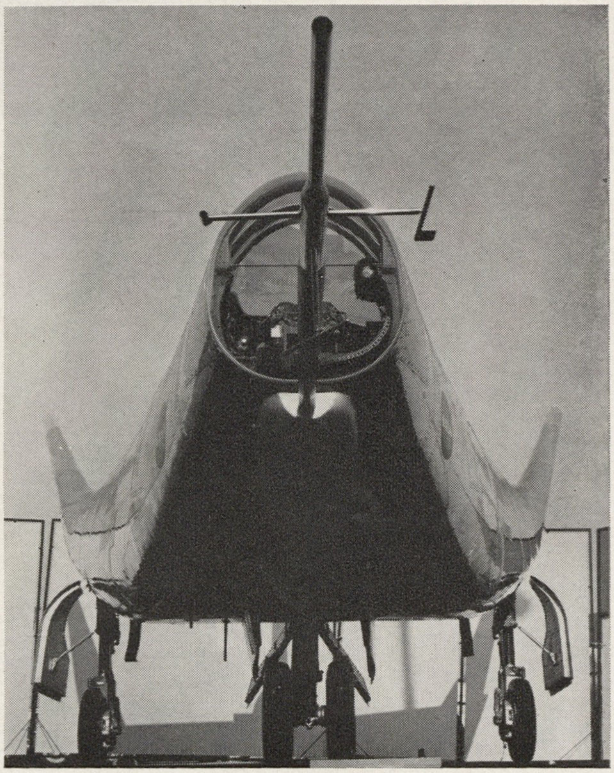
The Martin SV-5P and the Northrop M2-F2 and HL-10 are all roughly similar in size but vary in shape because of the varying degrees of lift designed into them.

Martin Company, which is already working with the Air Force on PILOT, is also going to do an 11-month study for NASA of costs, crew size, and problems of manned-lifting-body vehicle research programs.

—By William Leavitt



At left, the M2-F2 is fitted under the wing of the "mother" B-52 craft. At present the 2 Northrop vehicles do not have onboard rocket power, as the Martin SV-5P PILOT will have. But planners hope that budgets will allow inclusion of booster rockets to permit an increase in the research craft's performance.



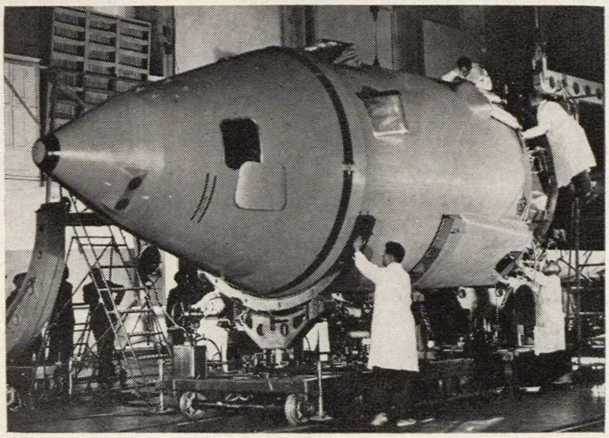
This is the second Northrop lifting-body research craft being built for NASA. It is the HL-10. It is somewhat different in configuration than the M2-F2, is half-conical, flat-bottomed, has 3 fins, and is 5.5 feet (1.7 m) wider across the tail than its sister craft. The HL-10 could evolve into a multiman vehicle. Martin Company is studying ways to mate it with various existing space boosters.

Soviet emphasis on manned spaceflight. . . .

U.S. achievements in applications . . .

Space 'Firsts'—America's and Russia's

Gemini-6 in rendezvous with Gemini-7.



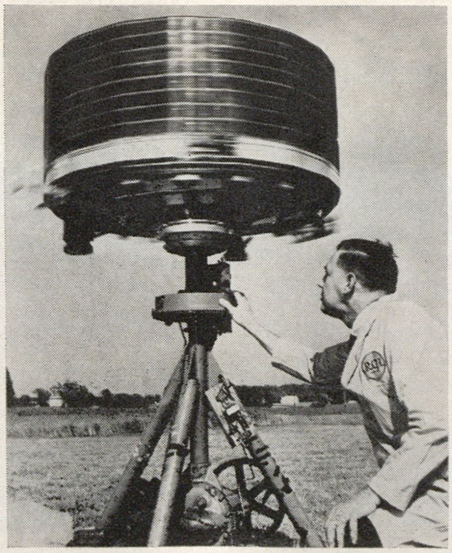
Vostok spacecraft being prepared for flight.

The Soviet emphasis on manned spaceflight from the very start of their space programs back in 1957 is evidenced by the chart (see opposite page) recently prepared by the National Aeronautics and Space Council.

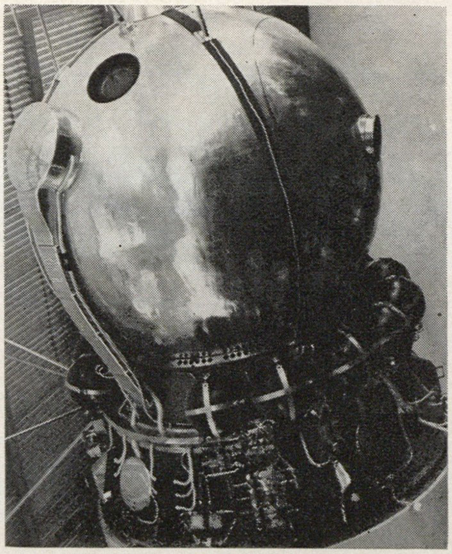
The Council is composed of major U.S. officials, including Secretary of Defense Robert S. McNamara and National Aeronautics and Space Administrator James E. Webb. It is the leading advisory group on aerospace policy in the White House. Council Chairman is Vice President Hubert H. Humphrey.

At the same time, the Space Council chart shows, the United States has led particularly in the field of "working satellites," such as weather-trackers and communications satellites. These are endeavors that the Russians are, relatively speaking, only beginning to get involved with.

The chart also indicates American scientific discoveries in space, such as the revelation of the Van Allen radiation belts in 1958, and the Mars photos of 1965, are considerable. But the Soviets have by no means neglected unmanned exploration, as witness their successful soft landing on the moon and earlier lunar dark-side photos in 1959, and their series of first Martian and Venusian "fly-bys." ☆☆☆



Tiros III infrared satellite in spin test.



Vostok capsule exhibited at 1965 Paris Air Show.

LISTING OF MAJOR SPACE "FIRSTS" ACHIEVED BY THE US AND THE USSR

	UNITED STATES			UNION OF SOVIET SOCIALIST REPUBLICS		
	Event	Satellite	Launch Date	Event	Satellite	Launch Date
SCIENCE	Discovery of Van Allen radiation belts	Explorer I and III	2/1/58 3/26/58	First orbiting geo-physical laboratory	Sputnik III	5/15/58
	Discovery that earth is "pear shaped"	Vanguard I	3/17/58	First photos of the moon's far side	Luna III	10/4/59
	First orbiting solar observatory	OSO I	3/7/62	First comprehensive cosmic-ray station	Proton I	7/16/65
	First successful probe of Venus	Mariner II	8/27/62	First pictures from lunar surface	Luna IX	1/31/66
	First geodetic satellite	Anna IB	10/31/62			
	First close-up pictures of the lunar surface	Ranger VII	7/28/64			
	First coded data over 100 million miles	Mariner IV	11/28/64			
	First space pictures of Mars	Mariner IV	11/28/64			
	First comprehensive micrometeoroid satellite	Pegasus I	2/16/65			
APPLICATIONS	First active communications satellite	Score	12/18/58			
	First TV pictures from space	Explorer VI	8/7/59			
	First weather satellite	Tiros I	4/1/60			
	First navigation satellite	Transit IB	4/13/60			
	First missile detection satellite	Midas II	5/24/60			
	First passive communications satellite	Echo I	8/12/60			
	First nuclear explosion detection satellite	Vela Hotel	10/17/63			
BIOASTRONAUTICS AND MANNED SPACE FLIGHT	First manned orbital maneuver	Gemini III	3/23/65	First biosatellite	Sputnik II	11/3/57
	First manned propulsion outside craft	Gemini IV	6/3/65	First orbited animals recovered	Korabl-Sputnik II	8/19/60
	First sustained space rendezvous	Gemini VII and VI	12/4/65 12/15/65	First orbited human recovered	Vostok I	4/12/61
	First docking of two craft	Agena Target Gemini VIII	3/16/66 3/16/66	First approximate rendezvous	Vostok III and IV	8/11/62 8/12/62
				First multi-manned craft in orbit	Voskhod I	10/12/64
				First man to leave capsule in space	Voskhod II	3/18/65
SPACE FLIGHT AND PROPULSION	First multiple payloads	Transit IIA and Solrad I	6/22/60	First satellite	Sputnik I	10/4/57
	First recovered payload	Discoverer XIII	8/10/60	First escape payload	Luna I	1/2/59
	First air snatch payload recovery	Discoverer XIV	8/18/60	First lunar impact	Luna II	9/12/59
	First synchronous satellite	Syncom II	7/26/63	First orbital launch platform	Sputnik V	2/12/61
	First multiple orbits	Vela Hotel I and II	10/17/63	First Venus fly-by	Venera I	2/12/61
	First hydrogen-fueled rocket to orbit	Centaur II	11/27/63	First Mars fly-by	Mars I	11/1/62
	First suborbital test of an ion engine	SERT IA	7/20/64	First ion engine test in orbit	Voskhod I	10/12/64
				First plasma rocket tested in orbit	Zond II	11/30/64
				First Venus impact	Venera III	11/16/65
				First lunar soft-landing	Luna IX	1/31/66
				First lunar orbiter	Luna X	3/31/66
AUXILIARY POWER SYSTEMS	First solar cells on craft	Vanguard I	3/17/58	As compiled by National Aeronautics and Space Council, April 15, 1966		
	First craft with isotope power	Transit IVA	6/29/61			
	First craft powered only by nuclear energy	Transit VBN I	9/28/63			
	First nuclear reactor in orbit	Snapshot I	4/3/65			
	First space use of fuel cell	Gemini V	8/21/65			

Two Air Force general officers have been selected for promotion to 4-star rank and high-level assignments in Europe, and 2 others will assume major commands in the U.S. . . . Lockheed is ending production of its spectacular Mach 3 SR-71 and YF-12A. . . . Danger of fire in jet crashes may be reduced through FAA tests now in progress. . . . The Air Force and Navy are collaborating on a new versatile fighter plane. . . . The Marine Corps has pioneered development of "instant airfields" . . . and studies in voice communications may lead to automatic translation into any language. Thus the month's aerospace news is highlighted by . . .

Promotions, Pyrostatics, and Phonemes

BY ALLAN R. SCHOLIN, Associate Editor

Lt. Gen. William S. Stone

Lt. Gen. David A. Burchinal

President Lyndon Johnson has nominated Lieutenant Generals William S. Stone and David A. Burchinal of the U.S. Air Force for promotion to 4-star rank and assignment to top military posts in Europe. General Stone will succeed General Robert M. Lee as Air Deputy to the Supreme Allied Commander in Europe (SACEUR), and General Burchinal will become Deputy Commander in Chief of the U.S. European Command (EUCOM) in place of General Jacob E. Smart. Both appointments are effective August 1, upon retirement of Generals Lee and Smart.

General Stone, 56, has been Deputy Chief of Staff for Personnel at U.S. Air Force headquarters in Washington for the past 4 years. A native of Cape Girardeau, Missouri, he is a 1934 graduate of the U.S. Military Academy and completed pilot training in 1935. For

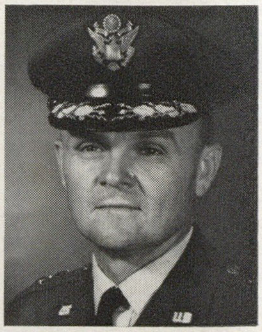
(Continued on page 40)

Lt. Gen. R. J. Reeves

Lt. Gen. James Ferguson

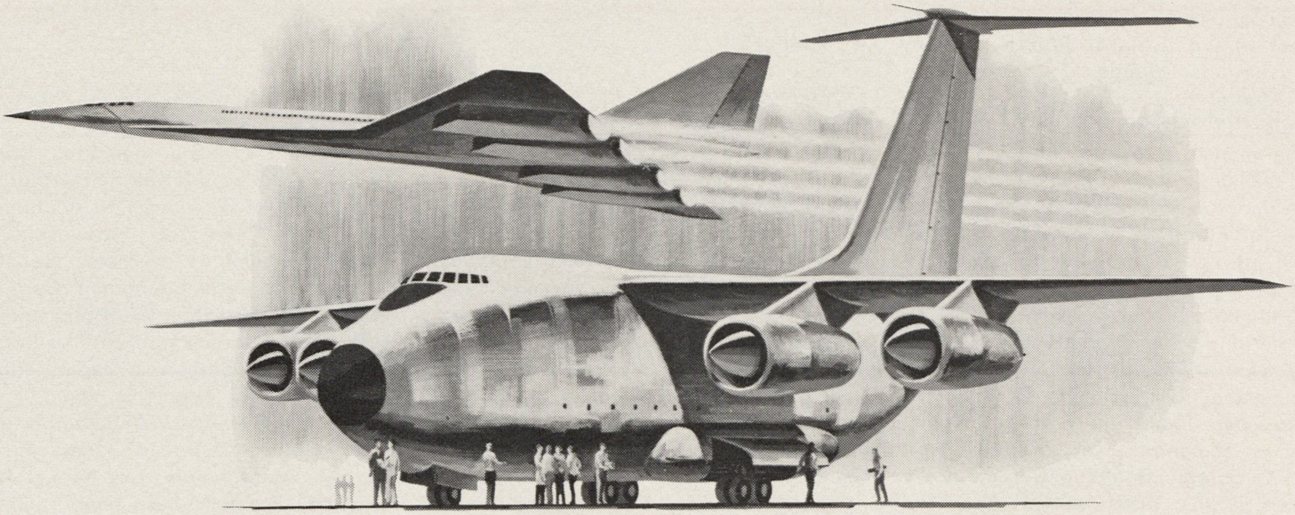
Lt. Gen. W. W. Momyer

Maj. Gen. Seth McKee



Maj. Gen. A. C. Agan, Jr.

Garrett's Total Integrated Pneumatic System concept can save several millions of dollars on the C-5A and SST programs. Here's how:



Garrett's Total Integrated Pneumatic System (TIPS) approach for major aircraft programs combines all air-using subsystems and secondary power in the airplane as a single system. Garrett is totally responsible to the customer for all phases of system design, development, manufacture and support.

Garrett-AiResearch's complete capability in the management of environmental and anti-ice control, secondary power generation, including engine starting and auxiliary power, is integrated for optimum *total* performance rather than as separate subsystems.

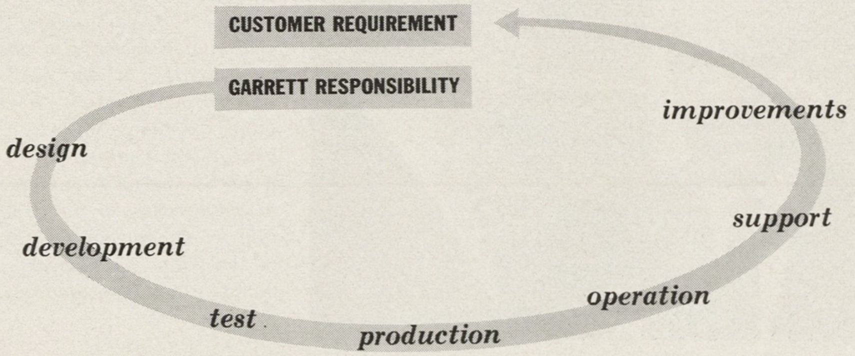
Equipment costs less. There is less of it. Trade-off within the system gives lowest cost solution.

Procurement time costs less. Lead time is shorter. Communication channels are shorter. Fewer people are required. Administrative, testing and support activities are simplified. Response to customer requirements is quicker.

Aircraft operation costs less. Aircraft performance penalties are less. Component details are standard for less expensive support. Single comprehensive system approach gives lower maintenance and higher reliability.

The aircraft user gets world wide service and support through Garrett's complete system responsibility.

For more information on how the TIPS concept can save money on your major aircraft programs, write to Garrett International S.A., Rue des Pierres-du-Niton 17, 1207 Geneva, Switzerland.



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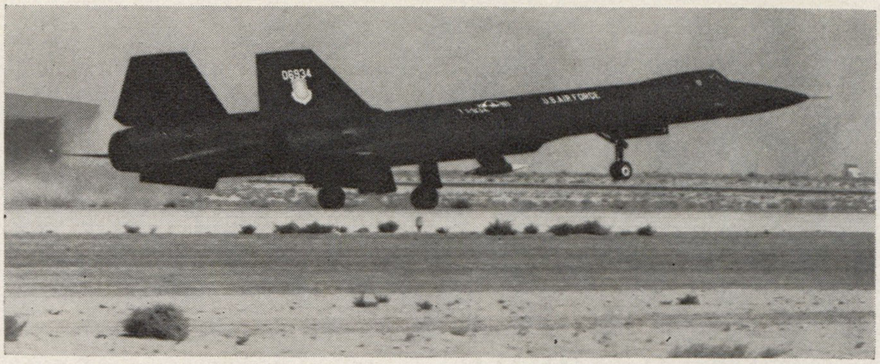
the next 12 years he served primarily in meteorology, rising to Chief of Staff of the Air Weather Service in 1946.

In 1947, General Stone was assigned to the faculty at the U.S. Military Academy for 3 years. After attending the National War College, he served in Europe for 2 years as Chief of the Plans Division at headquarters of the United States Air Forces in Europe (USAFE), in Wiesbaden, Germany. In 1955 he returned to Washington as the Air Force's Director of Personnel Planning, followed by 2 years as Commander of the Military Airlift Command's Eastern Transport Air Force (now the Twenty-first Air Force). From 1959 to 1962 he served as Superintendent of the U.S. Air Force Academy in Colorado Springs, Colorado.

General Burchinal, 51, has been Director of the Joint Staff under the Chairman of the Joint Chiefs of Staff in Washington since 1964. A native of Washington, Pennsylvania, he entered the Air Force as an aviation cadet in 1939 after being graduated from Brown University in Providence, Rhode Island. During World War II he served under General Curtis E. LeMay as Deputy for Operations of the 21st Bomber Command, flying Boeing B-29 Superfortresses. Immediately after the war, he was assigned as an analyst for the U.S. Strategic Bombing Survey. For 6 years in the 1950s he served in the Strategic Air Command, then was assigned to Washington as Deputy Director for Operations under the Joint Chiefs of Staff. Two years later he became Director of Plans at Hq. U.S. Air Force, where he served until his present JCS assignment.

Two other officers nominated by President Johnson for major command assignments and promotion to full general are Lieutenant General Raymond J. Reeves, 57, now Commander of the Alaskan Command, who will become Commander in Chief of the North American Air Defense Command (NORAD), and Lieutenant General James Ferguson, USAF Deputy Chief of Staff for Research and Development, named Commander of the Air Force Systems Command (AFSC). General Reeves succeeds General Dean C. Strother, who is retiring July 31, and General Ferguson takes over command of AFSC when General B. A. Schriever retires August 31.

Like General Stone, General Reeves also was graduated from the U.S. Military Academy in 1934, was assigned to USAFE headquarters in Germany in the early 1950s, served in high-level personnel posts, and was a senior officer in the Military Airlift Command. He was Vice Commander of MAC (then MATS) when he was appointed Alaskan Commander in 1963.



Although the world speed record holder, Lockheed's Mach 3 YF-12A, above, and its sister plane, the SR-71, are the most advanced aircraft now flying, the U.S. has no present intention of building more, according to Secretary of Defense McNamara.

General Ferguson, 52, born in Smyrna, Turkey, of British parents, became a naturalized U.S. citizen in 1930 and was commissioned in the Air Force after completing pilot training in 1936. As a fighter group commander in World War II, General Ferguson took part in the Normandy invasion and immediately after V-E Day was transferred to the Pacific, where he joined in the final phases of the war there. He subsequently served as Vice Commander of the Fifth Air Force during the Korean War. General Ferguson has held research-and-development positions since 1955, including more than 2 years as Vice Commander of AFSC under General Schriever before assuming his present assignment in December 1961.

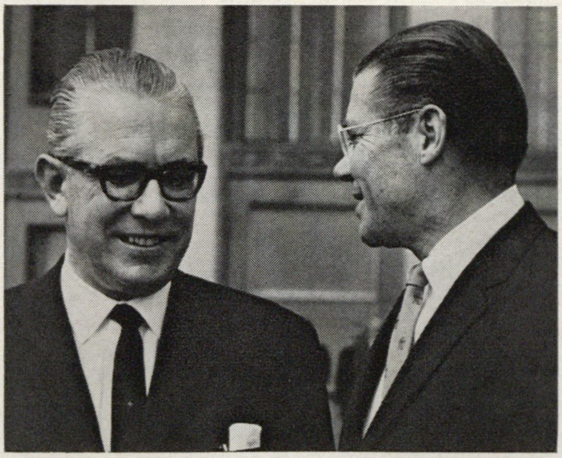
Appointment of Lieutenant General William W. Momyer to command the Seventh Air Force (formerly the 2d Air Division) in Vietnam, effective July 1, replacing Lieutenant General Joseph H. Moore, was also announced by President Johnson. In a 3-way shift, General Moore is moving to Pacific Air Forces Headquarters in Hawaii as Vice Commander in Chief of PACAF, succeeding Lieutenant General Sam Maddux, Jr., who replaces General Momyer at Air Training Command.

President Johnson nominated Major Generals Seth J. McKee and Arthur C. Agan, Jr., for promotion to lieutenant general to take over high-level Air Force assignments overseas. General McKee succeeds Lieutenant General Maurice A. Preston as Commander, U.S. Forces, Japan, and Fifth Air Force at Fuchu Air Station in Japan, while General Agan becomes Vice Commander in Chief, USAFE, upon the retirement of Lieutenant General Richard M. Montgomery on August 31. General Preston has been named Deputy Commander in Chief of the U.S. Strike Command with headquarters at MacDill Air Force Base, Florida.

* * *

Lockheed Aircraft Corporation's spectacular Mach 3 YF-12A interceptor and SR-71 strategic reconnaissance aircraft may be approaching the end of the production line. Only 3 YF-12As were built, and SR-71 production is scheduled to end with the completion of an estimated 17 aircraft.

U.S. Secretary of Defense Robert S. McNamara told a Senate committee



West German Defense Minister Kai-Uwe von Hassel, left, and U.S. Defense Secretary McNamara met in Washington recently to discuss progress in joint production and research programs, pending NATO changes, and efforts of NATO's Special Committee to achieve greater participation by nonnuclear nations in the Alliance's nuclear planning and consultation.

that he had rejected the unanimous Joint Chiefs of Staff recommendation to build 9 more SR-71s. The JCS recommendation would have increased the Strategic Air Command's reconnaissance capability and kept the production line open for a possible F-12 order.

"We don't need any more SR-71s than we now have," Mr. McNamara declared. "And, second, I am not at all worried about keeping the line open. . . . Lockheed can do that all right in any case."

U.S. Air Force Secretary Harold Brown differed with his boss, pointing out that the skilled production team would scatter when the line runs out. "The Secretary of Defense's position here is that the option can be kept open somehow by the contractor," he said. "I don't believe that is so, but the Secretary of Defense has a great deal of experience in production matters, and he may be right."

The YF-12A holds the world's absolute speed record of 2,070 miles per hour (3,330 km/hr). The SR-71 is reported to be even faster, with a top speed of 2,400 miles per hour (3,860 km/hr). Both are powered by 2 Pratt & Whitney J58 engines, each producing more than 30,000 pounds (13,610 kg) of thrust with afterburner.

The Air Force is working on plans for an F-12B model, which would adapt the larger SR-71 airframe to an interceptor role, increasing the speed and range. As of now, it is not likely to be built.

* * *

Minister of Defense Kai-Uwe von Hassel of the Federal Republic of Germany and U.S. Secretary of Defense Robert S. McNamara met in Washington, D. C., in May in the most recent of their continuing discussions on matters of mutual concern to their 2 nations.

In their defense meeting, the 2 leaders conducted wide-ranging discussions of issues posed for the North Atlantic Treaty Organization by recent developments, and agreed that the positive work of NATO should be continued and any necessary relocations and adjustments should be carried out as promptly and economically as possible.

They reviewed with satisfaction the progress already recorded by the NATO Special Committee of Defense Ministers in achieving greater participation by nonnuclear powers in nuclear planning and consultation in the Alliance. They expressed their confidence that the frank exchanges and hard work within the Special Committee and its working groups will continue to contribute to cohesion of the Alliance.

The 2 leaders were also briefed on the progress of design and development of the Main Battle Tank 1970, all major components of which are now undergoing tests.

They considered the broad field of cooperative research and development, in which joint efforts are proceeding under an August 1963 agreement, and discussed expansion of the program.

A framework agreement for the purchase of Hispano Suiza 820 20-mm guns in Germany was signed after Secretary McNamara advised that the testing program on the gun and ammunition was satisfactorily completed and that the U.S. Army's requirements could best be met through such action.

Prior to his visit with Defense officials in Washington, Minister von Hassel reviewed the pilot training program for German Air Force pilots at Williams Air Force Base and Luke Air Force Base, Arizona; reviewed the training program for antiaircraft and air defense missiles at Fort Bliss, Texas; observed German technicians being trained in the handling of Pershing, Sergeant, and other missiles at Redstone Arsenal, Huntsville, Alabama; and visited Lockheed facilities in California and Georgia.

* * *

In its capacity as manager for the International Telecommunications Satellite Consortium (INTELSAT), the U.S. Communications Satellite Corporation (COMSAT) has contracted with TRW, Inc., of Redondo Beach, California, for purchase of advanced spacecraft to be used for global commercial satellite service. (See also COMSAT article, page 28.)

The contract base price, not including penalties or incentives, was $31,985,000, for research, development, and production of 6 satellites plus 2 engineering models and 1 prototype, with options to purchase up to 18 more satellites. Delivery of the 6 flight spacecraft would begin about 21 months from the effective date of the contract and be completed in about 24 months.

The corporation, in cooperation with its partners in INTELSAT, plans to operate the satellites for global service in 1968. They will be able to handle all types of communications—telephone, telegraph, data, television, facsimile, and others. Each satellite will have a capacity for about 1,200 2-way voice channels (or 4 TV channels), and a designed operational life of approximately 5 years.

The cylindrical satellites, 56 inches (142 cm) in diameter and 37 inches (94 cm) high, weighing 240 pounds (109 kg) in orbit, will be larger and more powerful than the current Early Bird, or the improved Early Bird satellites to be launched.

The 85-pound (38.5 kg) Early Bird, the world's first commercial communications satellite, now provides transatlantic communications between North America and Europe. Two improved synchronous spacecraft of about 155 pounds (70 kg) each are scheduled to be deployed this fall, 1 over the Atlantic and 1 over the Pacific, to serve NASA's Apollo Program, as well as to provide other commercial service.

Terms of the contract were approved by the Interim Communications Satellite Committee, the representative body for INTELSAT, which is currently made up of 51 countries. Funds for the purchase and operation of the global satellites will be contributed by members of INTELSAT, including COMSAT, which holds a majority interest.

* * *

First tests of a vertical/short-takeoff-and-landing (V/STOL) transport aircraft aboard an aircraft carrier at sea were conducted in May with the Ling-Temco-Vought XC-142 on the USS BENNINGTON off the California coast near San Diego.

During the carrier operations, 44 short takeoffs and landings and 6 vertical takeoffs and landings were completed, including touch-and-go, full-stop, and go-around flight configurations. Landings and takeoffs were made from all sections of the flight deck.

The carrier flight program complemented the XC-142 test program in progress at Edwards Air Force Base, California, and at LTV's plant in Dal-

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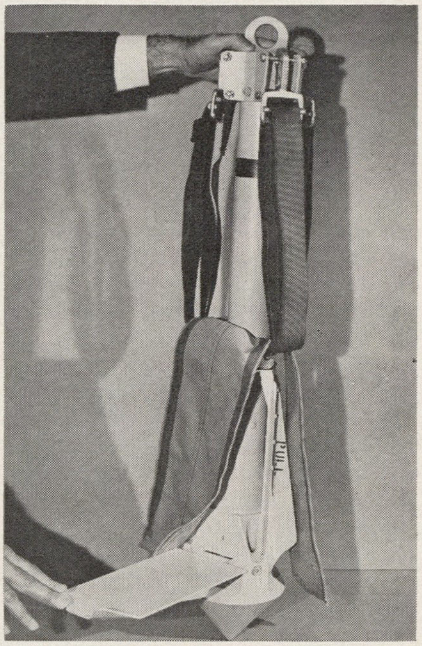
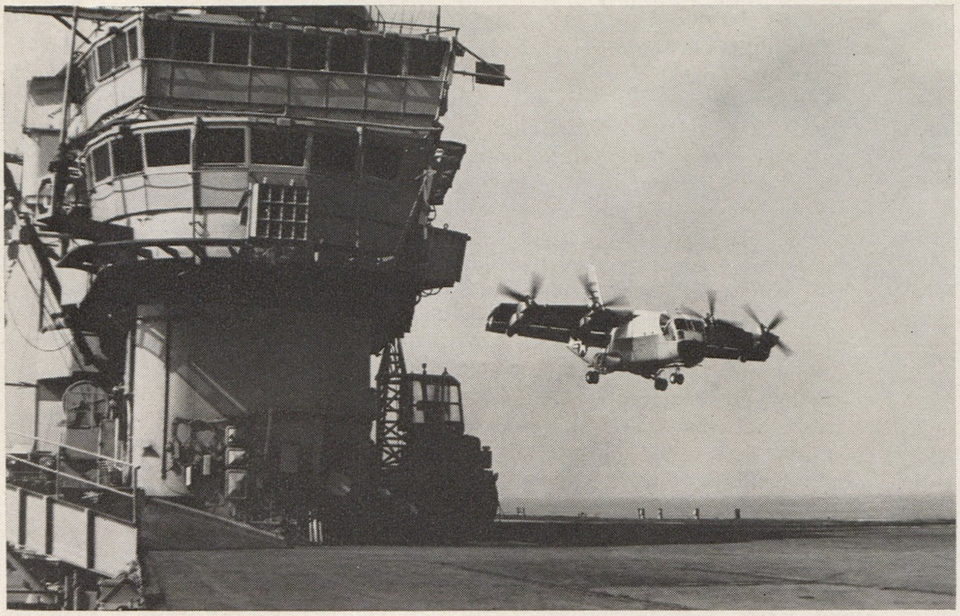


Rescue hook built by Kaman Aircraft for use in Vietnam will penetrate to jungle floor. Lowered by helicopter, it opens to seat 3, held by straps during hoist.



Flight tests of Ling-Temco-Vought's XC-142 V/STOL transport have included operations aboard Navy carrier, USS BENNINGTON, off coast of California. In this phase, XC-142 made 6 vertical takeoffs and landings and 44 in STOL mode. Winds over deck varied from zero to 32 knots. Five XC-142s have been built to perform operational evaluations for all 3 U. S. services. More extensive carrier trials are scheduled in November.

las, Texas. U.S. Air Force, Navy, Army, Marine, and LTV Aerospace pilots have accomplished more than 280 flights and more than 225 hours of flight time since the initial plane made its first flight September 29, 1964. Tests have been conducted from sod, desert, dry lake beds, pierced steel plank runways, and from membrane pads.

The XC-142A, 5 of which have been built, has operated from airspeeds of 35 miles per hour (56 km/hr) backward in hover, to 400 miles per hour (640 km/hr) in forward flight, and to an altitude of 25,000 feet (7,620 m).

Flights on the USS BENNINGTON evaluated the XC-142A for shipboard operations in V/STOL and STOL modes, with winds over the deck varying from zero to 32 knots. Also, preliminary data was gathered which will be used to formulate test plans for more extensive carrier trials scheduled for November.

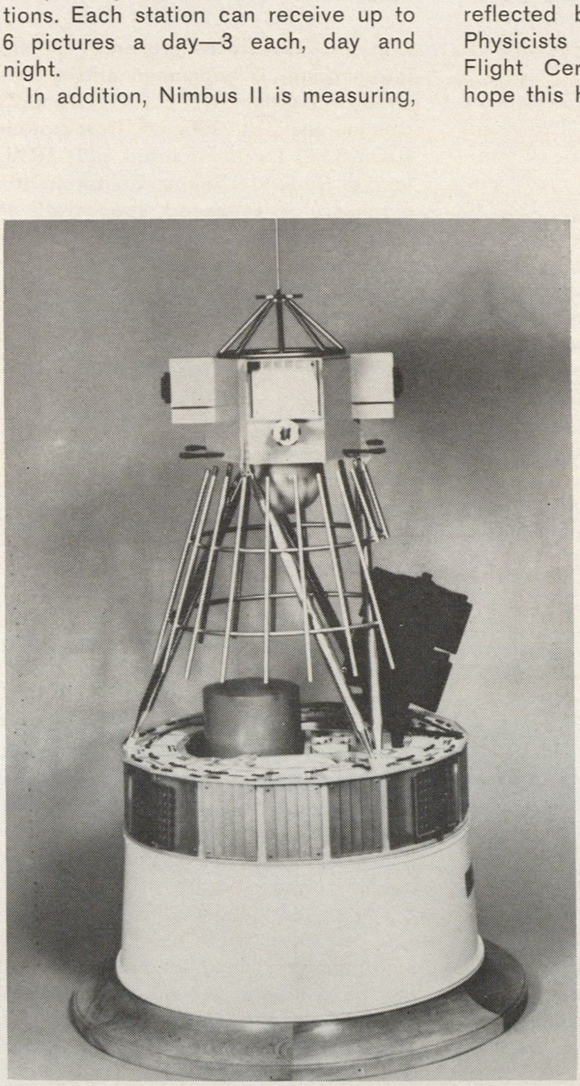
* * *

Nimbus II, a weather satellite capable of transmitting 3,000 pictures day and night in a 24-hour period to 150 stations in 27 countries, is working perfectly, according to the National Aeronautics and Space Administration's Office of Space Science and Applications. It was launched into a 700-mile-high (1,130 km) polar orbit by the U.S. Air Force from Vandenberg Air Force Base, California, on May 15 aboard a Thrust-Augmented Thor-Agena B booster.

During daylight, Nimbus II takes its pictures with 3 advanced vidicon cameras and 1 automatic picture transmission (APT) camera. In darkness, it employs a high-resolution infrared radiometer to photograph cloud cover.

The APT equipment aboard the satellite sends pictures of local weather automatically to small inexpensive ground stations anywhere in the world. It also transmits the infrared pictures to specially modified APT ground stations. Each station can receive up to 6 pictures a day—3 each, day and night.

In addition, Nimbus II is measuring, for the first time on a global basis, the heat balance budget (albedo) of the entire earth's area every day, recording how much of the sun's radiation the world absorbs and how much is reflected back into the atmosphere. Physicists at NASA's Goddard Space Flight Center, Greenbelt, Maryland, hope this heat balance study may un-



Next in the series of Nimbus weather satellites, to be launched next year, is this model built by General Electric and featuring radioisotope-fueled thermoelectric generators. Meanwhile, Nimbus II, launched into polar orbit in mid-May, has made possible, for the first time, worldwide reception of around-the-clock weather photographs from space on inexpensive ground equipment. In addition to 3 advanced vidicon cameras, Nimbus II carries an automatic picture transmission (APT) camera capable of sending day and night weather photos to 150 stations in 27 countries.

U.S. Army's M-109 self-propelled tracked vehicle, carrying a 155-mm howitzer, will be coproduced in The Netherlands under a recently-signed agreement with the U.S. About 100 M-109s will be purchased at cost of $14,000,000. The 155-mm howitzer swings in full circle with elevation from minus 3° to plus 75°.

lock some of the mystery of storm development and dissipation.

Manufactured by General Electric, Nimbus 11 is 10 feet (3 m) high and weighs 912 pounds (414 kg). Vidicon cameras and the APT system were designed and built by RCA's Astro-Electronics Division, Princeton, New Jersey, while infrared nighttime sensors are a product of ITT's Industrial Laboratories Division, Fort Wayne, Indiana.

* * *

An agreement to coproduce the U.S. Army's self-propelled 155-mm howitzer (M-109) for The Netherlands Defense Ministry has been signed by the U.S. and The Netherlands Governments.

It provides that The Netherlands will purchase approximately 100 of the armored vehicles from the U.S. at a cost of about $14,000,000. The U.S.-designed gun and mount will be manufactured and installed on vehicles in The Netherlands.

The M-109, built in the U.S. by the Allison Division of General Motors Corporation, is an aluminum armored vehicle which provides all-around protection for a 6-man crew against small arms, shell fragments, and flash burns. It is full-tracked and amphibious, and has a cruising range of more than 200 miles (320 km) with speeds up to 35 mph (56 km/hr) on land and 3 mph (5.6 km/hr) in water.

The U.S. Navy never would have agreed to buy the General Dynamics F-111 fighter plane if it had known how much it was going to weigh, Navy Secretary Paul H. Nitze disclosed recently before a Congressional committee.

He and Admiral David L. McDonald, Chief of Naval Operations, indicated the Navy is still far from certain it will place a production order for the F-111B.

Meanwhile, Dr. John S. Foster, Jr., Director of Defense Research and Engineering, disclosed that the U.S. Air Force won't buy as many F-111As as previously planned. To come up

(Continued on following page)

U.S. Navy Secretary Paul Nitze disclosed recently that the U.S. Navy would not have joined in ordering the General Dynamics F-111 swing-wing fighter if it had known how much it was going to weigh. Meanwhile, the Navy delayed its decision on F-111B production at least until December pending outcome of problems with Phoenix air-to-air missile with which it is to be armed.

with a better "mix" of tactical aircraft, the Air Force will get more Ling-Temco-Vought A-7 Crusader IIs and advanced McDonnell F-4s, while reducing its F-111 order.

The total buy of F-111s is now pegged at 1,398, Dr. Foster said, including 50 for Britain and 24 for Australia. This is down from a total of 1,704 in earlier estimates.

Admiral McDonald made it clear the Navy's interest in the F-111B is directly tied to the outcome of efforts to solve development problems in the Hughes Phoenix air-to-air missile, now 18 months behind schedule. "If the Phoenix missile does not work," he said, "we do not need the airplane."

Secretary Nitze said the Navy will not reach a decision on the F-111B until December at the earliest.

* * *

Jet-engine fuels which can be quickly changed from liquid to jelly are now undergoing tests in realistic accident conditions, a U.S. Federal Aviation Agency engineer has reported. The tests indicate that gelled fuel reduces the chance of fire in an airplane accident, according to Ralph A. Russell, FAA aircraft safety engineer in charge of the project.

Ultimate goal of the project is to develop jet fuels that will not burn if airplane fuel tanks are ruptured in a crash, Russell explained. The tests are part of a program under way at the FAA's National Aviation Facilities Experimental Center at Atlantic City, New Jersey, to find ways of reducing crash fire hazards.

For the tests, the consistency of fuels is varied from the thickness of applesauce to that of lard. Laboratory experiments have shown that the thicker the gel, the more effective it is in reducing ignitability and combustibility, Russell said. The gel melts and turns to liquid when heated to a temperature of 120-125 degrees F. (49-52 degrees C.).

At its Atlantic City Experimental Center, the FAA is testing different grades of gelled fuel, comparing burning characteristics and splash patterns under impact conditions. Both JP-4 and Jet A fuels have been tested.

Surplus auxiliary tanks, filled with various grades of fuel, have been catapulted into flames and also dragged along the runway by truck and ignited. In other recent tests, the fuels were turned into a mist and ignited.

Russell said that gels reduce the chances of fire in 3 ways: by physically binding the fuel, by slowing down vaporization, and by reducing exposed surface areas that support a fire. They burn with a smooth, even flame without leaving any deposits or residue, and without causing corrosion, he said.

Design details of a new multipurpose vehicle that will operate efficiently on paved surfaces, "walk" through mud and swamps, and "paddle" over water have been described by Lockheed Aircraft Service Company.

Commercial versions of Lockheed's TerraStar vehicle permit the exploitation of geographic areas heretofore inaccessible because of mobility limitations of conventional wheeled and track-laying vehicles.

TerraStar applications include mineral and oil exploration and producing operations; telephone and power-line patrol; rescue and fire-fighting operations; and the transport of cargo over land, through deep mud and swamps, and across water.

A unique, multienvironment locomotion concept is the key to the TerraStar vehicle's triple capability. Its running gear consists of wheel assemblies, called major wheels, each made up of 3 minor wheels. The latter are mounted on secondary axles positioned radially about the major-wheel main axle on large spokes. The minor wheels carry wide-base, low-pressure tires.

The major wheels propel the vehicle through mud and other soft-soil environments where conventional wheeled or tracked vehicles would be immobilized.

On paved surfaces and hard ground, the operator disengages the major-wheel drive and the TerraStar operates on its minor wheels much like a conventional vehicle.

Substantial agreement has been reached by the U.S. Navy and Air Force on performance and weight characteristics of a Mach 3 fighter-interceptor plane to replace the McDonnell F-4 Phantom II series in the mid-1970s.

The Navy refers to the proposed aircraft as the VFAX—"aircraft, fighter, attack, experimental"—while the Air Force calls it simply FX—"fighter, experimental." Both are now reported to be thinking in terms of a plane with a takeoff weight of about 30,000 to 35,000 pounds (13,600 to 15,900 kg), in contrast to the F-4's 50,000 pounds (22,680 kg).

"Specifications are more similar than in the case of the F-111," Air Force Secretary Harold Brown told a Congressional committee recently. "As far as I can tell, the Navy is looking for what we are."

Both want a fighter with all-weather close-support capability, combined with an air-to-air combat potential. The Air Force has contracted with the Lockheed Aircraft Corporation, the Boeing Company, and North American Aviation, Inc., for FX definition studies which are to be submitted in July. Pentagon sources point out, however, that results of the studies will be made available to other prospective bidders so that competition for the final development and production contract is still wide open.

Secretary Brown said studies of the FX aircraft are further along than those of the VFAX, but that schedules can

Wheels within wheels propel this Lockheed TerraStar vehicle over paved surfaces, mud, and swamps, or through water. Each of 4 major wheels is made up of 3 minor wheels mounted radially on spokes around main axle. On hard surface, vehicle runs on pairs of minor wheels. In mud or water, TerraStar "paddles" along by revolving major wheels.

easily be brought into line. Definition studies on the VFAX are to be ready by early 1967, which would make it possible for the Defense Department to select a development contractor as early as next summer.

Speed of the FX-VFAX in an interceptor role would be in the Mach 3 class, powered by a pair of engines with thrust of about 25,000 pounds (11,340 kg). On close-support missions its speed would be about that of the F-4—up to Mach 2.5—but its range would exceed the F-4's 2,000 miles (3,200 km). It will take off and land in less than 2,500 feet (760 m), and will employ either variable-sweep or an even newer wing design.

The FX-VFAX would complement the F-111, with the latter handling long-range strike missions. It would also work with the Ling-Temco-Vought A-7A Crusader II, preceding the Crusader II on strike missions, employing missiles to knock out enemy defenses in target areas, and then flying cover to guard the A-7 against enemy interceptors.

Air and ground crews of U. S. Navy's Lockheed P-3 Orion line up behind display of Orion's deadly weapons payload, including rockets, depth charges, mines, torpedoes, and depth bombs. Orions, operated by U. S. Navy from bases on Atlantic and Pacific coasts, have been ordered also by New Zealand, which will get its first 5 P-3Bs this year, and Australia has announced it will buy Orions to replace its P-2 Neptunes.

* * *

The force that causes teakettles to "sing" and that drives huge electric power generators can be used to launch missiles, researchers at Goodyear Aerospace Corporation have demonstrated.

The force is steam—superheated steam. Properly controlled, it can lift missiles from underground silos, giving them the initial impetus that now must be provided by the missiles' own rocket motors.

The "steam-launch" system, Goodyear engineers explained, would not only extend the range of a missile by reducing fuel consumption at launch, but would also protect missile silos from being damaged by flames from the rocket motors.

Heart of the steam-launch system is an energy storage container in which water is heated rapidly by the intense burning of a chemical charge contained in the water.

The container holds this water until it reaches 705 degrees F. (374 degrees C.) and has built up a pressure of 3,200 pounds per square inch (224 kg/cm^2). Then it is released as a surge of steam that provides the force that is needed to start the missile on its journey.

The steam-launch system, originally devised for small portable missiles, has now been tested with 2,200-pound (988 kg) dummy missiles.

The study was made under a contract with the U.S. Air Force Rocket Propulsion Laboratory at Edwards Air Force Base, California. Participating with Goodyear Aerospace was Dyna-Tech, Inc., Tempe, Arizona.

Joseph C. Satterthwaite, former ambassador and career foreign service officer, has joined the National Aeronautics and Space Administration as a consultant to Administrator James E. Webb.

Satterthwaite, who retired from the U.S. State Department in 1965, advises the Administrator in the field of international affairs in the general area of Western Europe.

An overseas Army veteran of World War I, he joined the Department of State in 1924 in Germany and was assigned to several diplomatic posts around the world before becoming Director General of the Foreign Service in 1957. His last post was U.S. Ambassador to the Republic of South Africa.

* * *

The first of 5 Lockheed P-3B Orions will be delivered to the New Zealand Air Force in August, to replace Sunderland flying boats in RNZAF maritime patrol squadrons.

The P-3B, latest version of Lockheed antisubmarine patrol craft, is equipped with 4 Allison T56-14 turboprop engines with a takeoff rating of 4,910 shaft horsepower, compared to 4,500 shp for the T56-10W in the P-3A. The new engine eliminates the need for water-alcohol injection on takeoff, while its increased power offers significant performance improvements in takeoff, climb, cruise ceiling, and speed.

Australia, which has announced plans to buy 10 Orions, will also get the new P-3B version.

Lockheed has produced more than 150 P-3As for the U. S. Navy since the first Orion delivery in 1962, replacing the P-2 Neptune as the backbone of the Navy's land-based aerial patrol forces. The Neptune also bears the insignia of 9 other Free World nations, including Australia. Production contracts for the P-3B Orion run through 1967.

Armed with rockets, depth charges, mines, and torpedoes, the Orion can perform search missions, skimming low over the ocean or cruising at altitudes up to 30,000 feet (9,100 m). It can throttle down and loiter over search areas at speeds between 200 and 260 mph (320 and 415 km/hr), or dash at speeds over 460 mph (740 km/hr). Utilizing its ability to fly on 2 of its 4 engines, it can remain on patrol for more than 17 hours.

* * *

Whittaker Corporation of Los Angeles, California, and Fabbrica Italiana Apparecchi Radio (FIAR) of Milan, Italy, have signed a technical assistance agreement involving air traffic control radar systems.

The announcement was made by Dr. William M. Duke, President of Whittaker, and Dr. Branimir Polic, General Manager of FIAR's Defense and Commercial Electronics Department.

The agreement will extend FIAR's present capabilities in the radar and communications fields by enabling the company to manufacture the Whittaker-designed advanced Secondary Surveillance Radar (SSR) system. A vital element in air traffic control, the system supplements primary radar in the identification of aircraft within 200 miles (320 km) of a ground station.

(Continued on following page)

A similar agreement was signed in 1965 between Whittaker and Telefunken Corporation of West Germany.

Whittaker's Technical Products Division, Chatsworth, California, has designed, developed, and manufactured IFF (Identification, Friend or Foe) and SSR equipment for the past 15 years.

Equipment produced by Whittaker has been installed at more than 150 ground stations throughout the United States and Europe, including installations in Holland, Switzerland, West Germany, and Australia.

* * *

Sale of 4 Beechcraft Queen Air B80s to the Venezuelan Air Force and 3 to Peru's Servicio Aerofotografica Nacional was announced recently by Michael G. Neuburger, Beech vice president for export sales.

Venezuela acquired 3 high-density, 10-place transport versions and 1 executive type, while those for Peru were equipped with a large camera hatch in the lower fuselage.

The Peruvian Air Force had previously purchased 18 Queen Air B80s for use as trainers and personnel transports.

Pilots of the Venezuelan and Peruvian Air Forces ferried their aircraft home from the Beech plant at Wichita, Kansas. Accepting delivery for Venezuela were Major Juan Mendez Portillo, Major Felix Perez Casanova, Captain Arturo Rivera Fernandez, and Captain Ramon Mendoze Ibarra.

The executive transport is now based at Caracas, and the 3 high-density aircraft, designed for quick conversion to air ambulance use, are operating from an Air Force base at Maracay, about 100 miles (160 km) southwest of Caracas.

Peruvian crews included Commandante Enrique Morey R.; Captains Romula C. Zapata S. and Peter Neufuss F.; and Lieutenants Luis Urrunaga T., Edurado Bedregal P., and Ariel Loayza P.

One of the first missions of Peru's 3 Queen Air photo aircraft will be to help map the eastern slope of the Andes Mountain range in connection with the Trans-Andean Highway project now under way. The new highway is designed to open up for colonization the "Selva," a broad, fertile region between the Amazon River and the Andes.

* * *

A new gyro-stabilized gunsight—designed by Hughes Aircraft Company to aim the U.S. Army's supersonic TOW antitank missile from helicopters—will enable gunners to hold the aiming cross hairs on moving or stationary targets such as tanks, armored vehicles, or ground emplacements even while the helicopter pilot is taking evasive action to avoid the ground fire.

The powerful TOW—which stands for Tube-launched, Optically-tracked, Wire-guided—missile will follow the gunner's line of sight to the target, steered by electronic signals that are jam-proof because they are sent over hair-thin wires that unreel during flight, John H. Richardson, Hughes senior vice president, explained.

Hughes recently received a $4,000,000 Army contract to develop the sight after demonstrating its feasibility to officers of the Army Missile Command at Redstone Arsenal, Alabama.

The TOW system is designed for installation on UH-1B helicopters, called "Hueys" by American forces in Vietnam. The system enables a gunner to lock on and track a target through a stabilized sight sensor mounted in the nose of the helicopter. Easily operated controls permit him to aim the missile despite the angular motion of the helicopter and regardless of whether the aircraft is hovering or pursuing a fleeing target.

A display panel will show each phase of the attack, such as when the target is engaged, when the missile is ready to fire, when evasive action is taken by the target, and when the missile is actually launched.

The TOW helicopter version is identical to the infantry TOW system now in final development by Hughes under direction of the Army Missile Command to meet the Army's needs for a heavy antitank assault weapon that can be handled easily by infantrymen. It will enable a soldier to "shoot and scoot" before an enemy can zero in on his position. Its effectiveness was demonstrated recently at Redstone Arsenal where prototype TOW missiles scored bull's-eye hits against tank-size targets more than a mile (1.6 m) away.

* * *

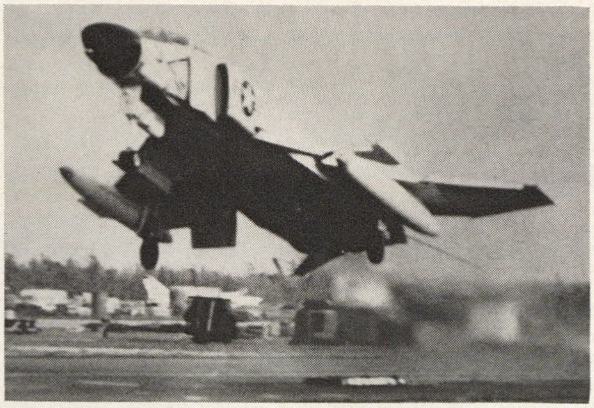
To improve air-rescue operations over North Vietnam, the Air Force is modifying 20 Lockheed HC-130H Hercules aircraft and 17 Sikorsky HH-3E helicopters for air-to-air refueling operations.

The refueling capability will extend the HH-3E's current range of 700 nautical miles (1,300 km) to flights several times that distance. Its ability to hover near target areas in combat will be greatly prolonged.

On missions off North Vietnam, the HC-130H would be assigned as a "mother" plane to 2 or more HH-3Es, enabling them to remain in the area for extended periods and to penetrate deep into North Vietnam if necessary.

Feasibility of in-flight helicopter refueling was demonstrated by Air Force-Marine Corps tests at Cherry Point, North Carolina, in which an Air Force CH-3C made 10 successful probe hookups.

The ability of the HH-3E to fly at speeds up to 140 knots permits normal formation flight with the tanker and



McDonnell F-4B fighter is catapulted into air by GE1-3 launch mechanism, part of Marine Corps SATS (short airfields for tactical support) system. Powered by 2 GE J79 engines, catapult launches combat-loaded F-4 within 1,750 feet (530 m).

After tests demonstrated feasibility of refueling helicopters in flight, U.S. Air Force is modifying HC-130A rescue aircraft to refuel HH-3E helicopters, thus greatly extending range of HH-3Es employed in rescuing downed pilots and wounded personnel in Vietnam.

Venezuelan and Peruvian Air Forces recently acquired Beech B80 Queen Air transports, 2 of which are shown here in Venezuelan markings. One of the first missions of camera-equipped Peruvian planes will be to map eastern slope of Andes Mountains for major highway project.

Artist's sketch shows U.S. Army UH-1B Huey helicopters equipped with TOW antitank missiles. Gyro-stabilized sight being developed by Hughes Aircraft Company, which also manufactures TOW missile, will enable gunner to keep weapon aimed on enemy tank, armored vehicle, or ground emplacement despite helicopter's evasive actions.

conventional probe/drogue hookups. One unusual aspect of refueling operations discovered in the Cherry Point tests is that once the helicopter has approached the drogue it can maintain formation speed at 2/3 power because the tanker's airflow literally drags the helicopter along with it—a phenomenon similar to "drafting" in automobile racing.

* * *

More than 7,000 U.S. Naval Academy and Naval Reserve midshipmen are participating in annual summer midshipmen training cruises scheduled between early June and September 10 in ships of the U.S. Atlantic and Pacific Fleets.

With more than 160 ships participating, midshipmen are being assigned to ships of the Sixth Fleet in the Mediterranean, and to units of the Second and First Fleets off the East and West Coasts of the United States. These ships will visit various East and West Coast ports in addition to Sixth Fleet ports in the Mediterranean.

Approximately 70 midshipmen will represent the U.S. Navy in the foreign exchange program with 21 countries. Another 35 students will train on Polaris submarines and cruise under the sea on 2-month patrols.

* * *

A land-based catapult is launching U.S. Marine Corps combat aircraft in Southeast Asia. The catapult is a jet-engine-powered device capable of launching fully loaded Marine and Navy tactical aircraft from airstrips only 1/3 the length normally required.

The CE1-3 catapult, as the launcher is designated by the Marine Corps, was developed and is being produced by All American Engineering Company of Wilmington, Delaware. It was chosen as the aircraft launcher component of the Marine Corps' SATS—Short Airfields for Tactical Support—program.

The Marine Corps's SATS package includes complete air station facilities that can be transported by plane, ship, or truck, and set up, ready for use, within a few days. These facilities are made up of crew quarters; maintenance, supply and operational facilities; and short runways equipped with catapults and arresting gear that will permit high-performance jet aircraft to take off and land.

The choice of the site of a SATS field is dictated by topography, but the intention is to provide such installations near or within areas where tactical air support is required. The design criteria for SATS equipment, therefore, includes stringent requirements for light weight, transportability, quick installation, high performance, and reliability.

Power for the catapult is provided by 2 J79 turbojet engines exhausting into General Electric LM1500 free power turbines. The turbines are connected to a gearbox and high-speed capstan that drives an endless loop of steel cable. The loop is wrapped on the capstan, around a tensioning device, and around sheaves at either end of the launch stroke.

The SATS CE1-3 has a maximum launch stroke of 1,750 feet (530 m), the stroke required to launch an F-4B weighing 55,000 pounds (24,950 kg) on a 100-degree F. (38 degrees C.) day. A lighter aircraft, of course, uses a shorter stroke; an A-4 on a similar day needs less than 1,100 feet (335 m). The 1,750-foot dimension is not a limitation. By merely extending the stroke slightly, the catapult's capacity can be increased to launch heavier aircraft at comparable speeds, or comparable weight aircraft at higher speeds.

Operation of the CE1-3 is similar to carrier-based catapults. The aircraft nose wheel is placed on a shuttle and a nylon bridle is connected between the shuttle and the aircraft launching hooks. An aircraft holdback similar to those used on shipboard is also attached. Bridle pre-tension, supplied by the idle thrust of the catapult turbine, is applied, after which the turbine is locked with a brake.

On the launching officer's signal, the operator presses the launch button. From that point on the launch is fully automatic. The turbine brake is released, the throttles advance to a predetermined setting, the holdback breaks, and the aircraft accelerates and takes off. The shuttle engages a nylon arrester that disconnects the cable clamp, stops the shuttle, and propels it back to the launch end of the runway. It is then ready for the next aircraft.

(Continued on following page)

An experimental speech recognition system that points the way toward direct voice control of machines such as typewriters, telephones, and computers has been developed by the Radio Corporation of America for the U.S. Air Force.

The experimental system employs unique electronic circuits which work functionally like living nerve cells, according to Thomas B. Martin, RCA project engineer for the system.

Mr. Martin said the equipment can ultimately be developed for such applications as using 1 standard telephone wire to serve 60 telephone conversations, but its interest to the Air Force is in transmitting voice conversations from spacecraft to earth with a small fraction of the power needed in conventional two-way radio systems.

The system's function—identification of the most basic parts of speech called "phonemes"—is expected to lead directly to such developments as voice control of telephone dialing, programming computers by voice command, voice-controlled typewriters, and automatic translation of speech messages into any language, Mr. Martin said.

A phoneme is the smallest unit of speech that distinguishes one utterance from another. The "p" of "pin" and the "f" of "fin" are 2 different phonemes. The speech-recognition system identifies these phonemes by abstracting their more salient features using circuits called "analog threshold logic elements," which operate functionally in a manner similar to neurons, or living nerve cells.

"This device has produced the best results in speech sound recognition ever reported—90 to 99 percent accuracy against about 70 percent for the best of the other systems," Mr. Martin said.

He said the machine presently recognizes 28 of the 40 phonemes in the English language, which are typed out by an electric typewriter in phonetic symbol form similar to the word-pronunciation symbols employed in a dictionary.

The key features abstracted from speech by the machine to identify phonemes are regions of increasing and decreasing energy. These frequency-energy relationships varying with time are largely independent of individual inflections and accents and thus enable the machine to identify a particular phoneme.

"We feel that recognition of conversational speech, with all that it implies in speech compression and voice control, is, by the further development of this neuron logic technique, just a few years away," Mr. Martin said.

By transmitting symbols over wires instead of voices and reconstructing them back into speech at the other end, "we may send as many as 60 conversations on a wire which previously could handle only 1," he continued. "Of course, everyone will sound the same at the other end of the line, because his voice must be reconstructed there from the 40 phonemes."

James W. Falter, Air Force project engineer for the system, said it would be very useful in deep-space voice communications, which will probably be transmitted in digital—or computer language—form. To digitize normal voice conversations might require some 30,000 bits of information per second, but the new phoneme technique would require only about 100 bits per second.

"In spacecraft, where power is a definite problem, this means that the same power required to transmit 1 digitized but unprocessed voice could transmit back to earth 300 conversations using processed speech," Mr. Falter explained. ☆☆☆

Almost 60,000 flight hours since 1961. In 1966, the Chinook will reach 100,000.

The 60,000 hours may have been flown at Ft. Rucker, Ala., or at Da Nang, Vietnam; at Ft. Benning, Ga., or at Boeing's Vertol Division Flight Center in Philadelphia, Pa.; or at any one of a number of other places and bases. There's no way to pin-point the exact spot. But this we do know: on combat duty in Vietnam, the CH-47A Chinook helicopter has been averaging well over 2500 flying hours per month, completing more than 54,000 sorties and over 20,000 combat hours by June.

What is more, use of the Chinook, which was deployed to Vietnam with the 1st Cavalry Division (Airmobile) in September, 1965, has been increasing at an accelerated pace. While it took a little less than 5 years to reach the first 50,000 hours, it is expected that the second 50,000 hours will be attained by December, 1966.

Since its arrival in Vietnam, the Chinook has proven its airmobile versatility. In its 30-foot payload compartment, the Chinook can transport a fully-equipped combat platoon, combat vehicles, infantry support weapons, a complete howitzer section—or 107 refugees, such as were recently rescued from the village of Pleiku in a single flight. As the needs of combat change and develop, the Chinook's unique flexibility in meeting this challenge becomes ever clearer.

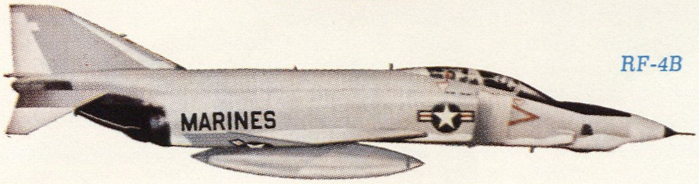
BOEING Helicopters

VERTOL DIVISION / MORTON, PENNSYLVANIA, U.S.A.

F-4B

F-4C

COMMONALITY

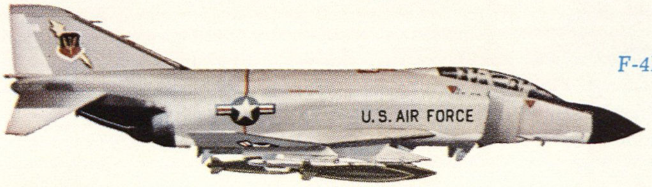


RF-4B

RF-4C

F-4B

F-4D

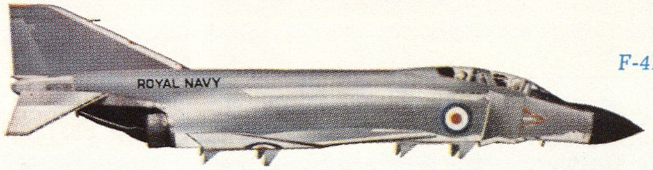


F-4E

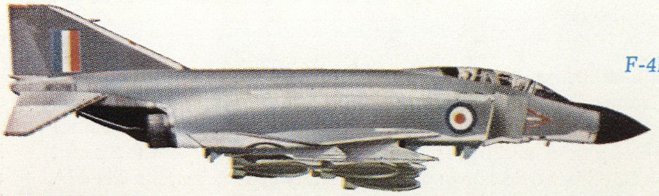
Commonality is a product characteristic sought after by defense planners. Commonality permits planners to meet economically and effectively the multiple mission weapon requirements of multiple services. Commonality is a characteristic of the Phantom.

F-4J

The McDonnell engineering team that designed commonality into the multiple-mission Phantom has proved that commonality can be achieved without performance compromises. This team is now designing even more advanced fighters in which commonality will be a fundamental characteristic.



F-4K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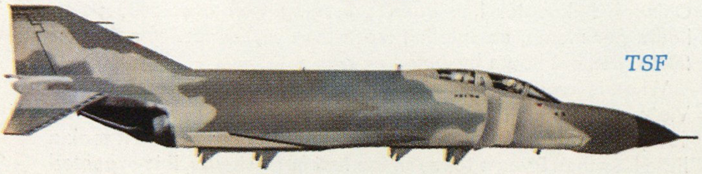
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MCDONNELL
ST. LOUIS