

SEPTEMBER 1966

Air Force/Space Digest — **International**

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



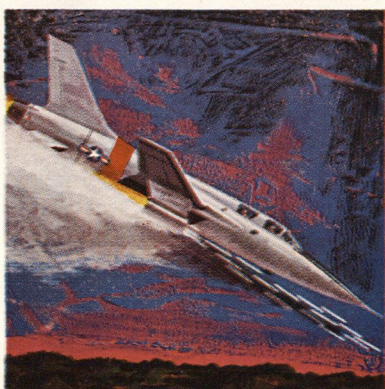
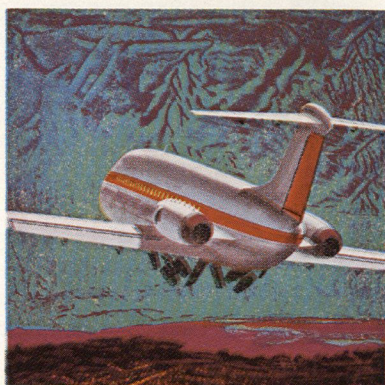
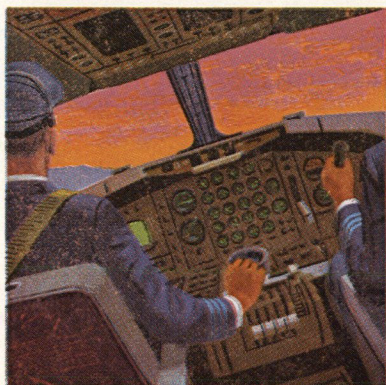
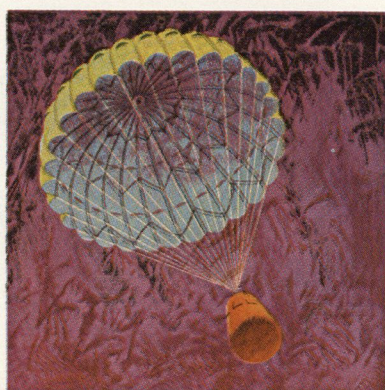
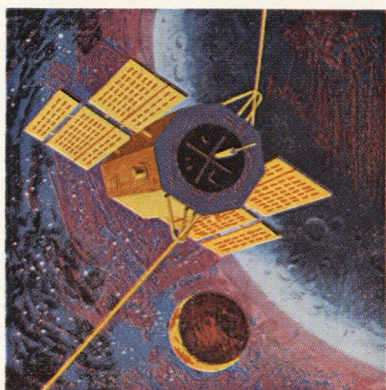
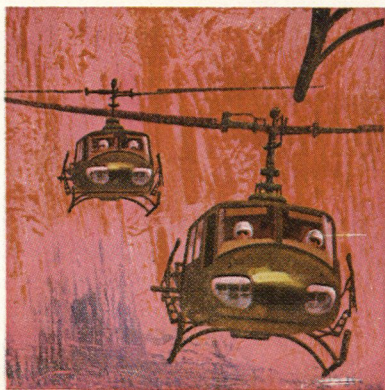
Relative size of a Boeing 747 is shown through comparison with scale model of a contemporary jet airliner.

JUMBOJETS— AIR TRAVEL FOR EVERYMAN?

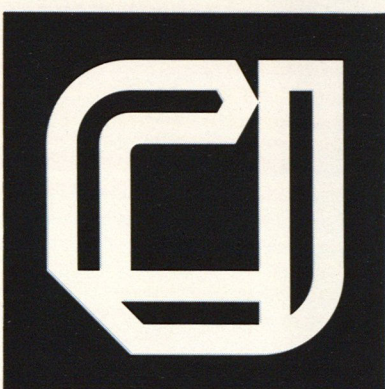
Increased productivity, made possible by the new large-capacity aircraft being built today, can make the airlines truly a mass-transportation media, competitive with land and sea transport. See page 16.

Also in this issue:

- ▶ A comprehensive report on the U.S. Department of Defense.
- ▶ "Utility Satellites"—Space experimentation that has become operational and is paying dividends in weather prediction, navigation, and communications.



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MEMORANDUM TO OUR READERS..... 4

By John F. Loosbrock, Editor

THE U.S. MEETS THE COLD WAR CHALLENGE..... 8

By Claude Witze, Senior Editor

The United States Department of Defense has been undergoing constant change since it was first organized almost 20 years ago. The Department struggles to keep pace with modern technology, the new pattern of world politics, the shifting nature of the Communist threat, and the rising cost of weapons. The power to make decisions is becoming more centralized and more civilians are in control of combat forces.

THE JUMBOJETS—AIR TRAVEL FOR EVERYMAN?..... 16

By Edgar E. Ulsamer, Special Correspondent



The U.S. Air Force's gigantic new heavy logistics transport, the C-5A, may be the original, but it will certainly not be the only new jumbojet competing for the market. But many questions about huge airliners remain unresolved, and the U.S. aerospace industry is busy adapting the new technology in a manner that allows for the vagaries of the civilian aviation market. This article, the first part of a two-part status report, reviews developments in the race toward giant commercial airliners.

MAN'S BRAIN IN SPACE—THE LIMITLESS HORIZONS OF "UTILITY" SATELLITES..... 26

By William Leavitt, Senior Editor/Science and Education

Manned spaceflight may create wider public enthusiasm for space-age accomplishments, but there is an army of unmanned working satellites already performing operational services and advancing scientific research. Their achievements in the fields of weather analysis, communications, navigation aid, military observation, and geodetic measurements—among others—have been considerable, but are only the beginning of a giant harvest to come. The usefulness of "utility" satellites, particularly to military operations, can scarcely be overestimated.

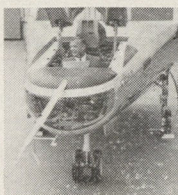
INTERNATIONAL SCIENTIFIC EXCHANGE—SOME NEW VISTAS OPEN... 35

By John Walsh

Scientific exchange between the countries of the world has been limited, due to political and ideological difficulties. However, there is a current drive within the United States to increase activities in this vital area. An important step taken recently by the U.S. was to permit scholars and other specialists to visit Red China. Thus far, however, the Red Chinese have not responded. Here is a report on some of the structural problems and attitudes that hamper the advancement of international scientific activities, and what is being done about them.

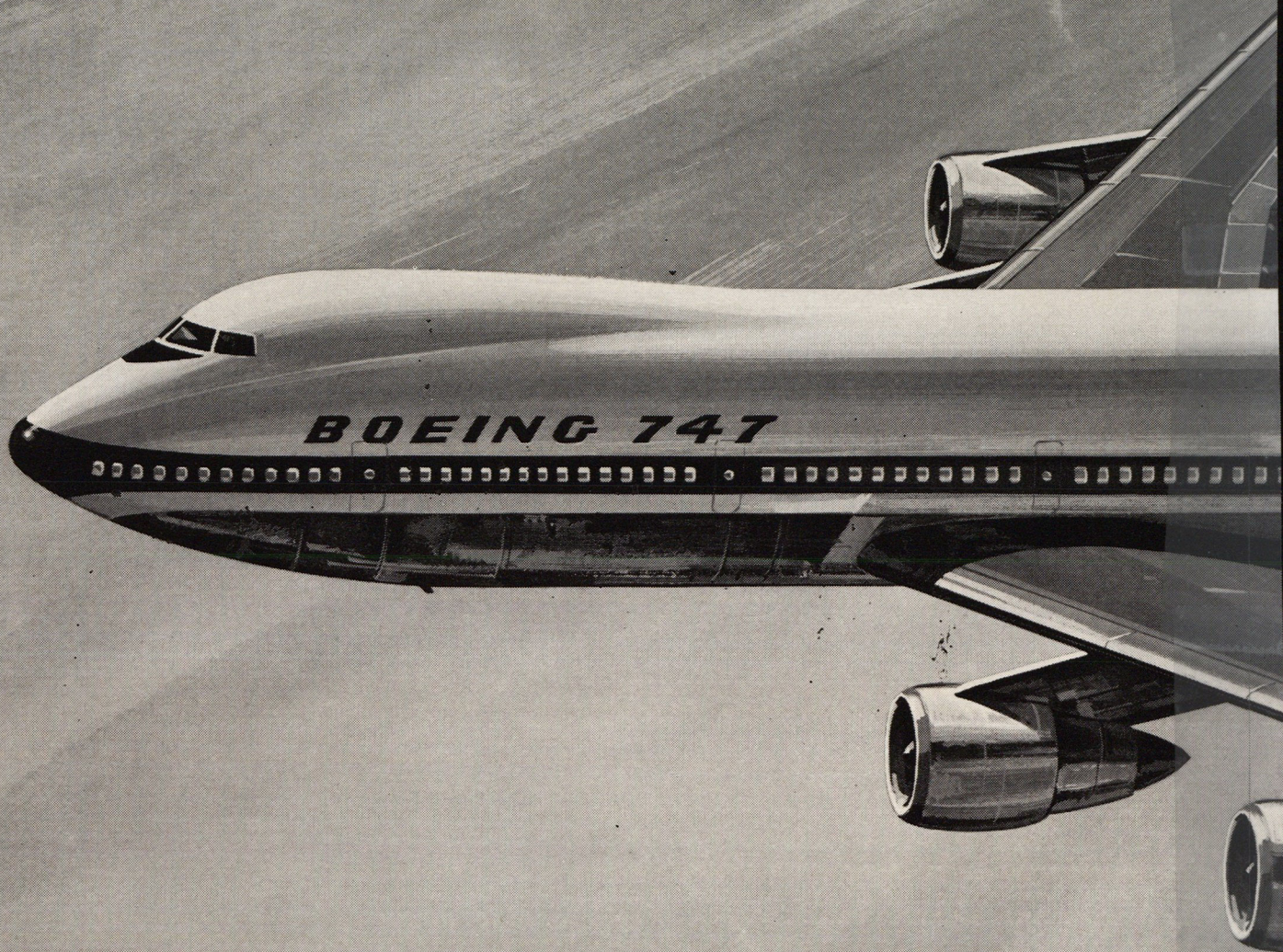
AEROSPACE REVIEW..... 39

By Judith Dawson, Editorial Assistant



This month's report features the actions and reactions to the recent announcement from Hanoi about treatment of captured U.S. pilots . . . U.S. space activities are not taking a summer vacation . . . USAF missile-measuring equipment is opening new possibilities for antimissile missile system development . . . Canadair is to build ailerons for the C-5A . . . flying motorcycle without wheels creates jet-propelled soldiers . . . NASA test of wingless maneuverable spacecraft is successful . . . and more.

WORLD'S FIRST 500

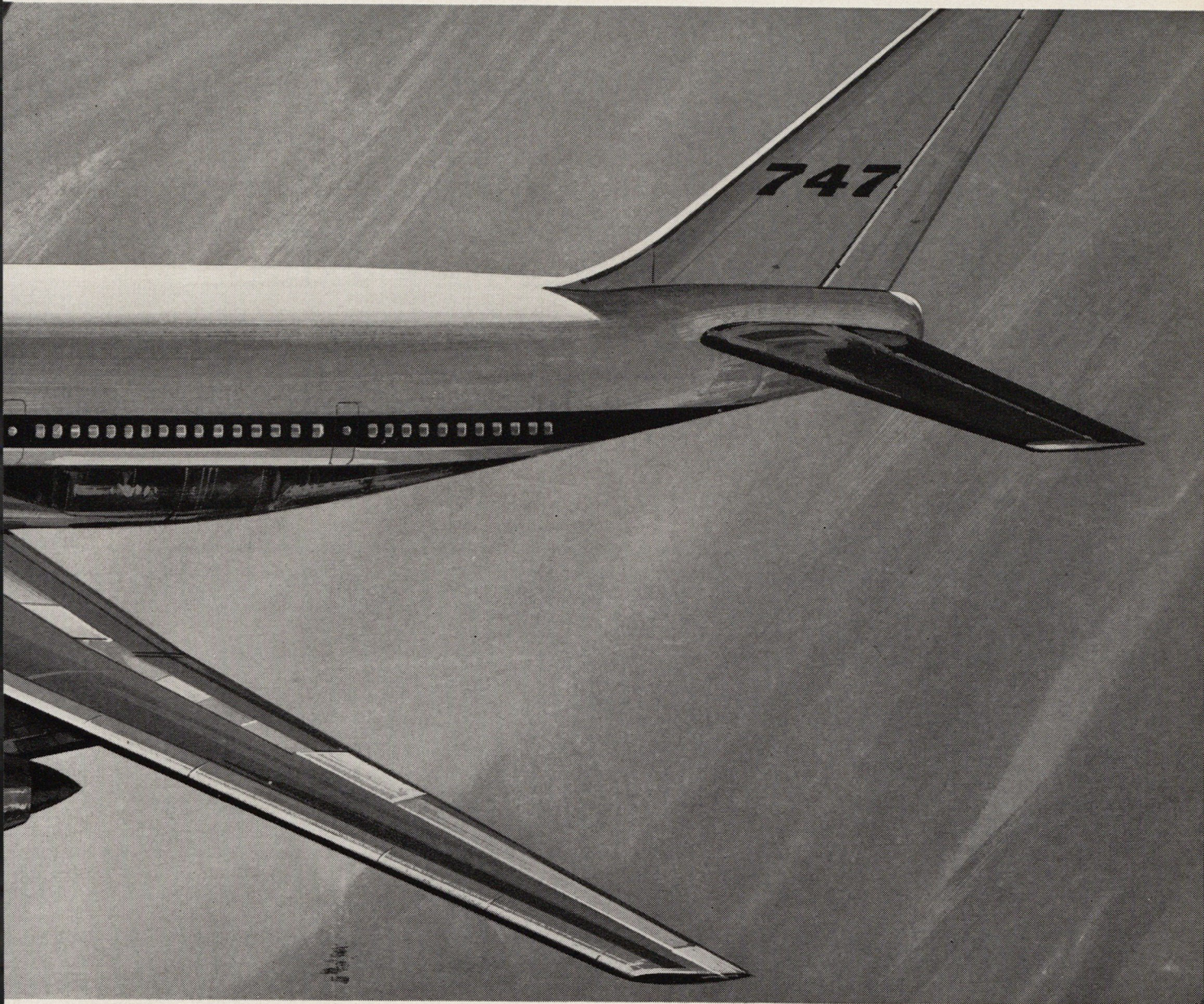


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PASSENGER AIRLINER



in Renton, Washington, working alongside their Boeing counterparts on the configuration and design of the fuselage.

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The aircraft industry has always shared the big jobs. But seldom is there a relationship as close as that between Boeing and Northrop. It's a result of performance on competitive contracts won by Northrop over the past 20 years. For Boeing, Northrop has built portions of the B-17, B-29, B-50, 707, 720, 737 and KC-135.

The 747 is the biggest job of all. For us. For Boeing. For the entire commercial aviation industry.

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MEMORANDUM

TO: Readers of AF/SD INTERNATIONAL

FROM: John F. Loosbrock, Editor

This month we would like to call your attention to a thoughtful article in the August issue of the monthly journal, "Harvard Business Review." The title of the article is "Technological Competition: Europe Versus U.S." The author is James Brian Quinn, Professor of Business at Dartmouth College in the state of New Hampshire.

Professor Quinn cites European concern that "in some industrial fields the United States may soon enjoy such technological leads that European companies may permanently lose their competitive positions in important world markets." He then asks the following questions:

- Why has the United States been able to develop such an enormous range and depth of scientific and technological capacities?
- What are European countries doing to counter U.S. strengths?
- Where will European companies be most competitive in the future?
- Are there major weaknesses in the U.S. scientific and technological posture?
- What new opportunities and threats will face U.S. industry as a result of its changing international competitive environment?

These points are discussed at length, of course, but Professor Quinn's conclusion sums it up:

"Many factors have contributed to the emergence of the United States as the dominant industrial technological power in the Western world. Its large integrated markets, its giant companies, its pragmatic and flexible mass-education system, the sheer size and depth of its scientific and technical communities, its strong patent system, and its more highly developed

techniques for managing research-and-development programs—these have been among the major contributions.

"But the world's second most advanced technological area, Western Europe, has awakened to the threat of U.S. dominance and is developing its institutions for more effective national and international competition. A longer tradition of basic research, a superbly educated elite, and distinctly greater capacities for industrial co-operation and planning at the national level give European countries a strong base from which to begin. Recent industrial consolidations, international cooperative efforts, reforms in educational and patent policies, and the developing potentials of the Common Market should add to Europe's future challenge."

We would be greatly interested in hearing your reactions to the above. To those readers who send us their comments we will be pleased to send, without charge, a copy of the article.

Letters from Our Readers

Gentlemen: I read with genuine interest and appreciation the excellent articles on Seapower in the Space Age which were featured in the April issue of your magazine.

You and your staff deserve great credit for the research and editorial skill which led to this well-balanced and comprehensive explanation of the role of the modern Navy.

By promoting better understanding of the supporting roles and common objectives of the individual services, you have helped to strengthen our defense posture.

Please accept my sincere congratu-

lations for bringing this information to the many influential readers of AF/SD INTERNATIONAL.

Admiral Roy L. Johnson, USN
Commander in Chief
United States Pacific Fleet
FPO, San Francisco, Calif.

Gentlemen: . . . We would be most interested in publishing the excellent article ["Aircraft and Missiles of the U.S. Fleet," April 1966 AF/SD INTERNATIONAL] in our official magazine "Bundeswehr." We are specially keen on this subject as our Navy has been very interested in all problems concerning aeroplane equipments. Could you give us the permission to translate and reprint this article? Naturally we will give you the proper credit and should be most grateful for a quick reply.

Kurt Neher, Editor
SOLDAT UND TECHNIK
Bonn, Germany

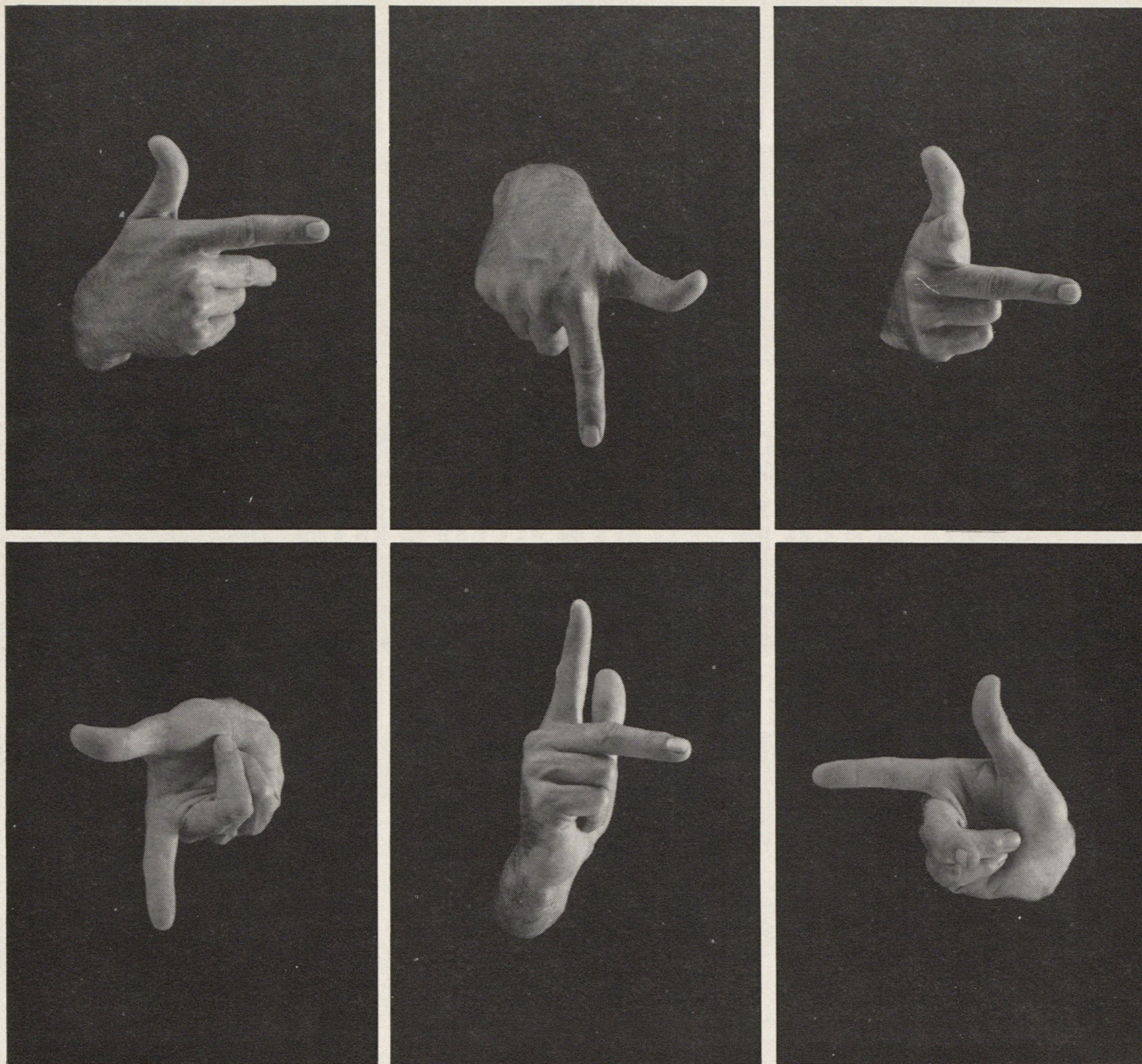
• Permission granted.—THE EDITORS

Gentlemen: It is always with the greatest interest that I read your publication Air Force/Space Digest INTERNATIONAL.

In a concise and readable form the reader is given a vast amount of valuable technical and military information.

I appreciate the objective and unbiased way in which you present your data. Your publication is of great assistance to me in my work and activities as a national and international Parliamentarian.

A. E. M. Duynstee
Member of Parliament
Chairman, Political Committee NATO
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Maastricht, The Netherlands



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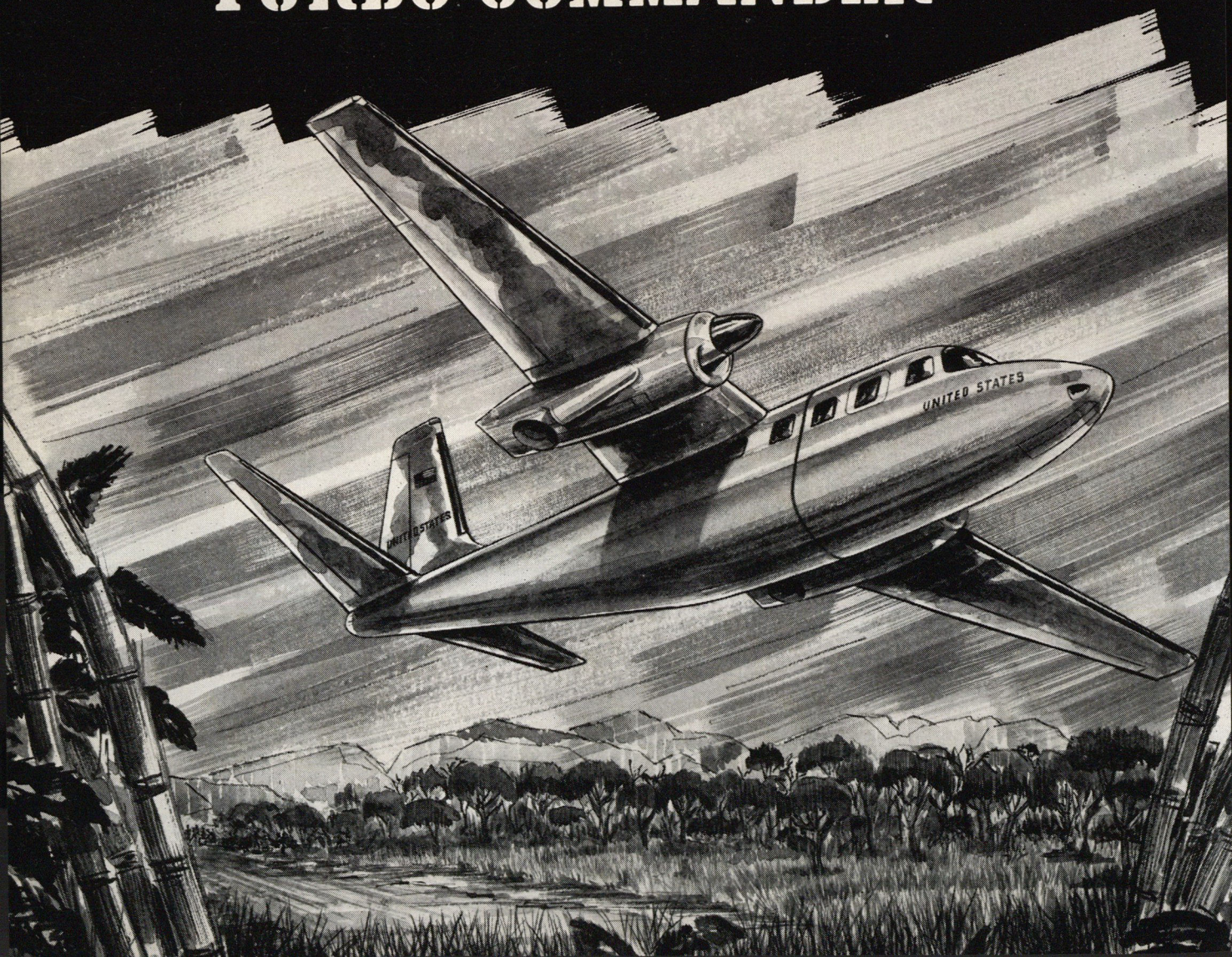
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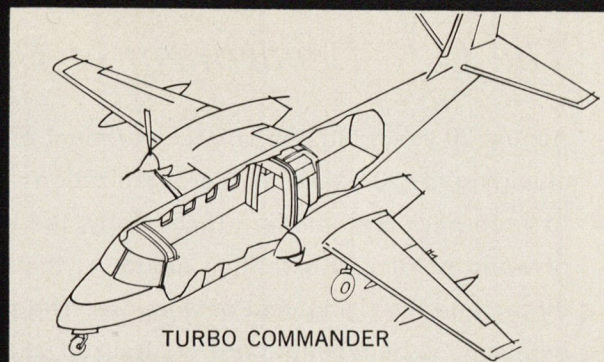
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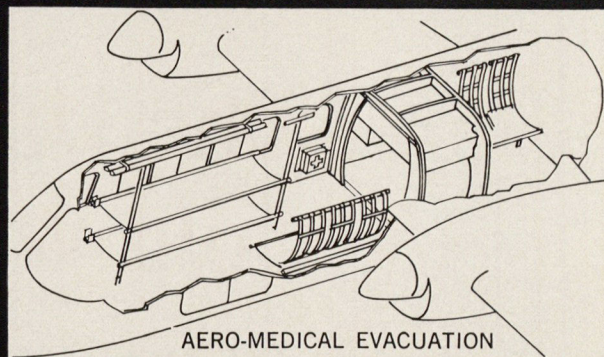
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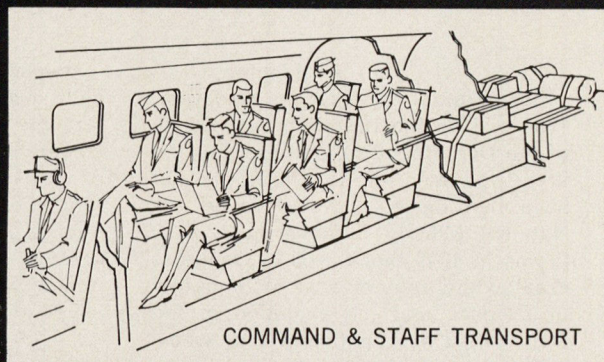
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INTERNATIONAL SALES DEPARTMENT
(CABLE: AEROCOM)
BETHANY, OKLAHOMA, U. S. A.



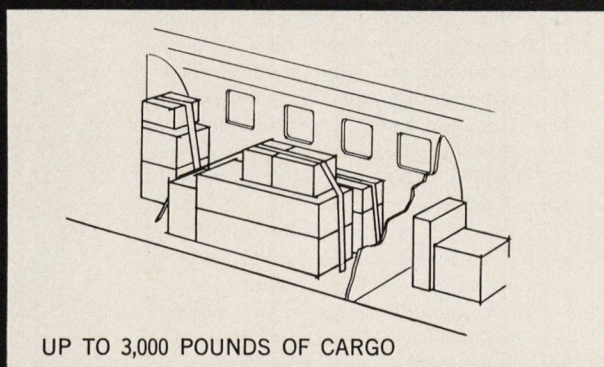
TURBO COMMANDER



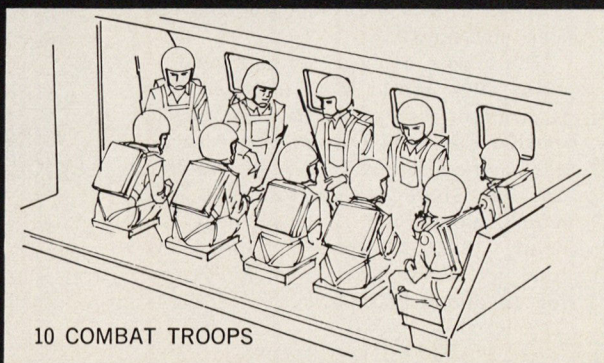
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10 COMBAT TROOPS

The U.S. Department of Defense

Almost 20 years old, the U.S. Department of Defense has been changing for 20 years, as the organization struggles to keep pace with modern technology, the new pattern of world politics, the shifting nature of the Communist threat, and the rising cost of weapons. The power to make decisions is becoming more centralized and control of forces in combat more firmly in the hands of civilians as . . .

The U.S. Meets the Cold War Challenge

By Claude Witze, Senior Editor

Washington, D. C.

For all practical purposes next year, 1967, will be the twentieth anniversary of the Department of Defense. For the first two years of its life it did not have that name, but was called the National Military Establishment. Still, it was in 1947 that the U.S. Congress created the cabinet post of Secretary of Defense and the evolution of the Department has continued ever since.

The essential background goes back no further than World War II, a contest that revolutionized U.S. thinking in the area of national security. The basic revolution was technological. It started during the war, followed by the hydrogen bomb and then the missile that could deliver it to a target 5,000 miles (8,000 km) away in a matter of minutes.

A second and equally important factor was the threat posed by the Soviet Union and the doctrines of World Communism. There are few who will argue with the success of American deterrent power, the "policy of containment," and the military aid program as efforts that discouraged Russian ambitions.

There was a short period, immediately after World War II, when the realization that a continuing threat existed was overwhelmed by the relief all America felt with the end of the hot war. There was an explosive demobilization. From a 1945 peak of nearly 12,000,000 men in arms, the total for Army, Navy, and Air Force fell to about 1,500,000.

Until that time, the United States had managed its military affairs through two executive departments, a Department of War and a Department of the Navy, each headed by a Secretary who was a member of the President's cabinet. There were evident reasons, by the time World War II had ended, why a change was needed.

For one thing, the war had demon-

strated the requirement for unified commands, such as the one that put General Eisenhower, an Army officer, in charge of all military forces for the invasion of Normandy. There were others, in all theaters. Then, there were the problems, in the great world conflict, of manpower and materiel. They made a divided military organization inefficient. On top of this, the



Joint Chiefs of Staff confer with President at the White House. Left to right are General Wallace M. Greene, Commandant, U.S. Marine Corps; General Harold K. Johnson, Chief of Staff, U.S. Army; General Earle G. Wheeler, U.S. Army, Chairman, Joint Chiefs of Staff; President Lyndon B. Johnson; Admiral David L. McDonald, Chief of Naval Operations; and General John P. McConnell, Chief of Staff, U.S. Air Force.



The civilian Secretary of Defense works closely with the military services every day. Here, Mr. McNamara confers in a Pentagon office with General Creighton Abrams, Army Vice Chief of Staff on the left, and Navy Admiral David L. McDonald, Chief of Naval Operations. At the right is an Air Force Lieutenant General, David A. Burchinal, Director of the Joint Staff. General Burchinal now has a new assignment in Europe.

Army Air Forces wanted to withdraw from the Army and become an independent Air Force, equal with the Army and Navy.

During the war, President Roosevelt had met the problems by creating the Joint Chiefs of Staff, composed of the military heads of the Army, Navy, and Air Forces, and chaired by Admiral William D. Leahy. Admiral Leahy was, in effect, the President's personal Chief of Staff. The JCS, as it is still known, became the top command organization, but without a law or executive order to support it.

There was a long debate, starting as early as 1944 when the House of Representatives created a Committee on Postwar Military Policy, and the Secretary of War, Henry L. Stimson, testified that the creation of a single Department of Defense was essential. In 1945 General Eisenhower told West Point cadets that unification of the Armed Services should be accomplished.

"If I had my way," he said, "they would all be in the same uniform." Behind the scenes, high Navy officials, both uniformed and civilian, were preparing to fight the proposal, but they were not successful.

Starting at least in 1945, the doctrine endorsed by Eisenhower kept advancing, but not to the point where the single uniform has been adopted, or real unification under a single Chief of Staff. Nevertheless, the direction and control of the Armed Ser-

vices has become increasingly centralized. Both Congress and the Executive Branch of the Government have contributed to the changes.

The National Security Act of 1947 replaced the War and Navy Departments with a National Military Establishment. The separate departments of the Army, Navy, and Air Force were to be administered under the "general direction, authority, and control" of a

Secretary of Defense. But there was no Department of Defense created by the law.

The 1947 act, which followed a two-year debate, designated the Joint Chiefs of Staff as the "principal military advisers" to the President and the Secretary. It authorized a Joint Staff of 100 officers and a National Security Council, including a Central Intelligence Agency. Two other well-established agencies, the Munitions Board and the Research and Development Board, were continued.

The first Secretary of Defense was James Forrestal, who was sworn in on September 17, 1947. He had been Secretary of the Navy. He soon found in his new job that he did not have sufficient power for the task, and early in 1949 he recommended changes. While Congress was working on a revision of the law, Mr. Forrestal was removed to the hospital in a state of exhaustion, and he died there in May of 1949.

The 1949 amendments to the National Security Act stressed that the Secretary of Defense was to be the principal assistant to the President in all matters relating to the Department of Defense. The Department also was given this new name instead of National Military Establishment.

The Army, Navy, and Air Force, under this new law, lost their identity as Executive Departments and became military departments within the Defense Department. The 1949 amendments also authorized additional staff assistants for the Secretary of Defense. It added a nonvoting Chairman to the Joint Chiefs of Staff and ex-

(Continued on following page)



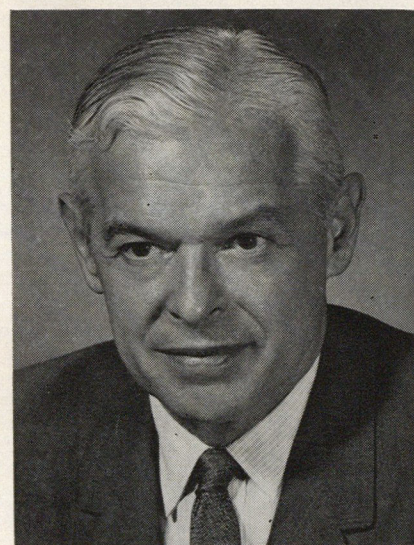
Outside of the White House, this probably is the most important desk in the U. S. It was built in World War I for General John J. Pershing. Today it is occupied by Robert S. McNamara. Portrait is that of James V. Forrestal, the first Secretary of Defense.



Secretary of the Air Force Harold Brown



Secretary of the Army Stanley R. Resor



Secretary of the Navy Paul H. Nitze

panded the Joint Staff from 100 to 210 officers.

The three Service Secretaries were removed as members of the National Security Council and replaced by the Vice President. A new section was added to the law, providing for uniform budgetary and fiscal procedures in the Department of Defense.

The evolution was continued in 1953. A reorganization that year abolished the Munitions Board and Research and Development Board. It took further recognition of the growing burden on the Defense Secretary, much of it growing out of the war in Korea. He was authorized to have six additional Assistant Secretaries and given the power to select the Director of the Joint Staff.

Five years later, in 1958, there were further changes. The Secretary of Defense took over more responsibility, formerly exercised by the Secretaries of the Army, Navy, and Air Force. In particular, these chores dealt with the selection of new weapons for development and deployment, a matter in which there had appeared considerable rivalry. In an age of expensive weaponry and scarce talent, competing systems were viewed as wasteful.

The 1958 reorganization also authorized the Secretary of Defense to transfer, reassign, abolish, or consolidate established combatant functions of the Army, Navy, and Air Force, subject always to a veto by Congress. It said the President, by law Commander in Chief of the Armed Services, could create unified commands for combat purposes. Again, the Joint Staff was expanded, this time to 400 officers, almost double the previous authorization. The 1949 decision that the Chair-

man of the Joint Chiefs was not entitled to a vote was repealed.

From the standpoint of how we fight a war and what we fight it with, the 1958 stage in the Defense Department's evolution may be the most important. In 1958, General Eisenhower was President and this law established a new chain of command. It is significant that Congress took the action after an elaborate investigation of the missile and satellite situation and the U.S. position in those areas.

The 1958 reorganization gave the Defense Secretary practically full responsibility for military operations. The law specifically said that all forces committed to unified and specified commands were responsible to the Secretary and the President. What this meant, in blunt words, was that the civilian secretary is in charge of the fighting in the event of war and will give his orders directly to the commanders of the unified and specified commands. These commands, of course, include men from all of the Armed Forces. In practice, the Secretary exercises his authority over the commands through the Joint Chiefs of Staff. But they hold their authority because he has delegated it to them.

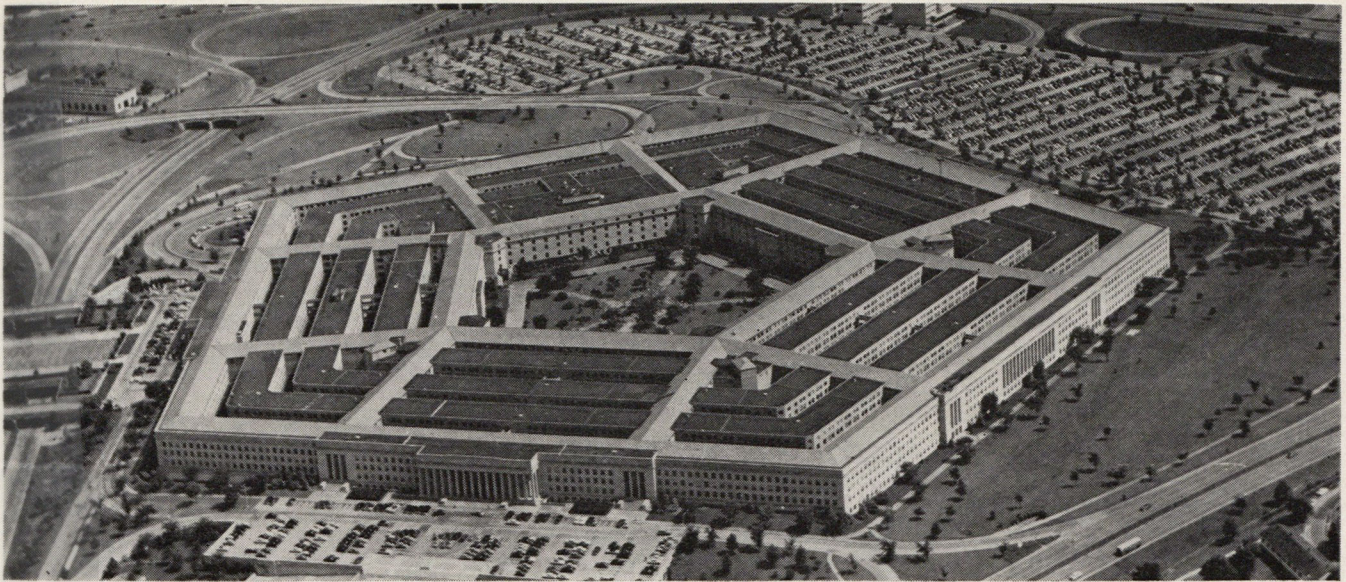
The situation has been defined by a Defense Department official this way:

"The Secretary of Defense has a dual responsibility, exercised through a dual chain of command. On the one hand he is responsible for directing and controlling the operations of the unified and specified commands; and on the other hand he is responsible for exercising authority, direction, and control over the military departments which provide, train, and equip the

(Continued on page 14)

Outside the Pentagon, at the River Entrance, Defense Secretary Robert S. McNamara holds an informal conference. With him are John T. McNaughton, Assistant Secretary of Defense for International Affairs, and General Earle G. Wheeler, an Army officer and Chairman of the Joint Chiefs of Staff.





PENTAGON, HOME OF DEFENSE DEPARTMENT, IS WORLD'S LARGEST OFFICE BUILDING

The Pentagon, as its name suggests, is a building with five sides. The largest office building in the world, it is the headquarters of the Department of Defense and presided over by Robert S. McNamara, the Secretary of Defense.

The Pentagon is not in the city of Washington or the District of Columbia, which is the U.S. capital. It is across the Potomac River, in the state of Virginia. The land on which it stands was reclaimed from a swamp and dump, and construction was started in 1941, about five months before the Japanese attack on Pearl Harbor, but almost two years after World War II had started in Europe. The building was completed in 16 months, ready for use in January 1943.

While it is the headquarters of the U.S. military effort, one supported by an annual budget of more than \$58,000,000,000, the Pentagon is occupied by more civilians than soldiers. During the peak of World War II, there were 26,500 persons employed there. The figure now is about 25,000 and only an estimated 40 percent of these are in uniform.

Taking orders from the Pentagon, and relying on it for support all over the world, are all of the civilian and military personnel working for the U.S. Department of Defense. These people are scattered from other buildings in the Washington area to remote posts at the South Pole and in all the foreign lands where the U.S. military has missions.

The Pentagon contains a total area of 6,281,027 square feet (583,510 m²). The building has 7,600 windows. The offices and corridors are illuminated by 65,000 light fixtures in which 1,000 bulbs are replaced each day. There are 700 men employed on the maintenance staff, including carpenters, painters, electricians, sign painters, locksmiths, and mechanics.

The building rises only five stories, despite the fact that inside it has three times as much floor space as a skyscraper, such as the Empire State Building in New York. Outside there are 200 acres (81 hectares) of lawns and terraces around the Pentagon, which itself covers 34 acres (14 hectares). There are 67 acres (27 hectares) of parking lots, with room for 9,300 vehicles.

Inside, there are 17.5 miles (28 km) of corridors. Each floor is made up of five concentric rings, connected by ten corridors running from the outside to the inside like spokes in a wheel. There are many jokes about visitors, and employees, who have become lost in the Pentagon, but not many of them are true. The design of the building, with its 150 staircases and 19 escalators, makes it possible to walk between any two rooms, a maximum of 1,800 feet (548 m), in about six minutes.

The rooms are numbered according to a simple plan. Once understood, it makes it simple to find any office. Room 3D925, for example, is on the third floor, in Ring D, near the ninth corridor, or spoke, of which there are ten. The innermost Ring is A and the one at the perimeter of the Pentagon is Ring E. Related activities are located in the same general area. Thus, the offices of the Secretary of Defense and his principal deputies and aides are on the third floor, in E Ring and between corridors seven and ten. The Air Force Headquarters is in the same general area on the fourth floor.

The Pentagon's telephone system is operated out of the world's largest switchboard. It handles 50,000 telephones for the Department, connected by 175,000 miles (281,636 km) of cable. The switchboard handles approximately 270,000 calls a day. There is a staff of 150 persons to run the telephone system.

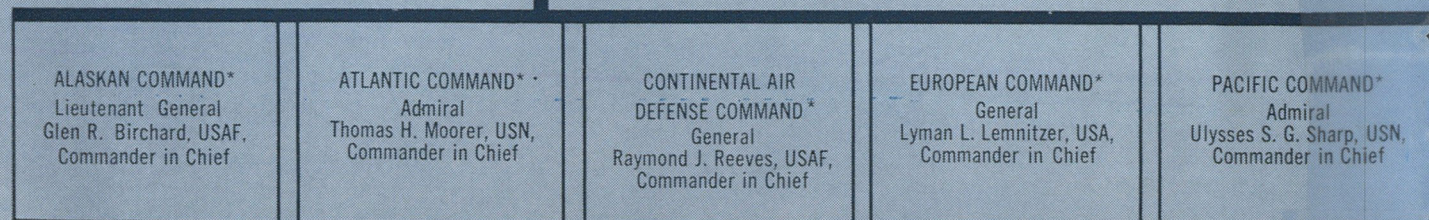
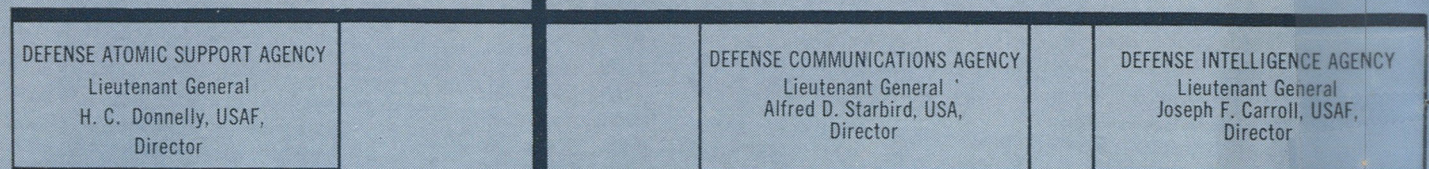
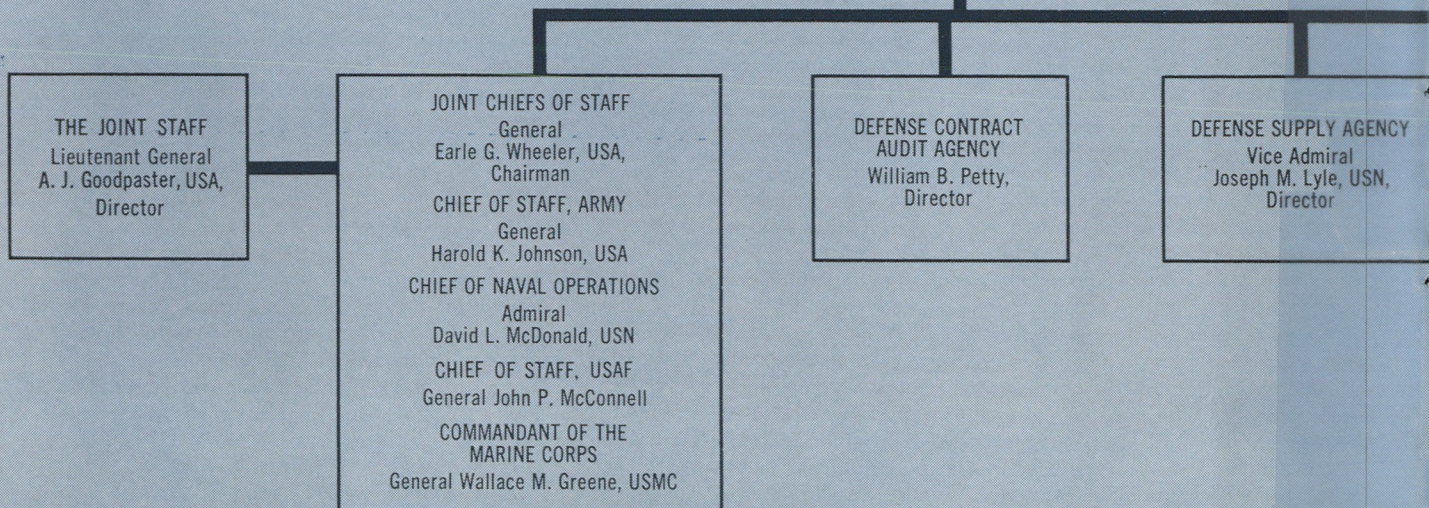
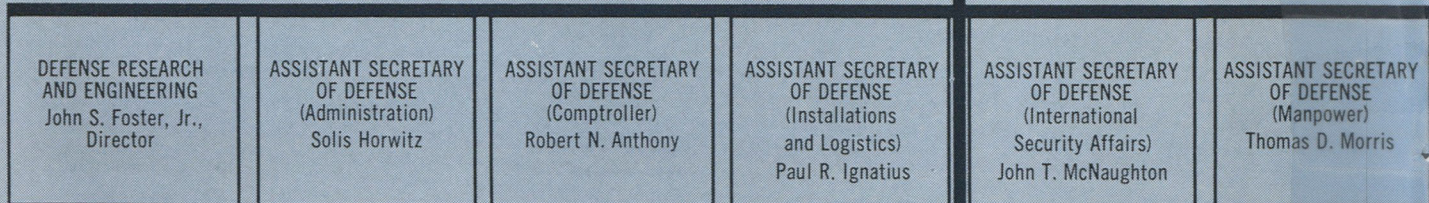
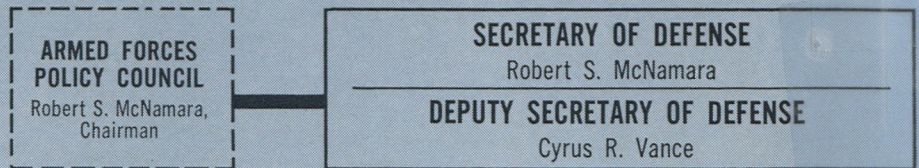
The main entrance to the Pentagon, for the most important people, is called the River Entrance because it faces the Potomac. In front of it, there is a lagoon, which was created when earth was excavated from the side of the river to fill road and parking areas. This makes it possible for Pentagon visitors to arrive by motor launch. On another side of the building, there is a helicopter landing pad, used daily by top military and civilian officials hurrying off to conferences or to one of the nearby airports.

Most Pentagon workers enter from the ground floor of the building, through the "Concourse." This vast entrance is similar to a modern airport terminal or huge railroad station. There are facilities for buses and taxicabs to unload. The terminal is bordered by a shopping center, including a rail and airline ticket counter, a newsstand, barbershop, department store, laundry, drug store, florist, bakery, candy store, bank, and post office—all under one roof.

The Concourse also includes a huge Information Desk, where strangers can locate the office they want to visit. The clerk will provide a card with a floor plan and mark a simple route to follow to any destination.

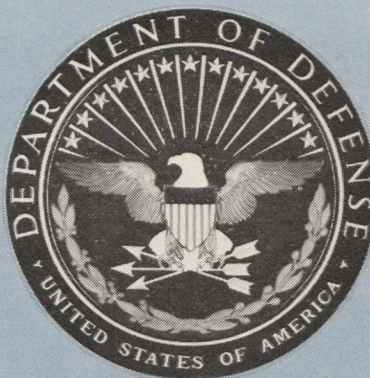
Many areas in the Pentagon are highly restricted, and entrance can be made only after careful scrutiny by guards. The most important of these areas is the National Military Command Center in the basement. Here there are conference rooms, a complex worldwide communications system, and huge screens on which maps and radar readings can be projected while the military commanders keep track of any crisis and determine the readiness of U.S. military commands.

DEPARTMENT



* These eight commands report directly to the Joint Chiefs of Staff. Seven of them are "unified commands," which means they include units from more than one service. The eighth, Strategic Air Command, is known as a "specified command."

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Robert W. Porter, USA,
Commander in Chief

STRATEGIC AIR COMMAND*
General
John D. Ryan, USAF,
Commander in Chief

STRIKE COMMAND*
General
Paul D. Adams, USA,
Commander in Chief



This is the main conference room of the National Military Center. Each position at the table has its own communications equipment. The military and civilian chiefs can talk to commanders anywhere in the world, to the ships at sea, and to pilots in flight.

forces which go into the unified and specified commands."

The only Specified Command is the Strategic Air Command. This, of course, is an Air Force operation. In case of war, the Navy's submarine missile system, Polaris, would be employed as a strategic weapon. This has led to the establishment of the Joint Strategic Target Planning Staff under the SAC Commander and located at SAC Headquarters in Omaha, Nebraska. The Navy is represented on the Target Planning Staff.

The unified commands, of which there are seven, are included in the chart on pages 12 and 13. They range from the key command in Europe, headed by General Lyman L. Lemnitzer, a former Chairman of the Joint Chiefs, to the newest, Strike Command, a joint Army-Air Force operation. Strike is a highly mobile force, prepared to meet the brushfire war threat anywhere in the world (see "Can Strike Command Really Strike?", July 1965 AF/SD INTERNATIONAL, p. 22). Geographically, it has responsibility

for military operations in the Middle East and Africa south of the Sahara.

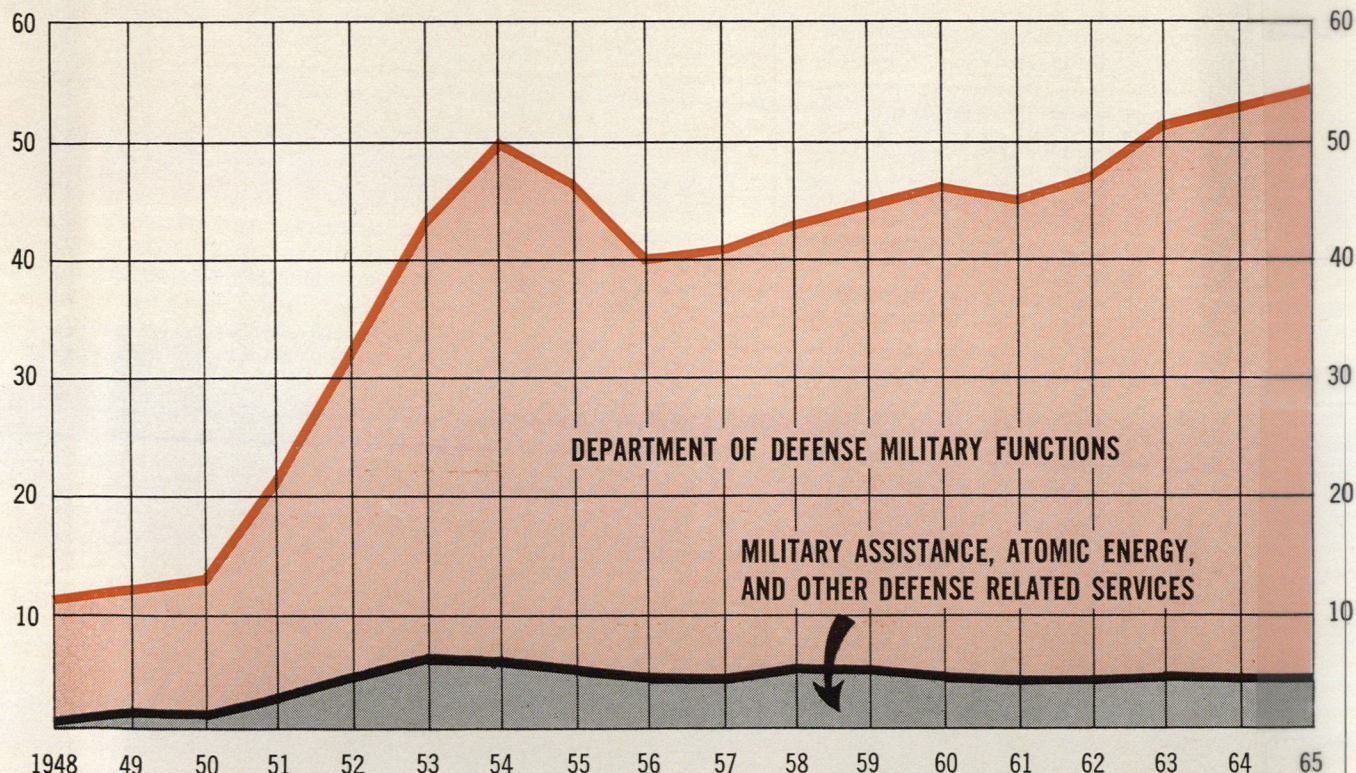
This review of the recent legislative history of the Defense Department and the growing centralization of its control should be put into focus against a background that shows the fluctuations in the size and makeup of the Armed Forces.

In 1947, when the first Secretary of Defense was appointed, there were 1,582,999 men in the uniforms of the three Armed Services. There were 859,142 civilian employees, and the budget was a little over \$11,000,000,000. The U.S. had demobilized from the peak of World War II, when there were 12,000,000 soldiers, sailors, and airmen and the budget was more than \$80,000,000,000.

Then, in 1950, there was war in Korea. By 1952, the military forces had gone back to 3,635,912 and the budget was pushed higher than \$41,000,000,000. Since then, the manpower level has stabilized in the area of a little less than 2,700,000. But the budget keeps rising, first with the growing cost of advanced weaponry, currently because of the expensive war in Vietnam. The Fiscal Year 1967 budget, recently before Congress, calls for \$58,600,000,000. The Vietnam War will re-

EXPENDITURES FOR NATIONAL DEFENSE: FISCAL YEARS 1948-1965

BILLIONS OF DOLLARS



quire additional funding later this year.

At least for the past five years, all discussions about Defense Department organization, funding, operations, and disputes have centered around the present Secretary, Robert S. McNamara. He has held the office since January 21, 1961—longer than any of his predecessors.

Mr. McNamara never has complained that he lacked enough power to run the department. In fact, he has exercised the power he has in major administrative actions. He has consolidated military intelligence and supply services. He has centralized control over procurement decisions. He is subjecting budget requests from the Army, Navy, and Air Force to new and more rigorous analysis. Weapon costs are studied according to their mission, not according to what they may contribute to an individual service. There is a definite comparison of the cost and effectiveness of all weapons.

The story is told that Mr. McNamara gave birth to the idea of a Defense Supply Agency one morning when he attended a meeting with his Deputy, the three Service Secretaries, five Chiefs of Staff, and seven Assistant Secretaries of Defense. Hours were wasted on a single topic: Should there be a single type of butcher smock for meat cutters and kitchen workers of all the services, or should the Army, Navy, and Air Force each be allowed to buy the particular smock it favored? Now the Director of the Defense Supply Agency, Vice Admiral Joseph M. Lyle, can make decisions like this, and the more important men are freed for important work. In practice, the Admiral now delegates this type of thing to some Colonel or Navy Captain down the line.

This does not mean that the men down the line decide what to buy and it automatically is purchased. The McNamara doctrine requires full justification and there are plenty of men and computers to check and recheck these decisions.

The Defense Supply Agency and the Defense Intelligence Agency were set up in 1961. In that same year, the Defense Department was placed in charge of the U.S. Civil, or home, Defense effort, a responsibility it has since turned over entirely to the Army. A Defense Communications Agency has been created for support of the worldwide command-and-control system and for the integrated development of a military telecommunications satellite system. Responsibility for all space research and development has been given to the Air Force. All training for automatic data-processing machines is done by the

Navy. The Army is in charge of foreign-language training. Thus, many chores previously done separately by all three of the services have now been consolidated.

Only last year there was a new post created and designated Assistant Secretary for Systems Analysis. This office monitors and reviews all analytical studies. It tries to improve techniques for estimating the costs of forces and weapon systems. It conducts studies of the economic impact of defense programs.

The U. S. Defense Department is the biggest single enterprise in the world. It is estimated that it has \$158,-

000,000,000 in assets, scattered all over the world. Its budget is more than the combined national budgets of Great Britain, France, West Germany, and Italy.

James Forrestal, the first Secretary of Defense, once wrote that "This office will probably be the biggest cemetery for dead cats in history."

What he was saying was that the job of running the department is staggering. There have been seven secretaries since Mr. Forrestal. Mr. McNamara is credited with having closer and more efficient control of the organization than any of his predecessors.

☆☆☆



Inside the National Military Command Center in the basement of the Pentagon is the central control board for telephone communications. The room is packed full of radio and teletype machines in addition to the telephone system. One telephone is the "hot-line" link to Moscow. This is where command and control of U. S. Armed Forces starts.

The C-5A, the USAF gigantic transport plane, will not only be able to revolutionize military strategy but will have equal impact on commercial aviation. The U.S. aircraft industry has under consideration three huge passenger-aircraft designs which are based on the C-5A technology. But many questions about the economy and utility of 1,000-passenger aircraft remain unresolved. In the following article, AF/SD INTERNATIONAL gives a status report on how the race toward commercial giants is developing and how it is affected by commercial aviation's other big race—the one toward Mach 2.7 SSTs . . .

THE JUMBOJETS— Air Travel for Everyman?

BY EDGAR E. ULSAMER
Special Correspondent

PART 1

The word that commercial aviation lives by is productivity—the measure of business generated by an airplane in relation to its operating cost and purchase price. One way to increase productivity is by enlarging size and payload. The other is by increasing speed.

These two concepts have led to two commercial aircraft design approaches that will have heavy impact on air transport in the years to come. One is the jumbojet—the subsonic commercial offspring of the U.S. Air Force's gigantic C-5A heavy logistics transport. The other is the three-times-faster-than-sound supersonic transport (SST), described in the July issue of AF/SD INTERNATIONAL (p. 6). Only one type of SST is scheduled to be built in the United States. But the number of jumbojet designs on order or under consideration, as well as the difference from model to model, keeps growing at a rapid rate.

The SST's daily average productivity, according to the Air Transport Association, will be about 4,500,000 seat-miles. The first jumbojet is expected to produce about 2,000,000 daily seat-

miles. Larger follow-on models could increase this value to close to the SST's total. The best contemporary jetliners produce about 600,000 daily seat-miles.

The largest jumbojet under consideration will haul three times the number of passengers as the SST at one-third the latter's speed. Conversely, the SST will transport only one-half to one-third of a jumbojet's passenger payload but at three times its speed. Purchase price of the jumbojet is expected to be just under \$20,000,000 apiece, while each SST will sell for something above \$30,000,000. Either aircraft should increase productivity between three and nine times the level of present commercial aircraft.

The first jumbojet will fly in 1969. The U.S. SST will become operational about five years later. Both types of airplanes have generated enthusiasm as well as some wariness within the aviation community. Reactions range from full approval for both, to rejection of one or the other.

It is taken for granted that the jumbojet will take over the lion's share of the burgeoning air-cargo market from

contemporary cargo freighters. This will apply not only on medium to long flights, but also on some shorter routes which have a high traffic volume.

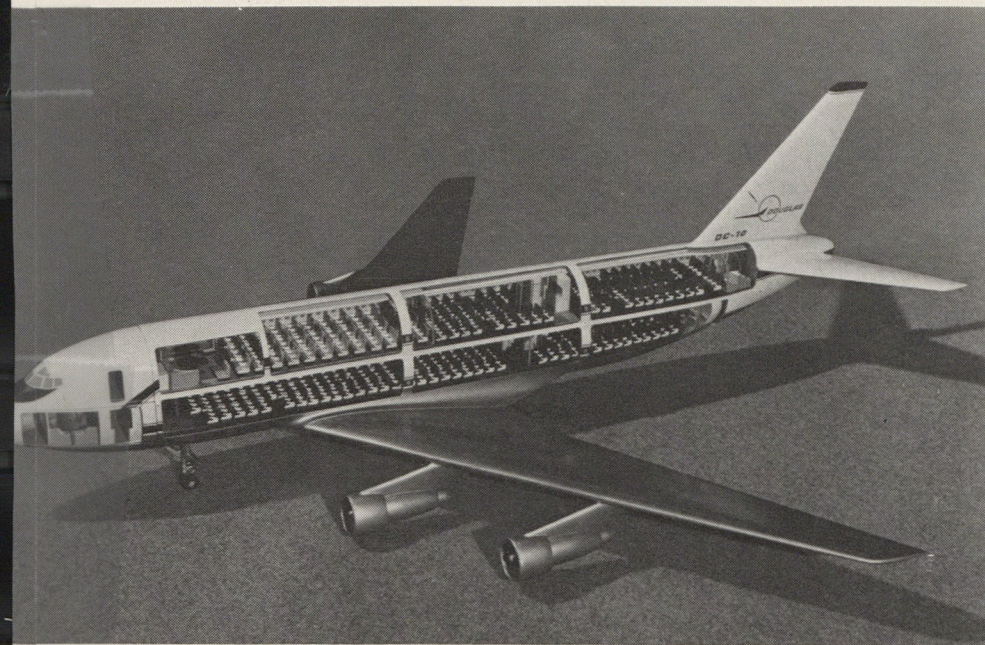
This cargo capability gives jumbojets a safe base to operate from. With air-freight growth expected to average 40 percent a year over the next five years, reaching 20 times the present volume by 1980, cargo jets of the C-5A type are deemed not only possible but necessary.

Lockheed Aircraft Corporation offers intriguing statistics to show what a C-5A-type cargo jet can do.

Take a shipment of one ton (.9 mt) of auto parts packed in five containers of equal weight to be sent all the way across the U.S., from New York to San Francisco. The present cost by rail is \$230, by truck \$240, and by air \$365. The commercial C-5A, called the L-500, could do the job for \$208—with normal profit margin for the airline operator and normal load factor, according to Lockheed.

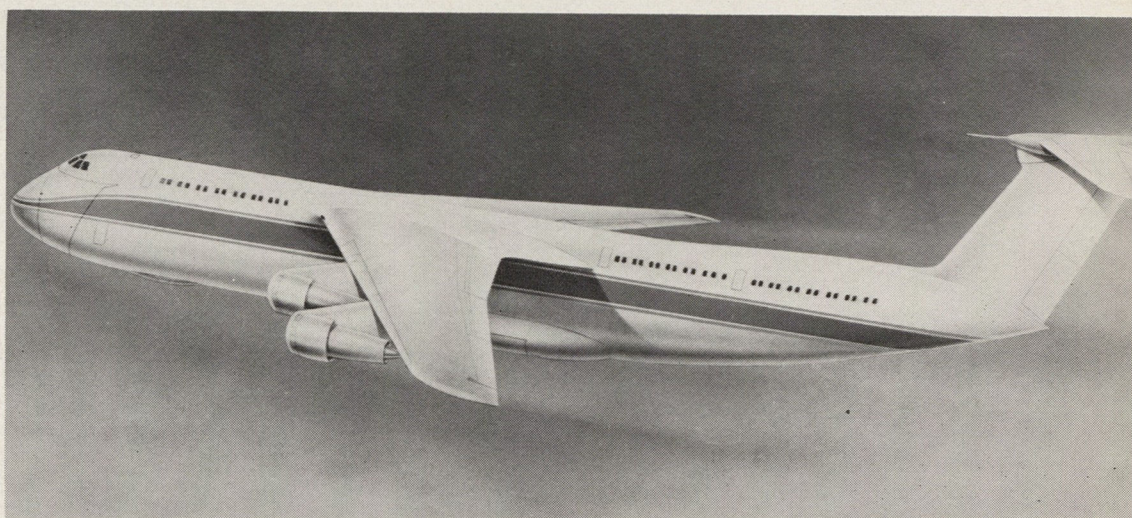
In transporting this same theoretical shipment over a New York-to-London route, the costs would be \$100 by sea,

(Continued on page 18)

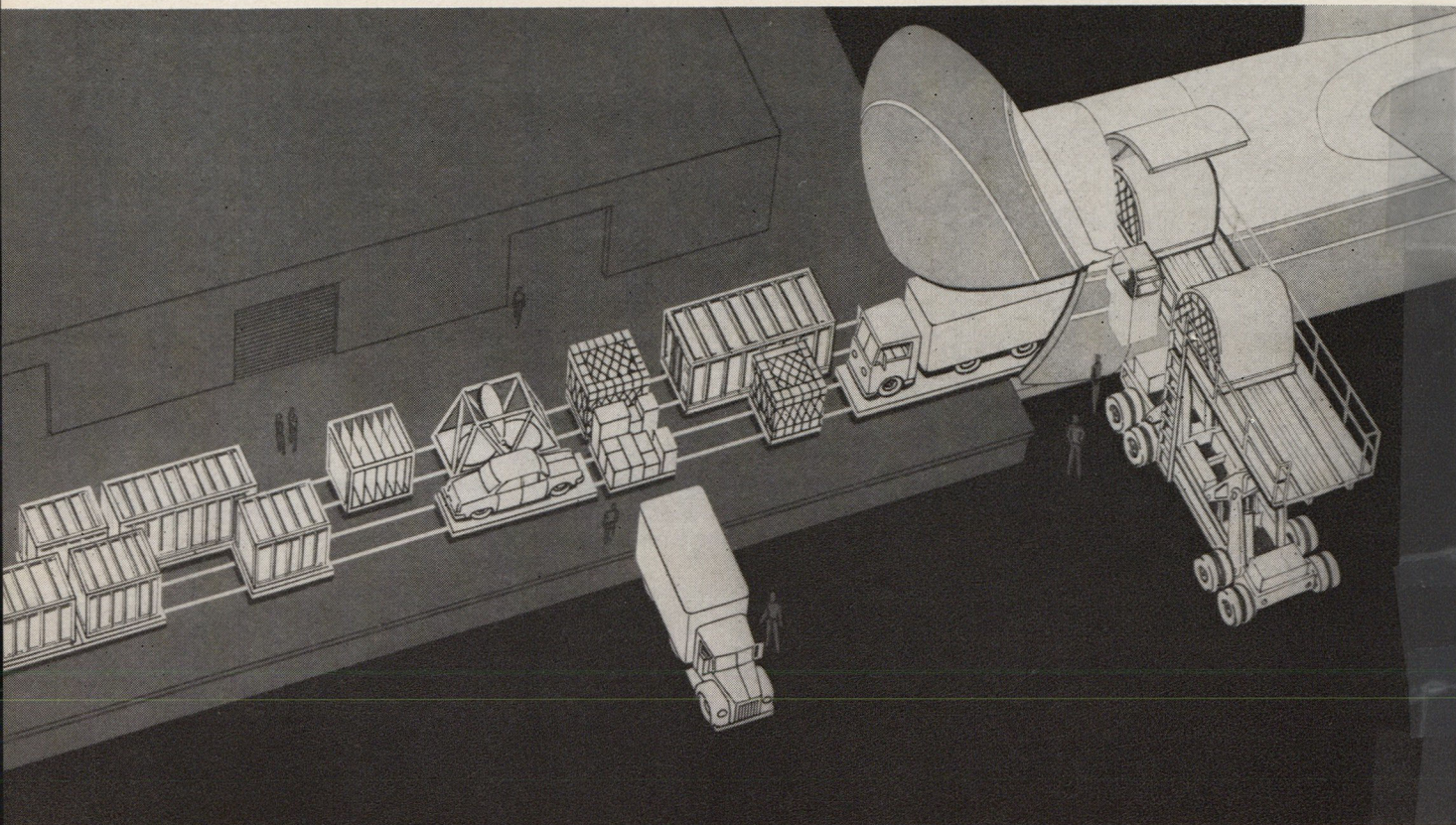


Douglas' jumbojet project, tentatively known as the DC-10, is in a fluid and exploratory state. If the company goes ahead with this program, it will be with the intention of producing a second-generation jumbojet, to be available by about 1975. That is because Douglas' marketing experts predict that the market for truly large passenger and cargo aircraft will take that long to develop.

Lockheed's jumbojet design bears the designation L-500 and could haul 902 passengers at rates below current bus fares. Company officials say the aircraft can be designed to have a payload of about 300,000 pounds (136,080 kg). It could produce 1,000,000,000 passenger-miles a year, or, on a time-dependent basis, three times the volume of the largest ocean liner.



Boeing expects that 400 or more of its 747s will be bought by the world's airlines within the next 15 years. So far, about 50 aircraft have been ordered, according to reliable, unofficial reports. The 747 can accommodate up to 500 passengers, and will be ready for delivery by 1969. Later models, company officials predict, may reach or exceed 600-passenger capacity. The 747 is available in cargo and passenger configuration.



As an all-cargo aircraft, the L-500 offers an interior gross volume of more than 51,000 cubic feet (1,444 m³) and a maximum payload ranging from 242,000 to 300,000 pounds (109,770 to 136,080 kg). With full payload, the aircraft's range is 3,220 miles (5,182 km). Palletized cargo would be handled automatically, and would be compatible with truck, rail, and ship transportation standards.

\$650 by air, and \$282 by L-500. Considering the time differential of days vs. hours between a freighter and the 550-mph (885 kmph) jumbojet, the giant cargo plane begins to compare favorably with sea transportation for many commodities.

The Jumbojet and the SST

The jumbojet is also planned to be a passenger aircraft, slated to accommodate from 350 to nearly 1,000 passengers. This prospect gives many airlines a bad case of nerves. Any number of unknowns can make or break the jumbojet's profit equation. One such factor is the market impact of the SST, with its great speed advantage. Most market studies indicate that the supersonic transport will attract the bulk of all business travel, which now represents half of the scheduled air-passenger business. How much of what's left can be expected to go to the jumbojets?

Marketing experts are losing sleep trying to find the answers.

Many other questions are being pondered about the SST-jumbojet market-sharing:

Will the SSTs be confined to long-stage lengths or are they going to be

economically attractive also on medium-length runs? It is being assumed that the short-haul market will continue to be dominated by aircraft of the 727, DC-9, and 737 types. Just how much growth in passenger capacity will the SSTs have? Present designs already have reached 300 passengers, almost double the capacity of present large jetliners and about 100 seats more than provided for in the initial SST plans. How much of an advantage will the SST derive from its compatibility with existing ground facilities as opposed to the jumbojets, which will require substantial changes?

The airlines are running their computers overtime trying to come up with the answers. For the time being, many have adopted a wait-and-see attitude toward the passenger jumbojets. Trans World Airlines' Vice President for Research and Planning, Robert W. Rummel, believes that there is room for the operation of both types of aircraft in the passenger field only if there is a "significant fare differential between the subsonic and supersonic" air transportation.

The former Chairman of the Board of United Air Lines, William A. Patterson, takes an even colder view of all-passenger versions of the jumbo-

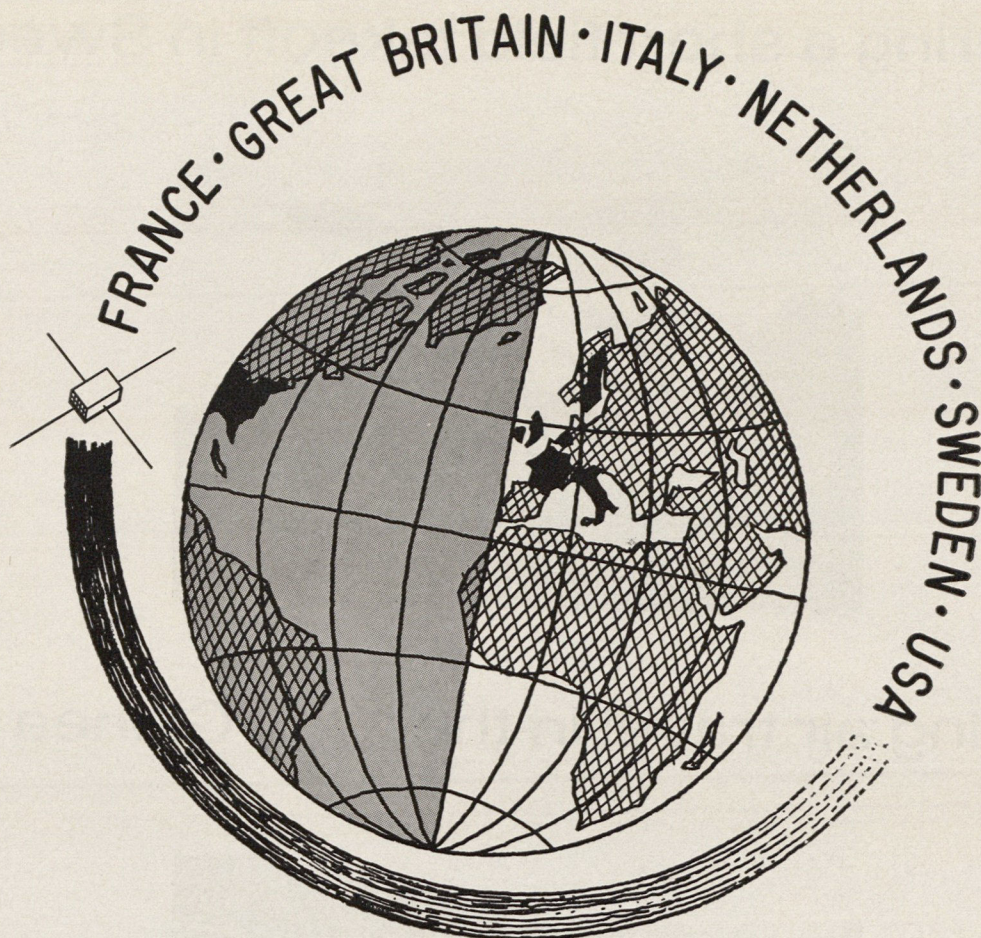
jets. He says there "simply is no market heavy enough to produce so many passengers for any one flight." On the other hand, Mr. Patterson foresees a profitable future for commercial cargo versions. Mr. Rummel draws a different line. He predicts that passenger aircraft may reach up to 400-seat capacity but does not consider it likely that substantially larger passenger aircraft will be needed in the foreseeable future.

Donald W. Douglas, Jr., President of the Douglas Aircraft Company, who confesses to "great optimism on air traffic growth," nevertheless stresses that it is "essential that you don't reduce frequency. . . . You should increase frequency if you want to increase traffic."

Knut Hammerskjold, Director General of the International Air Transport Association (IATA), believes that there are few routes in the world where a 1,000-passenger aircraft could find a "satisfactory rate of utilization."

He adds a statement that is significant primarily because of IATA's powers to approve or reject rate reductions in international traffic. "Because of uncertain factors regarding these new aircraft," he says, it is not yet

(Continued on page 21)



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A scientific satellite team of five leading Western European aerospace companies has selected General Electric Company of the U.S.A. as space systems consultants.

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MISSILE AND SPACE DIVISION

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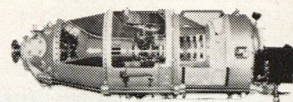
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With a fuselage that's almost twice as wide as the largest contemporary jetliner, the 747 can accommodate up to 500 passengers easily and comfortably. Nine-or-ten-abreast seating, as shown here in Boeing's interior mockup of the 747, allows for two aisles and easy access to all seats. Operating economy of the 747 will be between 20 and 30 percent above that of the present generation of large jetliners. Runway requirements for Boeing's jumbojet airplane are said to be considerably better than those of the 707 or DC-8.

possible to predict whether or not IATA "will consider lower fares for international routes" served by the jumbojets.

The Jumbojets on the Ground

Mr. Hammerskjold has further words of caution. "Present airport check-in formalities," he says, "will have to be given a complete examination. Otherwise the time involved will be excessive—not to mention the confusion." He also foresees the need for an extensive revamping of customs procedures in connection with the 1,000-passenger jumbojets. "Perhaps we can persuade governments to accept the substitution of a passport card, in the same format as a credit card, for passports," he suggests.

As an alternative, he says, passport or customs officers could travel on the big aircraft in the way they already do on certain ships and trains.

Obviously, the jumbojets will require changes and expansion of many ground facilities. For that reason airport managers have been apprehensive. But the supporters of the jumbojets point out that systems management techniques should be able to solve these relatively minor problems.

New Era in Aviation Economics

Obviously the most attractive feature of the jumbojets is economy. The theoretical price reductions they could effect are revolutionary. While produc-

tivity of the various jumbojet designs varies considerably, the following cost estimates compiled by marketing analysts of Lockheed Aircraft Corporation can serve as a benchmark:

The two generally accepted yardsticks for measuring aviation economics in the passenger field are direct operating costs and total operating expense. They are expressed in terms of how much it costs to generate a seat-mile, which means transporting one passenger for one mile under average occupancy rates, average trip lengths, and average aircraft utilization.

The Lockheed values are based on intercontinental operation. Direct seat-mile costs on the contemporary jetliners of the 707 or DC-8 type average out to 1.2¢; those for the U.S. SST are estimated at about 0.9¢; the Anglo-French Concorde runs these values up to 1.5¢; the 250-passenger version of the DC-8, known as a "stretched-out" jet and expected to enter service late this year, will lower direct seat-mile costs to 0.8¢; and the commercial version of the C-5A is projected to reach an all-time record in economy—0.5¢ per seat-mile.

In terms of total operating expense, which includes such costs as passenger service, ticket sales, and reservations, Lockheed's marketing experts attribute these seat-mile costs to the various airplane types: the jumbojet is 1.5¢; the stretched-out is 1.9¢; the U.S. SST is 2.0¢; the standard contemporary jet is 2.2¢; and the Con-

corde is 2.8¢. On the basis of these and similar findings by other marketing experts, sizable general fare reductions appear possible for the future jumbojets.

But there is a complicating factor.

Can air fares for the jumbojets be slashed without a matching reduction for the other subsonic jets? Most carriers feel that an across-the-board cut is necessary. As TWA's Rummel puts it: "Aircraft packed with 1,000 passengers will be neither faster nor more comfortable than contemporary smaller subsonic aircraft and, therefore, a fare differential would seem unreasonable." How much of a broad cut in air fares for all subsonic transportation can the aviation industry afford? Tentative figures indicate that a fare cut of between ten and 20 percent appears possible for all domestic subsonic traffic if jumbojets are employed in substantial numbers.

The Jumbojet is Needed

Many market forecasters document a need for passenger jumbojets on the basis of the predictable general growth of the air travel market. Estimates range from an annual growth rate of six percent to one of 11 percent over the next ten years. These figures may prove conservative, for actual growth over the past five years averaged 14.5 percent—considerably higher than the marketing men had predicted.

(Continued on following page)



Scale model of the 747 dwarfs standard contemporary jetliner of the 707-320 class. Maximum gross weight is 680,000 pounds (308,440 kg) for the 747 and 328,000 pounds (148,780 kg) for the 707. The 747's top speed of 630 miles per hour (1,014 km/hr) exceeds that of the 707 by 30 mph (48 km/hr). Cruising almost one mile (1.6 km) above the operating ceiling of contemporary jetliners, the 747 can be expected to alleviate congestion in the high-traffic corridors in the U.S., in Europe, and over the Atlantic Ocean.

Yet even at such moderate growth rates, there is little doubt that with present equipment the United States is heading for a traffic jam in the skies that may well rival what is being experienced on the nation's highways. John E. Steiner, Boeing Company's Vice President for Commercial Aircraft Development, predicts that scheduled departures of commercial aircraft will rise 75 percent over present levels in the next ten years, even if jumbojets are used on all routes that can support them. Without the new, more-productive aircraft, dangerous overcrowding of the airways could become insuperable, he says. The jumbojets, he adds, often viewed as a problem by airport management, are actually a powerful part of the solution to the air traffic problem.

In addition, none of the traffic forecasts makes allowance for fare reductions. But the air travel market, especially the pleasure and personal travel sectors, is "price elastic." This term means two things: Lower air fares lead to a larger number of people using

air transportation and also to more flying by those who already travel by air. Only one in ten persons in the U.S. now travels by air, and the potential for growth is substantial. A recent study indicates that a price cut of 20 percent would result in a market increase of a like proportion. Such a cut, while large, is considered possible when the jumbojets enter service. A market increase of this size, superimposed on the predictable general air travel market growth, would be revolutionary, making air travel everyman's means of transportation.

It is in this area that the jumbojet's real challenge lies, according to its supporters. They believe that the SST and the jumbojet will not cut into each other's market but rather will complement each other.

The progenitor of all jumbojet designs in the United States is the C-5A, the 700,000-pound (317,510 kg) giant, which is capable of airlifting more than 600 fully equipped troops, and which is scheduled to enter the U.S. Air Force inventory in 1969. Three

U.S. aerospace companies competed on the C-5A contract. Lockheed Aircraft Corporation won over Boeing and Douglas.

The same three companies are in the forefront of the commercial jumbojet race. Lockheed's design is the L-500; Boeing's the 747; and Douglas' the DC-10. This equipment will be covered in detail in the second part of this article in next month's special commercial and corporate aviation issue of AF/SD INTERNATIONAL.

Other Large Free World Aircraft

The race toward huge new aircraft is not confined to the United States. In a more modest fashion Europe is embarked on this course through a project known as the "airbus." Tailored to the specific market requirements of Western Europe, the airbus is to be a large aircraft in the 250- to 350-passenger range, capable of operating economically over relatively short-stage lengths. There is indication that a two-engine design would

New heights of luxury are possible in the Lockheed L-500, according to company officials. "Skylounge," depicted in this artist's conception, is one way of bringing a new degree of elegant living to commercial aviation. Private staterooms, a nursery, and 30 stewardesses per plane round out Lockheed's idea of first-class service aboard its L-500. Seat-mile costs would still be below current jet costs.

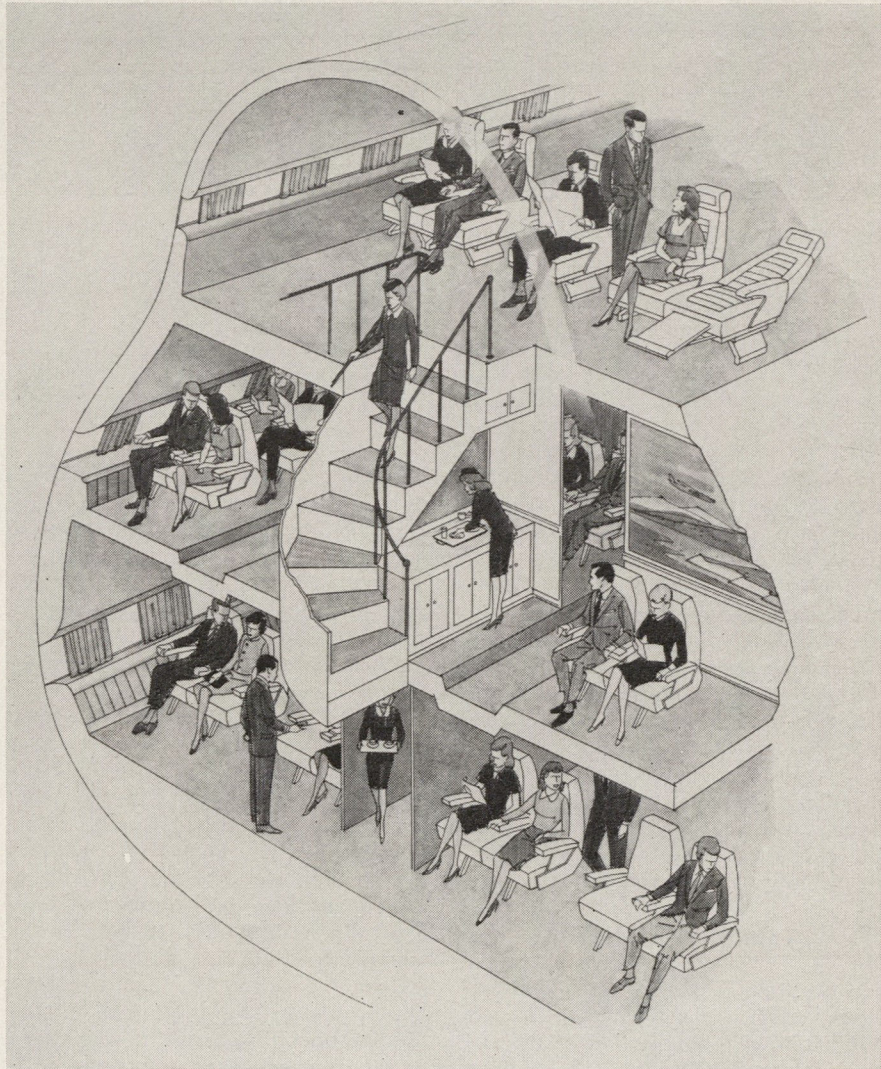


meet the basic requirements better than the four-engine configuration employed by the U.S. jumbojet designs. The Governments of France and England, along with the airlines and aircraft companies of those two countries, are involved in the airbus project. German participation in some form is likely. There will be a more comprehensive report on the European airbus project in the October issue of AF/SD INTERNATIONAL.

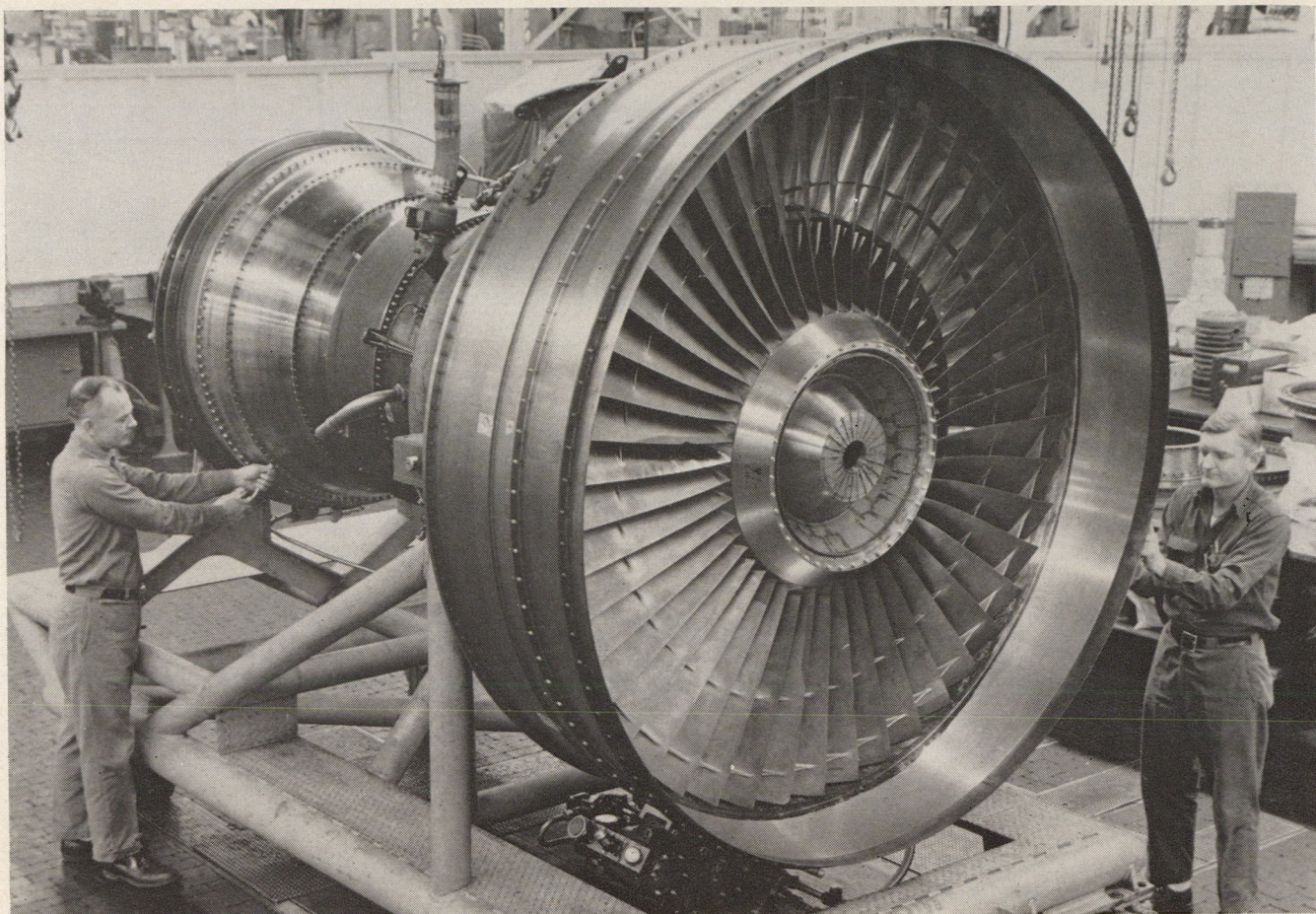
A number of European designs are currently under examination. Among the more imaginative entries are the two-deck Breguet BR-124 designed for 265 passengers and employing two Pratt & Whitney JT8 engines, Nord Aviation's 250-passenger "double-fuselage" N-400, and the Sud Aviation/Marcel Dassault 250-passenger Galion, featuring nine-abreast seating.

Douglas Aircraft Company has announced that it is studying the possibility of building an advanced-technology twin-engine airliner that might transport from 250 to 350 passengers. So is Lockheed-California Company. If a U.S. company goes ahead with this type of large twin jet, it might well be considered for the European airbus project. With European market analyses indicating a potential for up to 600 airbuses, interest in this project is hot on both sides of the Atlantic.

The Russians have always liked big aircraft. In 1934 Andrei N. Tupolev unveiled a 210-foot (64 m) wingspan, eight-engine, 58-ton (52.6 mt) giant airplane named the Maxim Gorki. Today the Soviets are again ahead of everybody in aircraft size, but little else. Their AN-22, introduced last year



Three-deck interior of the Lockheed L-500 is as tall as average three-story building. In first-class configuration the Lockheed jumbojet can accommodate 667 passengers. Seating may include lounge chairs which convert into daybeds. Cocktail bar and 12 galleys could be standard features, since gigantic aircraft has much room to spare.



Four Pratt & Whitney JT9D-1 turbofan engines, which generate 41,000 pounds (185,970 kg) of thrust, power the 747. Follow-on engine models, according to Pratt & Whitney, will increase thrust to 47,000 pounds (213,190 kg). High bypass ratio and the use of new materials are said to furnish this powerplant with extremely low specific fuel consumption and are the key to economy. Use of suitable foreign engines, primarily the Rolls-Royce RB-178, is possible in the case of aircraft to be ordered by foreign airlines.

at the Paris Air Show, is really a painted-over military freighter. But it can carry 724 passengers at speeds up to 465 miles an hour (748 km/ph). The AN-22 is powered by four turbo-prop engines of 15,000 horsepower, each driving eight-blade counterrotating propellers.

The Soviet Aviation Export Agency has announced that a commercial version, the AN-154, will be available for sale abroad in another year. Western aviation experts say the aircraft might satisfy special Soviet requirements but appears to be an attractive export item only to Soviet satellites.

Tomorrow's Market

The revenues of the Free World airlines in 1966 are estimated to exceed \$10,500,000,000, double that of the annual total of 1961. The U.S. airlines now transport seven times more passengers and cargo than they did 15 years ago, making aviation far and away the fastest-growing industry in

the world. Transatlantic air traffic will triple over the next nine years according to airlines' forecasts. The developing countries of the world can be expected to jump eagerly into the air age when they come of age, economically.

Aerospace industry executives involved in both the SST and the jumbojet programs point to indicators of this sort to document that there is ample opportunity for the SST, the jumbojets, and other advanced technology aircraft to "coexist" in the years ahead. To cope with aviation's growth between now and 1980, these executives say, high-productivity aircraft are vital. Equally vital will be the ability to furnish productivity all across the economic spectrum, from the luxury to the thrift market. The Europe-bound executive, to whom time is money, needs and wants the SST, and the newlyweds eager to honeymoon in Paris on the installment plan need the jumbojet.

The rate of technological improve-

ments in other modes of transportation is slowing down. In aviation the best is yet to come, they say. By 1980, the airlines of the world will need about 800 SSTs and possibly as many jumbojets to meet the market demands.

Perhaps the old maxim that aviation planners generally overestimate the short-term potential and underestimate the long-term growth is becoming obsolete. From now on they might well underestimate both.

The President of the Air Transport Association of America, Stuart G. Tipton, recently issued a warning:

"I think the gravest danger we face today in aviation is that we will underestimate the potential of the extraordinary machine which so many able people in the world have helped to develop—the extent of its power to stimulate economic development, to create new economic dimensions, to improve the quality of living, and generally to challenge the imagination of its creators."

(Continued in the October issue)

SCIENCE/SCOPE

Among its many other space "firsts, the Surveyor 1 spacecraft: proved out a terminal descent system very similar to that of the Apollo/LEM...recorded telemetry data on 140 channels during its descent that will now make possible more accurate earth-based simulation tests for other lunar-landing spacecraftsent back man's first detailed information on the surface bearing strength of another celestial body (it's sufficient to support a man)....carried out more complex commands than any other NASA lunar or planetary spacecraft.... used multiple- and variable-thrust vernier engines for automatic attitude and acceleration control....solved a major mystery about lunar radar reflectivitydemonstrated in space, for the first time, proper radar microwave operation through the highly expanded propulsion exhausts of both the main retro and the vernier engines (a measurement impossible to run on earth and hence an unknown of great concern to the Surveyor and LEM programs).

Lowest bidder on NADGE (NATO Air Defense Ground Environment) was an international consortium headed by Hughes Aircraft Company. Members of the International Planning Group (Belgium, Luxembourg, The Netherlands, West Germany) have already purchased Hughes' systems that will link up with the \$280 million NADGE system. During recent months Hughes' tactical air weapons control systems have also been purchased by Japan and Switzerland.

A new "multiple access" communications concept was disclosed during the recent inauguration of Hughes' synchronous communications satellite research station at Caddo Gap, Ark. New concept, developed jointly by Hughes and the Nippon Electric Company of Tokyo, is called STAR (for Satellite Telecommunications with Automatic Routing). It will enable any earth station in view of a satellite to talk to any other station at random. The STAR concept will be thoroughly tested at the new Arkansas research station, which is a prototype for a simplified, low-cost ground station that can enable many nations to join a worldwide communications network.

A new gyro-stabilized gunsight -- designed to aim the Army's wire-guided TOW anti-tank missile from helicopters -- enables the gunner to keep the crosshairs on target even while the pilot is taking evasive action to avoid ground fire. Missiles for the helicopter weapon system are identical to those used in the infantry TOW system Hughes is developing for the Army Missile Command. Prototype TOW missiles scored bullseye hits on tank-size targets more than a mile away in recent tests at Redstone Arsenal.

A new family of military computers is now in the planning stage at Hughes. Based on a modular concept, family will feature commonality of both hardware and software. It will be developed with existing technology but designed to incorporate new technology as it becomes available. Modules of the very-high-speed, real-time central processor can be grouped to meet the requirements of all types of military systems, from very small to very large.

HUGHES INTERNATIONAL
HUGHES AIRCRAFT COMPANY

CULVER CITY, CALIFORNIA, U.S.A.

An army of unmanned working satellites in space is already performing yeoman service in the fields of weather analysis, communications, navigation aid, military observation, and geodetic mapping, to mention just a few. Their already considerable achievements are but a small preview of what they will do tomorrow. Their usefulness, particularly to military operations, can scarcely be overestimated. They will be invaluable in such areas as providing instant, reliable field communications and even making possible tactical-missile close support of troops in the field . . .

Man's Brain in Space— The Limitless Horizons of "Utility" Satellites

BY WILLIAM LEAVITT
Senior Editor/Science and Education

Although manned spaceflight is by far the more glamorous endeavor, it is the unmanned "utility" satellites now coursing through space—watching the weather, aiding navigation, relaying communications worldwide, patrolling space for telltale radiation that would signal a nuclear test-ban violation, providing superaccurate geodetic measurements, and obtaining vital strategic reconnaissance data, among other tasks—that are leading the way in measurable benefits to mankind.

Their performance can only be considered remarkable, in view of the newness of the space age, less than ten years old, as measured from the first Soviet Sputnik of 1957. The fruits of their labors are but a preview of harvests to come.

- Today's world weather-watching satellites could lead eventually to some measure of weather control.

- Today's communications satellites, which are but relay towers at super-altitude, will evolve into high-powered, direct-broadcast radio and television transmitters.

- Today's navigation satellites will develop into more complex structures, able to provide, simultaneously, world air, sea, and land traffic control systems fixed in space.

- Today's observation satellites will

become tomorrow's multipurpose earth-survey satellites, able to report not only on strategic data but also to provide a broad array of information on everything from forest fires to locust migration and land erosion around the world.

In a relatively few years, perhaps by the mid-1970s, the full impact of today's first- and second-generation unmanned utility satellites and their more sophisticated successors will begin to be felt, not only in the advanced countries of the world, but also even in the most remote areas of the emerging world. This will be true in both civilian and military enterprises. Just as weather and earth-resource survey satellites will increasingly affect the lives of people everywhere, military utility satellite systems may well change the face of military operations around the world.

Not only will instant, reliable, and secure communications become routine from continent to continent via space relay; the foot soldier himself may soon be able to communicate with other nearby units via special-purpose tactical communications satellites (TACOM). This is already much more than a conceptual gleam in the eye of U.S. military research-and-development people. The U.S. Air

Force, only a few weeks ago, sent out requests for proposals to U.S. industry on research and development of an experimental tactical communications satellite system.

New Strategy and Tactics

The high interest of U.S. military planners in spaceborne tactical communications was illustrated by the quite recent remarks of Daniel J. Fink, Deputy Director for Strategic and Space Systems in the Defense Department's Directorate of Defense Research and Engineering. That is the Pentagon office where "yes" or "no" is said to the U.S. military services on whether or not to press ahead on advanced system developments.

"With regard to employing satellites for tactical communications, we expect that we may see entirely new and novel strategy and tactics evolving because our ability to interchange secure tactical information will no longer be horizon limited," Mr. Fink said.

The Defense Department official gave a pointed "here-and-now" example of what TACOM could do.

"Let us suppose," he said, "that a Marine field unit in Vietnam finds itself ambushed in terrain that does not



Daniel J. Fink is Deputy Director for Strategic and Space Systems in United States Defense Department's Directorate of Defense Research and Engineering.

permit line-of-sight communications. They need reinforcements and air support badly, and in a hurry. Today, they either must relay their communications by easily monitored, high-frequency radio, send a runner to another communications relay point, or use a field-telephone system. This can take considerable time, and the information can conceivably get pretty garbled in the process.

"But now let us suppose that this Marine unit can communicate by secure relay to base headquarters, a Marine air base, and an aircraft carrier steaming offshore. The unit commander, under these circumstances, cannot only get out the word that he is in trouble, but could provide sufficient detail to determine the armament load of the close-air-support aircraft that could be on the way much sooner than would be possible in today's field environment."

From a military point of view, TACOM's value would be in terms of its ability to replace present overlapping communications systems at reasonable cost. At the same time it would be easier to use and more reliable.

The availability of such advanced systems would present organizational challenges. They would call for new "team" approaches to military operations by air, sea, and ground services. Today, as Mr. Fink pointed out, "it is easy to distinguish between strategic and tactical communications, primarily on the basis of range. [But] satellite communications will blur this distinction considerably. Further, this may be the first time that hardware from the

start dictates that all services must play the game together."

With this in mind, the Defense Department already has all three military services working on the requirements of the tactical-communications system. The Air Force is involved with the spacecraft and its launch operations, the Army with ground-terminal development, and the Navy with sea-borne terminals.

Meanwhile, to bridge the gap until launch of actual experimental TACOMs, the Massachusetts Institute of Technology's Lincoln Laboratory, near Boston, is operating an Air Force-sponsored satellite program called LES, which is exploring a whole range of space-communications technical questions.

"I don't know," Mr. Fink said, "what other effects [a tactical communications satellite system] will have on organization, but, historically, command lines have pretty well followed communications lines . . . tactical satellite communications should be so reliable, flexible, and accessible that information will tend to flow faster than through the ordinary command lines."

To dramatize his point, the Defense Department official cited a "New Yorker" magazine cartoon, which he said depicted the "ultimate" in operational control via space communications. In the cartoon, two American soldiers were manning a machine-gun position in a jungle. One of the soldiers was surveying the field of combat and the other was speaking into a walkie-talkie radio. Underneath the cartoon, the caption read: "Yes, Mr. President, that is right, Mr. President."

Mr. Fink's suggestion that organizational changes of considerable consequence may flow from such an advance as a reliable and inexpensive tactical spaceborne communications system is borne out by Air Force planners working in the TACOM area. They point out that, for the most part, it is not the technology that is problematical, but rather the requirement to work out the most effective ways to use the new systems.

They are asking themselves such questions as: Should voice or teletype communications be used? What are the best ways to make as mobile as possible the ground terminals? What are the most effective approaches to "net discipline," so that the TACOM systems are used effectively and flexibly and serve basic battlefield requirements? In many ways, the prospective arrival of spaceborne tactical communications will have the kind of revolutionary effect on combat operations that wired telephone and radio had when they first came into use.

Tactical communications via space is but one of the current and oncoming capabilities of "utility" satellites. And it is clear that what such systems can do on the military side they can do also in nonmilitary areas. It is not idle to suggest that the same techniques can be put to work scientifically and commercially in the future in enterprises ranging from antarctic exploration to the building of new cities in hitherto inaccessible areas.

The same is true of the whole range of unmanned working satellites that have already proved themselves in the fields of weather-watching, long-distance communications, navigation, reconnaissance, and observation.

Defense Communications

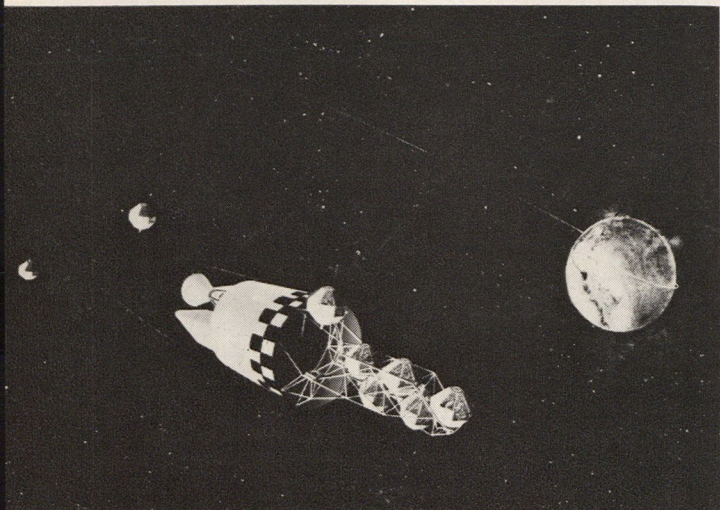
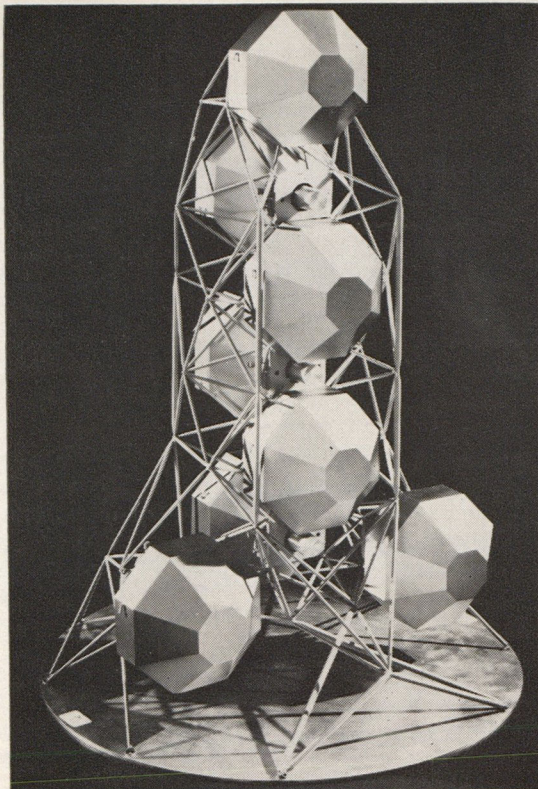
The success of the commercial Early Bird long-distance communications satellites, reported on in the July issue of *AF/SD INTERNATIONAL* (p. 28), is already being matched by the recently launched salvo of seven Philco-developed communications satellites now in near-synchronous orbit around the equator, which are, in the words of military planners close to the project, "working beautifully." Two more launches of batches of these satellites, called IDCSP (Interim Defense Communications Satellite Program), boosted by the highly successful USAF Titan IIIC rocket, are scheduled at this writing. And there is a chance, based on the very good performance of the solar cells providing the power for the spacecraft, that a five-year life may be expected from the defense communications-satellite system.

It is important to point out that the current system is considered merely interim and not optimum, despite its operational capability, and the fact that it has already been used for military communications. One of the principal problems that still plague communications satellites is the "focusing" of antennas so that relay power is most effectively and economically used. To explore this problem, launched with the first collection of defense communications satellites was a gravity-gradient research satellite. The prime purpose of the gravity-gradient spacecraft is to develop confidence in using the gravitational field of the earth as a reliable stabilizer for the crucial antenna components of the communications satellites.

The gravity-gradient system's advantage is its simplicity—it is based on known physical principles and not on moving parts which might fail. The Air Force reports that the gravity-gradient technique has worked well. But at the same time, the Air Force

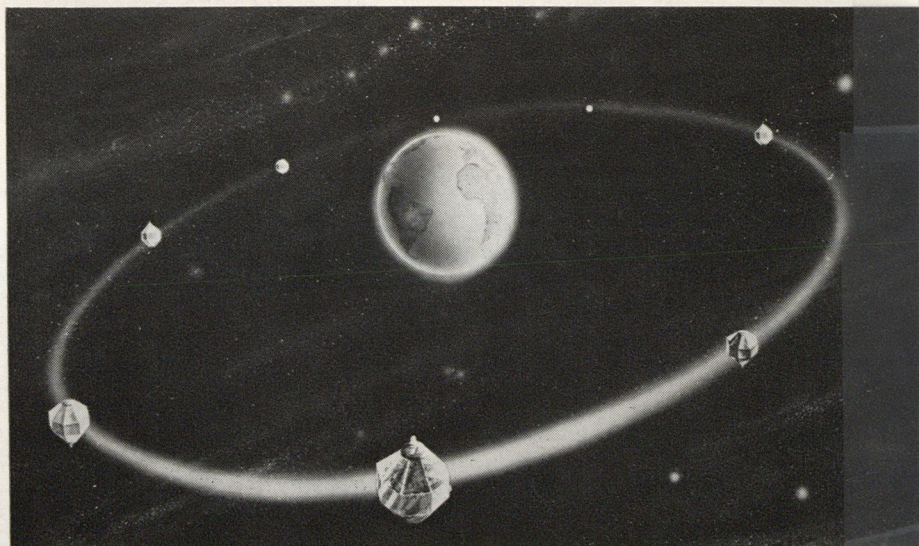
(Continued on following page)

The defense communications satellites rode into space in a dispenser atop a Titan IIIC booster, the most powerful rocket system used by the U.S. Air Force. They were then spewed into orbit, along with a gravity-gradient research satellite, and commenced operations. The seven Philco-developed satellites are now in near-synchronous orbit around the equator.



This is how the dispensing maneuver looked in space. The satellites were released one by one by delicately balanced springs and scattered in a random fashion. Using one booster to orbit several satellites is an economical method that may well become a routine approach.

And here is how the IDCSP satellites looked after they took their places in orbit. Additional launches are planned to build a complete network of up to 22 satellites. The satisfactory performance of the solar cells powering the spacecraft will make it possible for the defense communications satellites to function five years. The IDCSP system is considered interim, will be succeeded in 1970s by a more advanced system.



and the National Aeronautics and Space Administration are studying several other more complex approaches to stabilization.

The IDCSP satellites will be succeeded by an advanced system—ADCSP (for Advanced Communications Satellite Program) still under study. Eventual ten-year lifetimes for ADCSP and TACOM systems are contemplated.

Reflecting the general maturing of space technology in the U.S., and now that utility satellites have shown their abilities, there is increasing exchange and cooperation among various U.S. Government agencies involved in space research and development. This has scarcely happened overnight, nor without friction, but it has happened. There is a broad network of inter-agency panels and committees examining space technology questions and, at least in a general way, dividing up responsibilities.

Thus, NASA continues to develop and refine weather-satellite systems that have grown from the highly successful original Tiros satellite, which had limited earth-viewing ability and did not fly in polar orbit as do the newer Tiros and the even more advanced Nimbus systems, viewing the entire globe.

At the same time, the one-year-old Environmental Science Services Administration (ESSA), formed within the U.S. Department of Commerce from the old Weather Bureau, U.S. Coast and Geodetic Survey, and several other agencies, now has the responsibility for the U.S. operational weather-satellite system (TOS—for Tiros Operational System). TOS is already relaying weather data from space to stations throughout the United States and, through the World Weather Watch

(Continued on page 32)

A SPECIAL REPORT

IN NOVEMBER AF/SD INTERNATIONAL

NAVAL AVIATION

In keeping with AF/SD INTERNATIONAL'S broad editorial emphasis, the November issue will feature a special report on NAVAL AVIATION,

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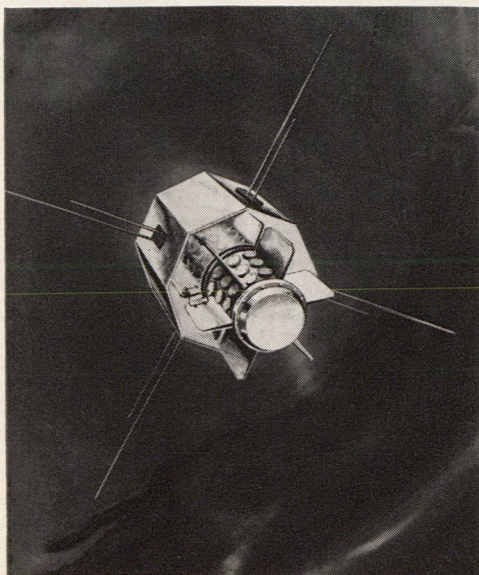
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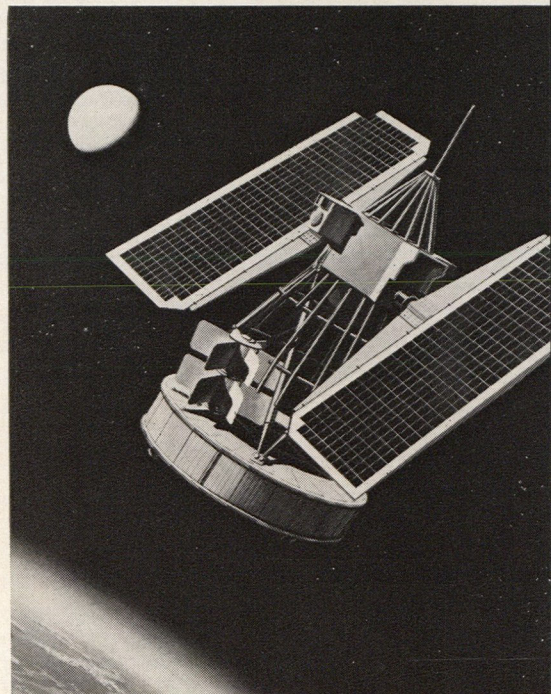
A Sampling of U.S. "Utility" Satellites

The U.S. unmanned utility satellites pictured here are representatives of the many unmanned spacecraft that are performing vital military and civilian jobs. In most cases, they can be described as "second-generation," working systems beyond the feasibility-demonstration phase. An impressive array of U.S. agencies—NASA, the Environmental Science Services Administration, COMSAT Corporation, the Atomic Energy Commission, the Defense Department, and all three military services, are engaged in the utility-satellite business, working closely with U.S. industry to perfect techniques and hardware.

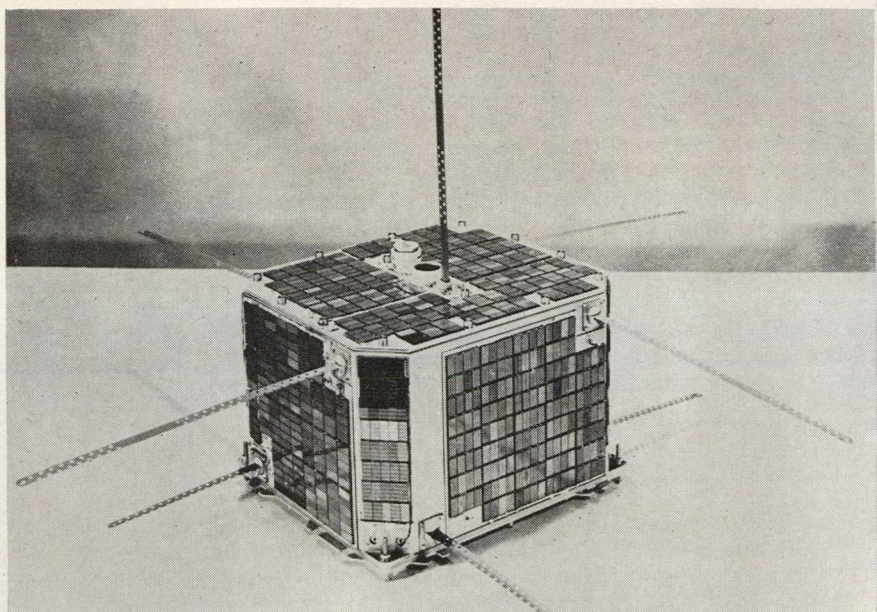


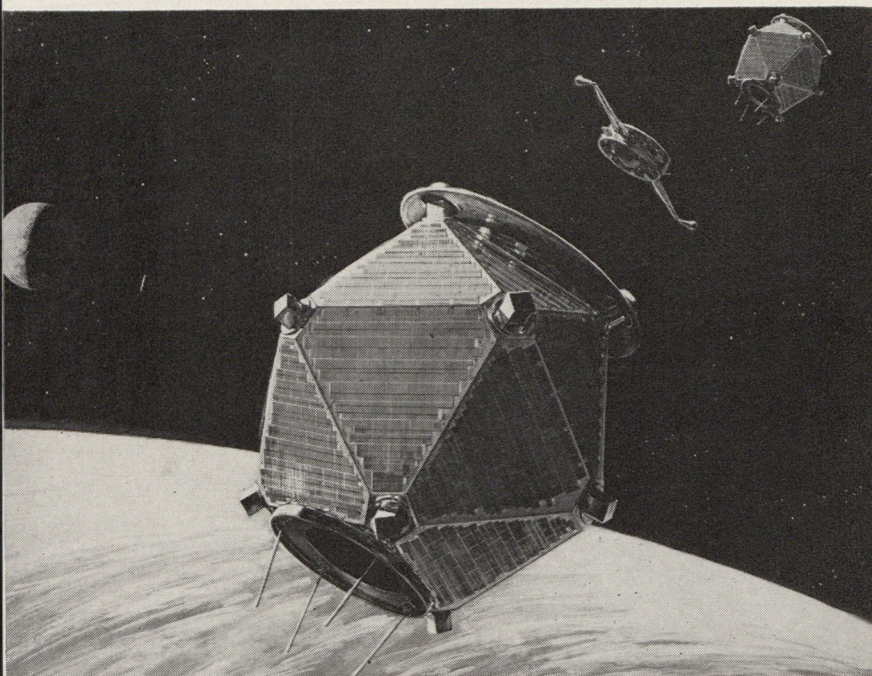
This is how Nimbus looks in orbit. Future Nimbuses will use two nuclear generators, fueled with plutonium-238, designed to deliver 30 watts of direct electrical current. Nuclear power sources are being developed for NASA by the Martin Company, Baltimore, Maryland.

Navigation of earthbound, seagoing, airborne traffic will increasingly be aided by satellite systems such as this U.S. Navy Transit spacecraft, already operational in support of U.S. fleet.



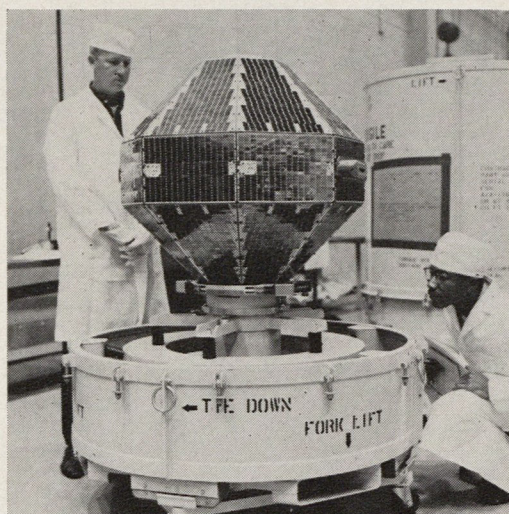
Accurate geodetic mapping is increasingly vital to civilian and military operations. A major current space tool meeting this need is the U.S. Army's SECOR system, which has already made important contributions. NASA also is using the SECOR principle.



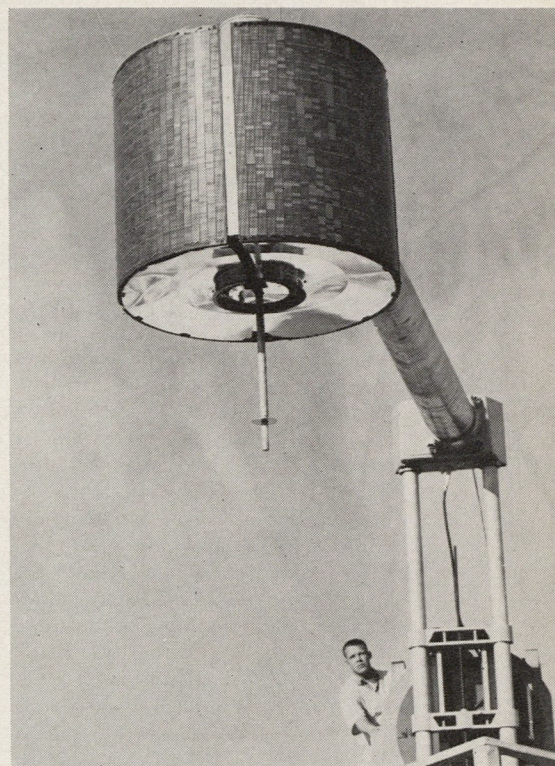


The nuclear test-ban treaty forbids spaceborne nuclear detonations and the U.S. is successfully using Vela satellites such as these in its continual inspection of space to ensure against violations. The U.S. military foresees a future multiple-purpose satellite warning system.

This is a closeup of the Defense Department's new IDCSP communications satellite, a string of which have been launched into near-synchronous equatorial orbit and are already serving military needs. While a five-year operational life span is considered possible for the IDCSP, a ten-year lifetime is predicted for the advanced ADCSP, which will succeed IDCSP.



Another approach to spaceborne communications is this recently launched U.S. Air Force balloon passive satellite. The balloon portion is designed to disintegrate under ultraviolet radiation, leaving the aluminum frame as a reflector for signals relayed from earth.



Today's communications satellites, such as the commercial Early Bird, above, will be succeeded by systems allowing direct broadcast of radio and video.



Several days' weather over the entire United States is revealed from 700 miles (1,130 km) in space by this montage of photographs taken by NASA's new Nimbus II meteorological satellite. Such capabilities are but a preview of systems to come, civilian and military. Space scientists are predicting a multiple-purpose satellite for earth-survey, scientific, weather, and communications missions.

system, to stations plugged into the TOS system around the world.

ESSA, excited by its broad charter, is busy exploring ways to use utility satellites for a wide range of earth-survey purposes. Meanwhile, NASA, in its eagerness to put space technology to work for the public good and to use existing launch and spacecraft capacities developed for the Apollo lunar-landing program (Saturn boosters and Apollo modules), is vigorously trying to sell the U.S. Administration on a billion-dollar commitment to what it calls Apollo Applications (reported on in earlier issues of AF/SD INTERNATIONAL). Apollo Applications would use Apollo-Saturn components for a large-scale program of earth-survey, biomedical research, and other useful purposes. Much of the Apollo Applications effort would be manned. Political-

ly, a major bar to NASA's campaign is the financial burden of the Vietnam War.

In meteorology, the millennium—perfect weather prediction and climate control—has, of course, not arrived, despite the great advances of spaceborne observation.

As the Defense Department's Mr. Fink puts it: "Perhaps by the year 2001 a limited ability for control of the weather may be acquired. Until then, we must be satisfied with taking its temperature, measuring its movements, and photographing its condensations."

"Spot" Weather Observation

As to specifically military uses for spaceborne weather observation and reporting, Mr. Fink adds: "We in the military share with others the total

data acquired by the Weather Bureau, and, in turn, are participating with the Department of Commerce and NASA in the TOS system. . . ."

Yet, he points out, "even as exceedingly useful as this system will be, it may not be able to fully meet the dynamic needs of military situations."

And again, using the nagging problem of Vietnam as an example, Mr. Fink says that military needs are often "intensely focused on a particularly limited area of the world. Knowledge of a break in the cloud cover for even a short period of time could provide critical opportunities for instant strikes against targets that conduct their activities under shadow."

How is this kind of requirement to be fulfilled? "Continuous watch of a particular area requires a stationary satellite, which has the potential of

providing near real-time weather data," in Mr. Fink's view.

"We recognize," he says, "that although the need is valid, to perform this mission with a satellite uniquely designed for the mission would be quite costly and difficult to justify. [But] we now believe that it may be possible to combine this meteorological function as part of a multiple-purpose, early-warning satellite system, where we expect that atmospheric environmental data will be a neutral by-product generated by its sensors.

Toward that end, a multiple-purpose satellite experiment is in the works.

"Multiple purpose" is a phrase frequently heard in the Pentagon these days, and the seriousness with which the idea is taken is underscored, again by Mr. Fink, who has enlarged on Congressional testimony given by his superior, Dr. John Foster, the nuclear scientist who is now the Director of Defense Research and Engineering.

Mr. Fink took the example of space-based antimissile defense to illustrate how a utility satellite might do several important jobs at once. His suggestions parallel ideas of NASA specialists who have talked of eventual large multimanned space stations performing a wide range of missions, including earth survey, scientific observation, weather, and communications.

"For several years," said Mr. Fink, "we have been exploring the potential of employing space platforms from which to detect ballistic-missile launches as close to [actual launch] as possible. As such, [this] would supplement the ground Ballistic Missile Early Warning System (BMEWS) capability by extending coverage beyond the northward-looking BMEWS. It could offer worldwide coverage capability for the detection of all strategic ballistic missiles, including those of Nth countries. Most importantly, it could watch for launchings from submarines.

"We have learned much from our efforts and succeeded in developing superior sensors for these purposes. During the past year, we have recognized that by the incorporation of additional sensors of other types, other functions could be performed simultaneously. The potential for exploiting the atmospheric environmental data which would accrue from such an early-warning system is one such possibility. Another is the inclusion of nuclear-test-detection sensors to provide for a truly multiple-purpose satellite system."

Already, highly successful "Vela" satellites, specifically designed by TRW Systems, Inc., with the Atomic Energy Commission, to patrol space for possible violations of the nuclear test-ban treaty, are in orbit. Their po-



Dr. Homer Newell, chief of NASA's Space Science and Applications Division, advocates multipurpose satellites serving ships, aircraft, and even spacecraft.

tential versatility is shown by NASA's interest in using them to report on radiation dangers to manned spaceflight.

The Defense official reported that the Department has concluded that such a marriage of functions could be achieved in a newly proposed satellite system and that, consequently, existing programs are being reoriented toward the multiple-purpose approach.

Again, there is no reason to believe that similar combinations of functions for civilian and commercial utility satellites could not be achieved. Why not combine communications, navigation, and air traffic control into one satellite system? Or weather observation, forest-fire patrol, agricultural-resource survey, even atmospheric-pollution analysis functions into one system? In the face of the success of existing working satellites, all the space research-and-development agencies of the United States are beginning to look at such possibilities.

This is in keeping with the "systems analysis" approach to problem solution that has been increasingly featured in technological planning in the military and civilian sectors in these maturing days of the missile and space age. Now that basic demonstrations of feasibility and reliability of a wide range of space missions and operations have been achieved, the systematic approach is much easier to apply. Only a few years ago, basic problems of booster and electronic-component reliability plagued each mission. Now boosters are in the 90-plus percent reliable category. And, although booster progress continues, the emphasis has

shifted to satellite working components.

Electronics Reliability

In unmanned utility satellites, as well as manned space vehicles, electronics still have a long way to go. As Dr. John Foster, Director of Defense Research and Engineering in the Defense Department, has said:

"Of course, for some kinds of equipment, such as submarine-cable repeaters or communications satellites, one might consider the mission lifetime as the total lifetime. . . . In the case of communications satellites, one has two urgent reasons for assuring high reliability. The first is the high cost of rocket launchings, and the second is the lack of ability to repair the satellite if it fails. For both these reasons large sums of money and much effort are expended to assure a high probability of no failure during several years of operations.

"I suggest," Dr. Foster said, "that we must now begin to think about military electronics equipment, which has a high probability of no failure, not just for an individual mission, but for its entire military lifetime. Of course, this will require an enormous increase in equipment reliability—but the implied savings in both total cost and highly skilled technical manpower would be so great as to have a truly important impact on defense operations."

The same is true for the civilian and scientific space sectors. Broadly defined, the enormously successful first Surveyor vehicle can be described as a utility satellite and is an excellent example of reliability payoff. Although its cost-and-development time far exceeded greatly original planning that was done in the Neanderthal era of the space age, its incredible performance in relaying vital data from moon's surface, and its survival and revival after the long lunar night, have made it worth its high price.

The potential of utility satellites—designed to do a single job or a set of jobs—seems limitless. Take, for example, the area of geodetic mapping, with its commercial and military promise in the fields of navigation and targeting. There are a number of NASA Geodetic Earth Orbiting Satellites (GEOS) researching this field, and a little-publicized operational military system called SECOR, built by the Cubic Corporation, used in conjunction with GEOS and in a set of U.S. Army satellites. The SECOR system (SECOR stands for Sequential Collation of Range) was developed for the U.S. Army Map Service.

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It works this way: SECOR ground stations are placed at geographical points the coordinates of which already have been accurately surveyed. Then a fourth station is located at a point whose location is not known exactly. Radio signals are sent from the ground stations and returned by a transponder aboard the satellite. Since the satellite's position is known, its distance to the fourth station can be accurately determined by computation. SECOR satellites have already shown that Japan's islands were not where map makers had thought they were. That is only part of their yield.

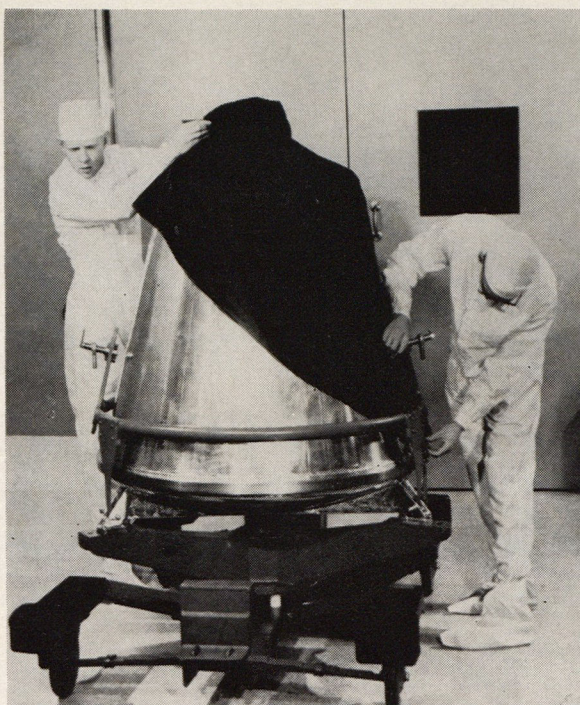
The military significance of such accurate mapping is suggested by the fact that defense planners are talking of the possibility of dissimilar military units in a joint operation getting a simultaneous accurate position, which ties them together with a common set of relative coordinates. At the same time, satellite navigation devices could help eliminate targeting errors between tactical units. Defense planners are even suggesting, as a consequence of really accurate mapping, the use of long-range tactical bombardment missiles for close support of troops in the field.

The emphasis in this article on the military potential of unmanned utility satellites should not be interpreted to mean that America's prime civilian space agency, NASA, is lagging in the field.

NASA's research-and-development efforts are extensive and complementary in several ways to the military's approaches. Multiple access to communications satellites is a case in point. As Dr. Homer Newell, chief of NASA's Space Science and Applications Division, told Congressmen recently:

"Not only is it necessary that we be able to simultaneously communicate with small terminals, but also with an ever-increasing number of terminals such as ships, aircraft, other mobile vehicles, and even spacecraft. . . . This can be provided by increasing the power-handling capabilities of the satellite and by being able to direct energy back to the users with increased precision. [This] generally means increasing the accuracy with which we can control the orientation of the satellite."

Toward these ends, NASA is working with the U.S. Navy in the study of the applicability of the Navy's operational Transit navigation-satellite system to civilian purposes. And it is expected that the space agency will soon begin work in the area of air traffic control by satellite with the U.S. Federal Aviation Agency, which would probably have operational primacy. As reported in the July issue of AF/SD INTERNA-



For the past several years, U. S. observation satellites have kept careful track of strategic data beyond the Iron Curtain, using unmanned systems originally called SAMOS. Arms-control capability of such systems is likely to grow in importance during coming years.

TIONAL, the Communications Satellite Corporation (COMSAT) is already proposing a demonstration satellite specifically for airline use. And COMSAT itself, according to its President, Dr. Joseph V. Charyk, is planning to create a research-and-development operation of its own.

Direct-broadcast satellites are still a way off, in Dr. Newell's view. But the problems are recognized. As Dr. Newell pointed out to the Congressmen:

"A direct-broadcast satellite will have to radiate a great deal of power so that the signals it retransmits to home receivers will be strong enough to be picked up by simple antennas, which are no more complex than listeners are now generally accustomed to use with their home TV receivers."

NASA's Research

Right now, Dr. Newell says, nuclear-reactor turboalternators under development are not capable of providing the amount of power that would be required for direct video broadcasting, covering a "useful area of the earth, say larger than 1,000,000 square miles." Thus, he says, such direct broadcasts are beyond the state of the art today, and will be until perhaps the late 1970s.

But, Dr. Newell adds, "rather modest improvements in the sensitivity of the receiver and its antenna would greatly change this picture and bring direct television broadcast into a much closer period."

In its wide-ranging Applications Technological Satellite program (ATS), for

which Hughes Aircraft is principal contractor, NASA is studying such approaches to direct broadcast as launching very large antennas, erectable in space, which would also be useful for aircraft communications, naval navigation, and large-scale digital data relay from point to point on earth. ATS is also exploring advanced spaceborne weather-watching. Other areas being explored by NASA, among many, are direct systems that would be able to broadcast FM and/or shortwave radio directly to home receivers.

The large pointable, erectable, spaceborne antennas, mentioned above, might, in Dr. Newell's words, minimize considerably the electronic complexity of the spacecraft, since power could be focused economically. Less power might therefore be required.

Such satellites could find great utility for reaching normally inaccessible geographic areas and may be of great interest as an educational aid in various parts of the world. The use of large erectable antennas could also lessen the problem of frequency allocation (see July AF/SD INTERNATIONAL, page 28). Such antennas could be accurately focused on selected geographical areas.

On these pages we have talked of the amazing demonstrations of usefulness by utility satellites. What has happened thus far is but a beginning. The military, commercial, and scientific consequences are even now only dimly seen. The unmanned satellites are unmanned only in the literal sense that humans are not aboard in body. Man's brain flies daily through space. ☆☆☆

Although political and ideological difficulties continue to limit international scientific exchange, there are some trends toward increased activity in this vital field. One important item is the recent U.S. action to permit scholars and other specialists to visit Red China. Thus far the Red Chinese have not responded. Here is a report on . . .

International Scientific Exchange —Some New Vistas Open

BY JOHN WALSH

Reprinted, with permission, from Science magazine, pages 1605-1607, Vol. 152, No. 3759, © June 17, 1966, by the American Association for the Advancement of Science.

The axiom that science knows no frontiers seems to have been respected in a literal way until the Napoleonic era, at least in the Western world. During the American Revolution, Benjamin Franklin was playing by the accepted rules when he wrote a safe-conduct letter addressed to captains of American naval vessels and privateers on behalf of Captain Cook, who was sailing off to explore the South Seas.

England and France were at war with each other as often as not during the 18th and early 19th centuries, but British and French men of science corresponded freely, passed through the lines to visit one another and conduct scientific business, elected each other to their academies, and mutually explored the work of the politicians.

But the rise of the national state, the increasing importance of science and technology in warfare as the long day of the musket and massed formation passed, and the growing efficiency of communications and police techniques blurred the old civilized distinction that science is strictly the affair of scientists and war the affair of politicians and professional soldiers.

For most scientists in the United States today, however, the spirit of the Enlightenment still, in some form, survives. The credo that science is international owes something as well to the practical belief that there can really be no secrets in basic research, and that more is to be gained from the open exchange of ideas and mutual cooperation than from scientific isolationism. A good many scientists unquestionably also see the international dialogue among scientists as one way

open to them in the nuclear age to help prevent catastrophe.

It is unquestionably much more difficult now than it was 200 years ago to separate science from politics. Old-fashioned nationalism has been made more severe by ideological differences which complicate relations, particularly between the United States and Western European nations on the one hand, and Communist countries on the other. Forces which propelled a generation of great theoretical scientists to the United States from Germany, Italy, and Hungary also produced Pontecorvo, Klaus Fuchs, and the fictional Dr. Strangelove.

The Soviet Union, with its old academic ties to Western Europe, coexists with the West more comfortably scientifically than it does politically. Mainland China, with its cultural pride, its sense of outrage over injuries and insults inflicted by the West, and its special hatred of the United States for being the most powerful Western nation and so deeply involved in Asia, is something entirely different.

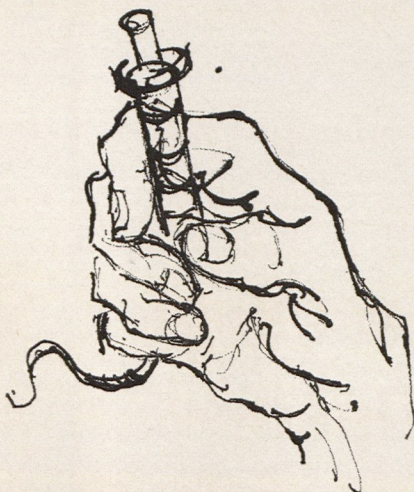
In the United States, the international activities of American scientists have been to a major degree institutionalized. The apparatus, however, has not yet fully developed, although it is clear that the most important organizations, from both the policy and the administrative standpoints, are the U.S. State Department, the Office of Science and Technology (OST) in the Office of the President, and the quasi-governmental National Academy of Sciences.

The United States does not have the equivalent of the minister of science

found in the cabinets of many European countries. The closest approximation is the director of OST, who is also the President's science adviser and often represents the President at international meetings. But the OST staff is currently small and fully occupied with domestic problems. A committee now, however, is looking into the possibility of OST's engaging in greater activity in international scientific matters.

For at least a decade the State Department has been seeking, without great success, to acquire the scientific competence it needs in the second half of the 20th century. The State Department's difficulties in this sphere have been dramatized by a failure over the past year and a half to fill the top scientific job in the department, that of Director of the Office of International Scientific and Technological Affairs.

One difficulty is that the role of the science director has not been well defined. The State Department badly needs to be able to understand the significance of scientific and technical developments, in this country and abroad, relevant to foreign-policy decisions. Lately, the Department has taken steps that indicate it is more serious about increasing its competence than it has been before. But it is still not clear whether the science director, who is also science adviser to the Secretary of State, is to be an administrator running the science attaché program and overseeing our activities in international organizations and other functions of the Department in which science is involved, or whether
(Continued on following page)



er he is to act primarily as a policy adviser and scientist-diplomat.

The scientific community has not rallied energetically to the aid of the State Department, perhaps because of a feeling that science has, up to now at least, not been taken seriously by the foreign-policy makers. It is probably true that in international matters scientists have preferred to work through the Academy, which the scientists regard as their own and as essentially nongovernmental despite the federal source of most of its funds.

Historically, the academies have

been the instruments of international activities. The Royal Society and the French Academy of Sciences, both founded in the 1660s, set the style. And the U.S. National Academy of Sciences, established 200 years later, followed the lead zealously from the start, since the United States was then a developing nation with a lot to gain from contacts with scientists in the more advanced countries.

While the distinction between the Academy and government agencies may seem less sharp to scientists from countries with other arrangements, the Academy does have a prestige and an operational flexibility in international scientific affairs which give it definite advantages.

Academy members have been deeply involved in international scientific organizations and cooperative "international years." Almost all of the Academy's divisions are implicated in international projects, and in recent years there has been a marked increase in concern among U.S. scientists with the problems of developing nations.

Charged with promoting and coordinating the international activities of the Academy is the office of the Foreign Secretary, Harrison Brown of the California Institute of Technology, Pasadena. Brown, an energetic occupant of the post, was reelected this year for a second four-year term.

In a report on the work of his office, published earlier this year, Brown gave emphasis to bilateral efforts being made to establish sustained contact

through meetings between American technical experts and their opposite numbers in Brazil, Peru, the Philippines, and Nigeria.

In his report Brown said, "This modest social and scientific innovation bears great promise for the strengthening of scientific ties between America and these nations and for creating an American competence in the problems of scientific and technical growth in new and developing lands."

Rapid Reconciliation

Scientists have demonstrated a capacity to pick up the pieces rapidly after war or an era of particularly bad feeling between countries. Academy scientists, for example, are making special efforts, which are apparently being reciprocated, to establish closer contact with Indonesian scientists, after a period during which the U.S. and Indonesia have been politically estranged.

Science in the United States and science in Western Europe are similar enough so that transatlantic barriers have been falling rapidly. But in the case of developing countries, U.S. scientists have sometimes simply not known enough about a nonindustrialized, non-Western country to contribute very concretely, or have given advice in a way that grated on the sensitivities of their opposite numbers in the developing nation. To come to grips with these problems, the Academy has taken pains recently to be sure that Americans knowledgeable





about particular areas are included in the working groups formed by the Academy. Social scientists with relevant experiences are often added even when the problem under study might be regarded as strictly technical.

In dealing with the Communist nations another dimension of difficulty is added. In the case of Soviet scientists, contact with Americans has occurred fairly regularly at international meetings and the sessions of international scientific organizations. There has been a certain amount of correspondence on a fairly normal basis between U.S. and Russian scientists, but other contacts have largely been regulated by a carefully negotiated and closely regulated formal exchange program. A similar program, in recent years, has applied to scientists from Eastern European countries.

The U.S.-Soviet exchange program negotiated this year reflected a reduction of about 25 percent in the over-all level of exchange activity in science. This reduction was proportional to the cut in the broader intergovernmental program which covers cultural and educational exchanges—a cut attributed to Soviet reactions to U.S. involvement in Vietnam.

A chill breeze was also generated recently when the Soviet press carried charges that U.S. scientists act as intelligence agents. Such charges about tourists and students have been fairly common, but this was the first time in recent years that scientists had been singled out. Some observers here think the accusation may actually have been a warning to Soviet citizens not

to relax their cautious attitude toward foreigners in a year when the Soviet Union is the site of an unusual number of scientific meetings which foreigners will attend.

In the case of U.S. relations with mainland China, science has been overwhelmed by politics. The Chinese have cast the United States in the role of an international enemy of the people, and contact of any kind is anathema.

Even on the traditionally neutral ground of international scientific organizations, U.S. scientists have had no significant contact with their counterparts from the People's Republic. Mainland China has withdrawn systematically from these organizations, usually in protest against participation of the Nationalist Republic of China, and blames the U.S. for championing the Nationalist cause.

Especially since the deterioration of its relations with the Soviet Union in the early 1960s, mainland China has been largely isolated from the international scientific community.

Other Western nations, particularly Britain and France, however, have not been so rigorously shunned as the U.S. Since the late 1950s, the Royal Society and the Chinese have exchanged delegations and have made visits to main centers of research in each others' countries.

A Friendly Reception

The British received a friendly reception and, as a result of talks, two dozen Chinese are now in English universities and government research

establishments such as the National Physical Laboratory. The arrangement cannot yet be called an exchange, although there have been a few British students, mostly in Chinese studies, in universities of mainland China. The British Foreign Office has approved the program and is watching it attentively, and there is hope that the traffic in scientists and science students will go two ways.

Recently the United States has taken unilateral steps aimed at modifying the virtual boycott on travel by U.S. journalists, scholars, doctors, and scientists to Communist countries with which we do not have diplomatic relations.

Late last year both the U.S. Secretary of State, Dean Rusk, and the Presidential science adviser, Donald F. Hornig, made statements which did more than hint that a reappraisal was under way. In March, it was made known, although with little fanfare, that permission for U.S. scholars and scientists on legitimate business to visit countries on the prescribed lists would be more easily obtainable than in the past; presumably Albania, Cuba, North Korea, and North Vietnam, as well as mainland China, are included in the list. In April, several universities were informed by the U.S. State Department that scholars and scientists from mainland China would be permitted to visit the United States.

While the number of passports validated for Americans has increased markedly under the new dispensation—a dozen physicians and scholars re-

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ceived permission between April 30 and June 6—no visas have been issued by the Chinese. And this is a reminder that it takes two to coexist.

U.S. scientists have wanted, for pragmatic as well as fraternal reasons, to open up relations with scientists on the Chinese mainland. There has been a rudimentary kind of communication between scientists in the U.S. and there in the form of exchanges of publications and society proceedings. But there have been no visits and the barest minimum of correspondence (on testing of drugs in a few cases, for example).

The National Academy of Sciences, in concert with leading scholarly societies in other fields, has now formed a group to explore ways to improve communications and promote scholarly interchanges between scientists in the U.S. and in mainland China. As Harrison Brown puts it, "We are looking forward to doing everything we

can to extend the hand of friendship to colleagues in Cuba and mainland China and other countries with which there has been no regular contact."

Informed observers see no prospect of an immediate transformation in scientific relations. Certainly no encouragement has yet come from the Chinese.

One underlying difficulty may be the fact that the Western attitude that science is separable from politics goes against the ideological grain in mainland China. The view that science might be placed above class and above politics is regarded there as pernicious, in fact as reflecting a bourgeois taint. The Chinese teach that the scientist's first duty is involvement in the class struggle. Individualism and liberalism, characteristics which in the West seem to be held as virtues in a scientist, are viewed as the opposite in mainland China. Scientists are classed as intellectuals in China, and

intellectuals at the moment seem to be in for a stiff course of "correction." Some observers, however, draw hope for better relations in science with mainland China from the precedent of the improvement in scientific relations with the Soviet Union from a near-zero point in the late 1940s.

However frail the analogy, there is evidence that the United States is engaged in a general and apparently serious reappraisal of her China policy. This great diplomatic glacier is not likely soon to melt, but some think that science, and particularly medical science, is the area where it might recede a bit. At any rate, in view of the evolving official view toward scientific contacts and the acknowledged urgency of the need to strengthen scientific ties with developing countries, it appears that international scientific activities for this country are entering a period of greater emphasis and importance. ☆☆☆



Actions and reactions characterize Southeast Asian conflict as President Johnson speaks out on U.S. Vietnam policy . . . Summertime booming with U.S. space activities . . . Valuable data gained from USAF missile measuring equipment may mean antimissile missile system development is near . . . Phantom IIs get British engines . . . Canadair to build ailerons for the C-5A . . . Flying motorcycle without wheels creates jet-propelled soldiers . . . Navy aerobatic team celebrates twentieth anniversary . . . and test of wingless maneuverable spacecraft is successful. This month's news features . . .

Retaliation, Rendezvous, and Research Vehicles

BY JUDITH DAWSON, Editorial Assistant

As if in retaliation for the U.S. bombing of North Vietnam's major fuel-storage and distribution facilities in mid-summer, the North Vietnamese Ambassador in Peking, Tran Tu Binh, announced shortly after the raids that captured U.S. pilots in Vietnam could face trial as war criminals. He said that U.S. pilots who had taken part in the bombing of North Vietnam "cannot be considered as prisoners of war and cannot benefit from the Geneva convention," and that the prisoners were regarded as war criminals.

(Ho Chi Minh has said, in response to a later query by the Columbia Broadcasting System, that there would be no trials. This was confirmed by U.S. Administration spokesmen.)

The threat, nevertheless, aroused the grave concern of 18 U.S. Senators who had been previously opposed to escalation of the war. They issued a statement warning Hanoi that the execution of American prisoners as war criminals "would incite a public demand for retaliation" and "would provide the gravest reprisals." Among the signers were two of the most severe Senatorial critics of the Administration's Vietnam policy: Senator Wayne Morse, Oregon Democrat, and Senator William Fulbright, Arkansas Democrat and Chairman of the Senate Foreign Relations Committee.

Furthering the cycle of retaliations and reactions, the South Vietnamese Government extended another peace feeler in the form of a proclamation issued on July 20, Geneva Day, stating it would ask the U.S. to withdraw from the country if North Vietnam would

withdraw its troops from South Vietnam and dissolve the Viet Cong. (It was on July 20, 1954, that the Geneva Accords were signed, partitioning the country into North and South Vietnam.) Hanoi made no reply.

The bombing of North Vietnam's major fuel depots was intended to persuade Ho Chi Minh to give up his adventure in South Vietnam or to severely weaken his ability to support

his regulars and Viet Cong guerrillas. If this strategy fails, the U.S. is ready to apply still more pressure—and soon—to force North Vietnam out of the war.

This is the picture that emerges from statements by President Johnson and other Administration leaders following the decision to hit fuel tanks and offloading systems in the port of
(Continued on following page)



Republic F-105 Thunderchiefs perform precision bombing on North Vietnam target through clouds by flying close formation under radar control of Douglas RB-66 Destroyer. Photo was made by Lieutenant Colonel Cecil J. Poss flying RF-101 Voodoo immediately above. RB-66 is also tuned in to North Vietnamese ground and airborne radar, ready to warn fighters of possible attack.

Haiphong and fuel facilities at Hanoi.

"The air attacks on military targets in North Vietnam have imposed and will continue to impose a growing burden and a high price on those who wage war against the freedom of their neighbors," President Johnson said in Omaha, Nebraska, the day after the attacks.

"Until the day they decide to end this aggression and to make an honorable peace, I can assure that we—speaking for the United States of America—intend to carry on.

"No one knows how long it will take. Only Hanoi can be the judge of that. No one can tell you how much effort it will take. None can tell you how costly it will be.

"But I can and I do here and now tell you this: The aggression that they are conducting will not succeed."

The Air Force and the Navy shared in hitting fuel-storage facilities on June 29. From the USS RANGER, the Navy sent 45 F-4B Phantom IIs and A-4 Skyhawks against storage tanks and facilities used to pump oil from tankers in the port of Haiphong. More A-4s from the USS CONSTELLATION struck a smaller petroleum, oil, and lubricant (POL) storage area at Do Son, southeast of Haiphong. From Thailand bases, the Air Force sent 70 F-105 Thunderchiefs against a major petroleum distribution center just across the Red River from Hanoi. Flak over Hanoi was as heavy as any encountered in the Vietnam War, but from all these early missions only a single F-105 was lost.

Defense Secretary Robert S. McNamara listed five military objectives of the raids: first, to neutralize at Haiphong the only existing North Vietnamese shore facility for offloading petroleum directly from tankers; second, to wipe out 60 percent of North Vietnam's fuel supply—40 percent at Haiphong, 20 percent at Hanoi; third, to cripple in-country transshipment facilities, primarily at Hanoi; fourth, to force North Vietnam to divert manpower and materiel to erect new fuel-storage facilities; and, fifth, to further reduce the truck movements of men and supplies to South Vietnam.

The bombings were generally headlined, in the U.S. and around the world, as a new phase of the war, but this interpretation is perhaps an exaggeration. USAF and Navy fighter-bombers have hit other petroleum-tank farms in North Vietnam many times, and have previously hit power stations in the Haiphong-Hanoi area.

The Chinese, while advising Hanoi that North Vietnam was, for the present, on its own, do not overlook, as many Americans do, that the tactical situation for ground forces is much



First strikes against major petroleum storage and distribution center in Hanoi area were flown by Air Force F-105s while Navy A-4s hit similar targets near Haiphong. At left, smoke billows up to 35,000 feet (10,670 m) as all 32 fuel tanks at Hanoi are destroyed or severely damaged.

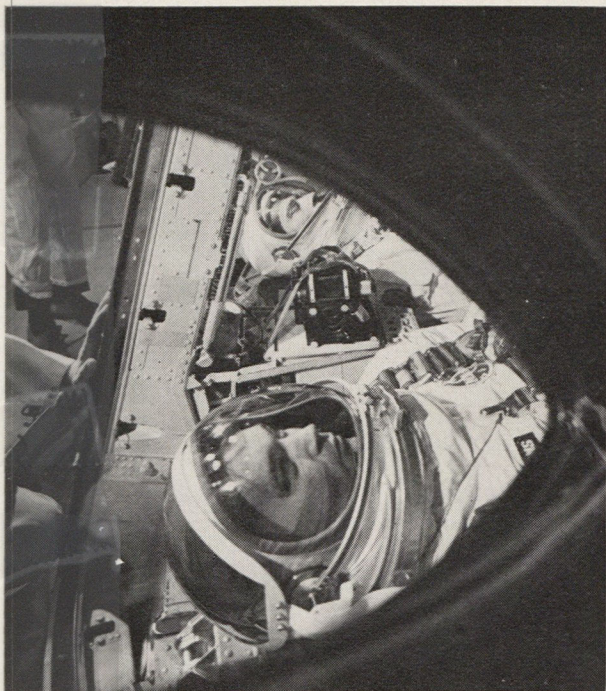


Low-level photo above shows oil tanks burning fiercely following initial strikes. Note also craters of bombs among pump houses, support buildings, and warehouses in POL storage complex. Despite heavy antiaircraft fire, only one F-105 was lost of 70 engaged.

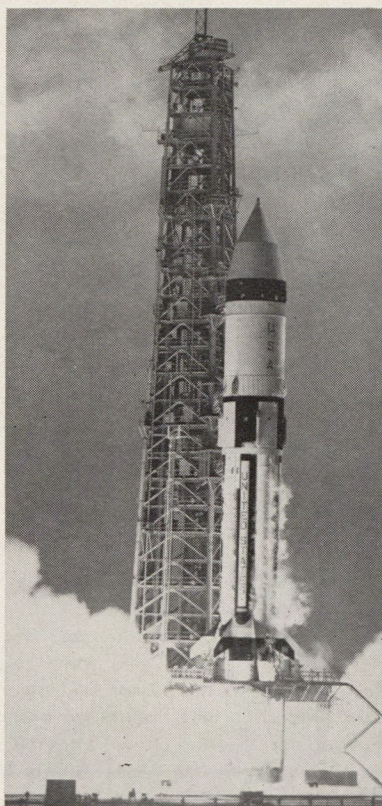
different in Vietnam than it was in Korea 16 years ago. There, Chinese troops had only to cross the Yalu to make contact with U.S. forces. In Vietnam, Chinese units are separated by the 600-mile (960 km) length of North Vietnam from U.S. ground forces. If the Chinese were to enter the war, they know their troops and supplies would be subjected to air attack all

along the way, and the U.S. has made it clear that this time there will be no sanctuary, no geographical boundary, beyond which it will not strike.

The U.S. is entering a new phase in the Vietnam War, however, in that it has virtually completed the logistics buildup under way for the past two years and is now ready to apply its superior logistic leverage. New air-



Gemini-10 Pilot Michael Collins, foreground, and Command Pilot John W. Young make final checks of their spacecraft prior to launch from Cape Kennedy, Fla., July 18. Astronauts were launched 100 minutes after Agena target was orbited.



Up-rated two-stage Saturn booster was launched from Cape Kennedy on July 5. The Chrysler S-IB booster sent the Douglas-built S-IVB upper stage into orbit where cameras photographed the behavior of its hydrogen fuel in the near-vacuum of space. Photos revealed that the fuel remained stable enough so that it could readily have been restarted in orbit, an essential step for the lunar mission.

fields are in operation, port facilities have been expanded so that supplies now move more smoothly from ship to shore and on to combat units, trans-pacific air cargo flights are delivering increasing tonnages of high-priority equipment, and the effectiveness of in-country airlift is steadily improving. At the same time, airpower is curtailing North Vietnam's ability to support its forces in the South. The odds of simple attrition are now running heavily against North Vietnam and widening every day.

* * *

America's space program moved forward at a rapid rate during July with the complex three-day Gemini-10 mission which included the first dual rendezvous in space, and a successful flight test of an unmanned two-stage Saturn rocket, both launched from NASA's Kennedy Space Center, Florida.

The Gemini mission began with the launch of the Agena X target vehicle by an Atlas booster July 18. An hour and 40 minutes later, the spacecraft, carrying Navy Commander John Young, Command Pilot, and Air Force Major Michael Collins, was launched by a powerful Titan II booster and sent on its way to rendezvous and dock with the Agena X. Then it hunted for and caught up with the unpowered Agena VIII rocket, still in orbit after being launched in March with the Gemini-8 mission.

The dual rendezvous was marred only by the excessive amount of fuel

used during the tricky maneuvers. As a result, Astronaut Collins had to cut his space walk slightly short. Although some planned activities had to be called off because of the fuel shortage, the astronauts were able to carry out most experiments and several other assignments during the space walk, including testing the umbilical cord, studying the effect on Collins' movements of the umbilical cord attaching him to the spacecraft, and steering of the craft toward the space-walker and picking him up. Collins was able to retrieve a meteorite impact experiment package from the corpse of Agena VIII. He was unable to complete an assigned experiment to photograph the earth's terrain because of the escape of a pungent chemical, apparently lithium hydroxide used to scrub carbon dioxide from the space cabin, which made both men's eyes water and affected their vision temporarily.

In spite of these minor difficulties, the mission was lauded as a success, with the primary goal, the dual rendezvous, being made possible by the sturdy Agena X. In order to catch the dead Agena VIII, the astronaut's, aboard their Gemini capsule, had to catch up with the Agena X, dock with it, and then use the Agena X's rocket power to soar into an orbit reaching as far as 474 miles (762 km) into space. It was the first time any spaceman had been able to link up with a rocket in space and use its power to fly.

Preceding the Gemini mission was

a successful flight test of an unmanned two-stage Saturn on July 5, which may have advanced the date of the first U.S. manned mission to the moon.

A key objective of the Saturn launch was to study the behavior of liquid hydrogen in the S-IVB second stage in the near-vacuum of space. It was launched atop the Chrysler S-IB first stage, powered by eight Rocketdyne H-1 engines generating a total of 1,600,000 pounds (725,760 kg) of thrust.

TV cameras mounted in the Douglas-built S-IVB stage, which will comprise the third stage of the Saturn-V moon rocket, showed that the fuel remained stable enough so that it could readily have been restarted in orbit, an essential step for the lunar mission.

When the S-IVB stage achieved orbit, NASA announced it was expected to remain in space for several days before being drawn back into the earth's atmosphere. However, the stage exploded in space on its fourth orbit, about six hours after launch. NASA said the explosion was intentional, in a test to measure the rate of pressure buildup in the liquid-hydrogen tank when corresponding pressure in the adjoining oxygen tank was allowed to drop by venting the oxygen fuel. The intent to explode the Saturn after its mission had not been disclosed earlier by NASA, which normally releases detailed information on all primary and secondary mission objectives.

A third Saturn test was scheduled
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for August 20. If the present Saturn success record is maintained, some NASA officials now believe the first manned lunar mission may be possible some time in 1968.

* * *

The forty-first and last of the currently authorized fleet ballistic missile (FBM) submarines, the WILL ROGERS (SSBN-659), was launched July 21 at the Electric Boat Division of General Dynamics Corporation, Groton, Connecticut.

The nuclear-powered submarine, of the LAFAYETTE class, is outfitted to carry 16 A-3 Polaris missiles with a range of 2,880 statute miles (4,630 km), and carries a crew of 130 officers and men.

The launch was sponsored by Mrs. Muriel Humphrey, wife of Vice President Hubert Humphrey. Secretary of the Navy Paul H. Nitze delivered the launch address.

* * *

Valuable data to be used in the eventual development of advanced ICBM warheads and an effective anti-missile missile system was obtained recently in a successful first test of U.S. Air Force missile measuring equipment.

The Air Force's Ballistic Systems Division's newest missile-tracking program scored a 5,000-mile (8,046 km) bull's-eye in its first test near Kwajalein Atoll in the mid-Pacific in June.

A comprehensive record of an ICBM's reentry into the atmosphere was obtained by the TRAP (Terminal Radiation Program) equipment mounted in a specially modified Boeing KC-135 jet tanker aircraft. Data obtained was forwarded to Aerojet-General Corporation's Von Kármán Center, Azusa, California, for full analysis.

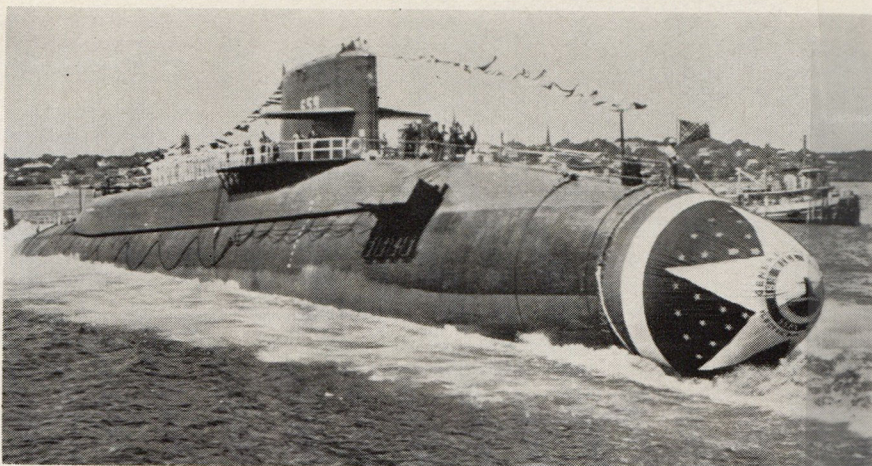
The ICBM was fired from Vandenberg Air Force Base, California, while the KC-135 and a crew of seven "flying physicists" hovered 5,000 miles (8,046 km) downrange near Kwajalein at an altitude of 40,000 feet (12,190 m).

The missile's countdown, liftoff time, and estimated impact point were relayed to the TRAP aircraft.

The missile was first sighted when it was at an altitude between 200,000 and 300,000 feet (60,000 and 90,000 m), and the TRAP's photo and recording equipment recorded the ICBM's plunge through the atmosphere into the Pacific.

The TRAP equipment's performance was almost perfect, according to Philip H. Stoddard, head of Aerojet's tracking team, and only a few minor adjustments will have to be made on the KC-135 for subsequent tests.

The successful mission followed a year-long program in which Aerojet fabricated or modified more than a dozen instrument pedestals and meas-



—Wide World Photos

The WILL ROGERS, U.S. Navy's newest and last-to-be-authorized nuclear-powered submarine, slides into the Thames River, Connecticut, after launching ceremonies recently. The Polaris missile-firing 7,000-ton (6,350 mt) vessel was built by General Dynamics.

uring devices for TRAP under a \$3,000,000 contract with USAF's Ballistic Systems Division. Additional tracking flights are planned over Kwajalein and downrange from Cape Kennedy and White Sands Missile Range, New Mexico.

Richard H. Newton of Aerojet's Astrionics Division, Von Kármán Center, is manager of the TRAP program.

* * *

F-4K and -M Phantom IIs, being built for the British Navy and Royal Air Force, respectively, will be almost as much a British as a U.S. product. Though produced at the McDonnell Aircraft Company plant in St. Louis, Missouri, some 46 percent of the plane's cost will be represented by British-designed and -built equipment.

Economic, prestige, and performance benefits are involved in the all-out effort to put as much British equipment as possible in the F-4K and -M.

"It would have been much easier for all concerned had Britain bought the standard U.S. Phantom," said Sir Patrick Dean, British Ambassador to the U.S., at F-4K rollout ceremonies.

"However, because of our balance

of payments problems we had to take every opportunity to reduce dollar expenditures on the aircraft. A target of 50 percent of the project cost was set for the British fit, and it is most gratifying that this has nearly been achieved. . . . I can assure you that we feel we have not only saved dollars, but have also obtained a Phantom of even enhanced performance."

Principal item of British equipment is the Rolls-Royce Spey engine in place of the General Electric J79 in the U.S. Phantom. Spey engines are reported to produce 30 percent more thrust with less weight and lower fuel consumption per pound of thrust.

"We are perhaps a little sad that the large numbers of Phantoms being produced for the U.S. services are not also fitted with Rolls-Royce engines," said Ambassador Dean. "This would have helped our balance of payments situation and we believe, naturally enough, it would also have given your services an even better aircraft."

But the U.S. has a balance of payments problem, too, which favors retaining U.S. engines. An improved version of the J79 is now being readied

McDonnell F-4 Phantom is being bought by Britain as a replacement for the Hawker Hunter fighter in the Royal Air Force. F-4s will be flown by the Royal Navy as well. British-designed and -built equipment will represent 46 percent of the plane's cost.



to go into later models of the U.S. Phantoms, which will narrow—but not close—the performance gap.

The possibility of equipping later U.S. models with the Spey is not out of the question. In World War II, the North American P-51 Mustang offered only ordinary performance with a U.S. engine, but became one of the war's outstanding fighters with the Rolls-Royce Merlin. Since the Spey's greater thrust permits carrying a heavier weapons payload on carrier takeoffs, and increases range and speed, Speys are attractive to the U.S. Navy. These factors are not as critical in Air Force F-4 aircraft because of longer runways and readily available in-flight refueling.

Other British equipment going into the F-4K and -M are a miniature inertial navigator; an advanced navigation, computing, and weapon-delivery system—one of the Phantom's most crucial components; airborne communications; autopilot, fuel meters, and controls; IFF (identification, friend or foe) equipment; and various airframe components, including tailplane, outer wings, and segments of the boundary-layer-control system. All Phantoms, U.S. as well as British, are equipped with British-built Martin-Baker ejection seats.

Some British-designed modifications will definitely be incorporated in U.S. F-4s. To improve low-speed flying characteristics, British engineers designed larger flaps and drooped ailerons, coupled with a slotted stabilator. These will go into U.S. Phantoms on the production line, and earlier models will be retrofitted with the British improvements.

The first F-4Ks are scheduled for delivery to the Royal Navy in October 1967, with F-4Ms following early in 1968. The initial contract calls for 150 to go to the Navy, and 60 to the RAF.

Like the deadly snake for which it is named, the U.S. Army's UH-1H HueyCobra packs lethal striking power into 9,500-pound (4,309 kg) maximum takeoff weight. Its empty weight is 5,288 pounds (2,399 kg), and maximum payload, including fuel, 4,212 pounds (1,911 kg).

The UH-1H's chin turret can carry a pair of 7.62-mm Gatling guns, each firing at a rate of 6,000 rounds per minute, or two 40-mm grenade launchers, or one of each. The minimum ammunition loads are 8,000 rounds of 7.62-mm, or 462 grenades. In addition, it is fitted with four wing-mounted pylons to carry 2.75-inch (70 mm) rocket launchers or machine-gun pods.

The two-man crew includes pilot and gunner, the latter seated forward above the gun turret.



Bell Helicopter's UH-1H HueyCobra, ordered by the U.S. Army, will be world's first aerial-weapons-platform helicopter. Retracted gear, stub wings, improved rotor system, and clean configuration add to speed and maneuverability.

New A-7A Corsair II light attack bomber may soon be in service with U.S. fleet. Test flights by Ling-Temco-Vought pilots have demonstrated the plane can carry up to its own 15,000-pound (6,804 kg) weight in armament.



The Army defines UH-1H capabilities in the following terms:

"Primary mission of this aircraft shall be that of an armed tactical helicopter, capable of delivering weapons fire, low-altitude, high-speed flight, search and target acquisitions, reconnaissance by fire, multiple weapons fire support, and troop helicopter support. Aircraft shall be capable of performing this mission from prepared or unprepared areas, day or night flying, and navigating by dead reckoning or by use of radio aids."

Although the fuselage is only three feet (.9 m) wide, stub wings bring the span to 10 feet 11 inches (33.3 m). Rotor diameter is 44 feet (13.4 m), height 11 feet 7 inches (32.3 m), length, including rotors, 52 feet 11 inches (161.3 m). It is powered by a Lycoming T53-13 gas-turbine engine, which is normally 1,400 horsepower, but has been derated to 1,100 hp for the UH-1H.

Cruising speed at maximum payload is 160 miles per hour (257 km/hr), top speed 218 mph (351 km/hr). Operating radius is 150 miles (241 km). This performance readily enables the HueyCobra to escort troop-carrying assault choppers like the Boeing CH-47 Chinook and Bell UH-1D Iroquois, which normally cruise at 115 to 125 miles per hour (185 to 200 km/hr).

The first HueyCobra production models are due off the Bell Aircraft production line in Ft. Worth, Texas, in May 1967. Estimated unit cost is \$200,000.

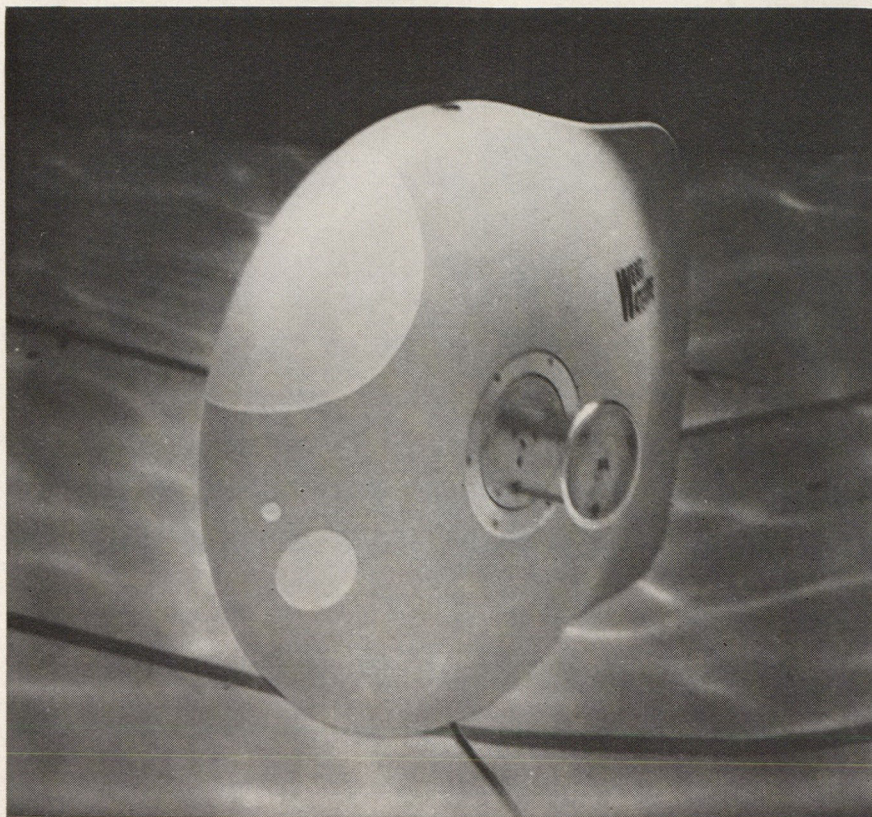
Tactical air support in Vietnam may soon have the advantage of a new agile Navy attack bomber. The A-7A Corsair II, the Navy and Marine Corps' answer to warfare requirements for heavy bomb loads delivered over long distances, has moved a big step closer to service with fleet aviation.

During the summer, two A-7As piloted by Ling-Temco-Vought Aerospace Corporation test pilots conducted contractor demonstration flights at Naval Air Test Center, Patuxent River, Maryland. One, flown by William Cato, made 70 flights carrying a total of 100,000 pounds (45,360 kg) of bombs, rockets, and missiles, ranging from 250-pound (113 kg) general-purpose bombs to 2,000 pounders (907 kg). Aerial firings were accomplished with Zuni and 2.75-inch (70 mm) folding-fin rockets from wing pods containing up to 19 rockets. The plane's 20-mm cannons were fired out.

The Corsair II's six wing pylons have been loaded with 250- and 500-pound (113 and 226 kg) Snakeye and general-purpose bombs, 1,000-pound (450 kg) general-purpose bombs, and 2,000-pound (907 kg) Mk 104 bombs, as well as Aero ID fuel tanks. Zuni, Sidewinder, Shrike, and Bullpup A rockets and missiles have been fired at Patuxent River and Bullpup Bs dropped to check their lanyard-firing mechanism. Aerial mines also were dropped.

During one flight a total of 114 rockets were fired successfully. The airplane can fire Sidewinder and Zuni

(Continued on following page)



Advanced underwater research vehicle with a unique underseas propulsion system will enhance oceanographers' investigation of the depths. Developed by Weber Aircraft Division of Walter Kidde & Company, the "Watercoupe" will be five feet, seven inches high; three feet, eight inches wide; and nine feet, two inches long (170 x 112 x 279 cm).

rockets from fuselage-mounted locations and has satisfactorily completed firing tests on the installations at the extremes of flight conditions for which the airplane was designed. The airplane can carry up to its own 15,000-pound (6,804 kg) empty weight in armament, pylons, and bomb racks.

A second Corsair II, with Don Wilson as pilot, made 45 flights and was catapulted 70 times. It made 50 arrested landings at the Navy's land-based "aircraft carrier" installation at Patuxent to test the plane's carrier suitability. During the catapult launching, the plane flew at gross weights as high as 38,000 pounds (17,240 kg), more than double its empty weight. Later this year, it will go aboard a Navy carrier for its sea trials, flown by Navy pilots.

* * *

Construction of a very-low-frequency (VLF) radio station in Norway for the North Atlantic Treaty Organization (NATO) will be begun by Continental Electronics Systems, Inc., Dallas, Texas, subsidiary of Ling-Temco-Vought Electrosystems, Inc.

J. O. Weldon, President of Continental Electronics, said the \$15,000,000 contract was awarded by the Norwegian Joint Signals Administration,

acting for NATO, and will be financed by NATO.

"A large part of the contract involves civil engineering and construction," Mr. Weldon said. "This effort has been subcontracted to the Norwegian firm of Thor Furuholmen, A/S."

The VLF station will be located north of the Arctic Circle in the county of Salten in Norway, he said. Contract negotiations were conducted in Oslo.

Continental Electronics has been a contractor in every major VLF station for operational use in the Free World for the past 15 years. These include the 2,000,000-watt stations for the U.S. Navy at Cutler, Maine, and Northwest Cape, Australia, and stations for NATO located in England and in the Mediterranean.

* * *

Development of an advanced underwater research vehicle employing a unique underseas propulsion system will allow oceanographers to investigate the sea at depths ranging from five to 600 feet (1.5 to 180 m) while traveling at ten miles per hour (16 km/hr).

Developed by Weber Aircraft Division of Walter Kidde & Company, Inc., Belleville, New Jersey, and known as

the Weber Watercoupe, the small submarine is driven by paddle-wheel-like devices called cycloidal propellers, a technique never before used on an underseas vehicle.

The Watercoupe has dual cycloidal propellers, one located on each side of the hull. Weber scientists claim this type of propulsion system will reduce underwater vehicle noise and turbulence, making it extremely difficult for the vehicle to be detected by sonar and other sensory instruments.

Designed as a two-man submarine, the Weber Watercoupe will be used for exploration, antisubmarine warfare, and mineral prospecting, and is capable of remaining in a submerged condition for more than eight hours.

Constructed of fiberglass, the Watercoupe borrows its shape from the sunfish or perch. The unique oblate spheroid design, coupled with the paddle-wheel-like propulsion system, gives the craft several operational advantages over conventional cigar-shaped propeller-driven submarines. Its crew will sit in a normal side-by-side upright position in a shirt-sleeve environment. Weber's Watercoupe is able to hover on the ocean floor without creating a turbulence to the surroundings. Visibility is equal to that of an airplane, compared with small port-hole visibility in standard torpedo-type vehicles.

* * *

The U.S. Department of the Army Distinguished Civilian Service Medal has been awarded to Dr. Fritz Engelmann in recognition of his service as Federal Republic of Germany Program Manager of the Joint U.S.-German Main Battle Tank Program.

Dr. Engelmann was cited by Stanley R. Resor, Secretary of the U.S. Army, for his outstanding contributions to the success of the Main Battle Tank (MBT) recently completed design phase. Particular mention was made of Dr. Engelmann's distinguished leadership in melding two distinct groups of military and civilian professionals, from diverse military, cultural, linguistic, technical, and national backgrounds, into one effective working team.

Noting that this joint cost-sharing partnership agreement between two sovereign governments for the purpose of developing a major weapons system was unique in U.S. Army history, the citation complimented Dr. Engelmann for his key role in the program. He was the first German Program Manager and German member of the two-member Program Management Board that implemented the August 1963 agreement between the two countries calling for a cooperative tank development program.

Dr. Engelmann is a graduate of the Munich Institute of Technology and has been in the employ of Germany's Government for several years.

* * *

A subcontract has been awarded by Lockheed-Georgia Company to Canadair Ltd., Montreal, Canada, for ailerons for the C-5A transport. Canadair, a wholly owned subsidiary of General Dynamics Corporation, will also build main landing-gear fairings and doors for the giant transport.

The first of 58 C-5As, ordered for the Military Airlift Command, is scheduled to roll out in February 1968. Developed under the direction of the Air Force Systems Command, the 728,000-pound (330,220 kg) airplane—world's largest—will make its first flight in June 1968.

The U.S. Department of Defense holds an option for 57 additional C-5As.

* * *

A battlefield radar weighing only two pounds (.907 kg) has been developed by the Radio Corporation of America.

Believed to be the world's smallest, the radar is so light that it can be mounted on the barrel of a man-held firearm. In darkness or in jungle foliage, it can locate moving objects smaller than men, and distinguish between such targets as walking and running men and animals, or jeeps, trucks, and tanks. Instead of a scope picture, its readings are in the form of sounds ranging from low grunts to high-pitched squeals.

The device can be used for surveillance, for ranging on targets, and for voice communications. In surveillance, the radar scans an area six degrees wide and up to 250 meters long, and detects moving objects anywhere within that range. When he locates a target, the operator switches a control on the back of the radar through up to ten positions to determine the target's range within a few meters—well inside the spray pattern of typical weapons on which the radar would be used, such as a grenade launcher or light machine gun. In conjunction with another radar, voice communications are possible up to a 500-meter range.

Since the radar returns are from the doppler effect of moving targets, only objects in motion are picked up. It detects motion from two feet (61 cm) per second (low grunts) to 45 mph (72 km/hr) (high squeals). The operator can readily distinguish between characteristic sounds returned by men walking, crawling, or running, and by light or heavy vehicles. The device employs a "pseudo-random" code which appears to be noise to an enemy monitoring the signal; thus it does not present a target for return fire, and

The world's largest balloon was launched from Holloman Air Force Base, New Mexico, recently. In later flights, the balloon will carry NASA's 1,700-pound (770 kg) Voyager Mars landing capsule to an altitude of 130,000 feet (39,620 m) where it will be released to test its rocket deceleration and parachute systems. Only a small portion of the balloon is inflated on the ground, but as it reaches its cruise altitude, it expands to 26,000,000 cubic feet (736,200 m³).



it is practically immune to jamming.

The radar is also useful in civilian applications. Mounted on a car, it indicates whether another vehicle ahead is moving at the same speed, faster, or slower. It can serve as a radar altimeter and ground-speed indicator for small aircraft, and as a burglar alarm in detecting intruders.

The only auxiliary equipment needed for operation of the radar is a small battery, also weighing two pounds (.907 kg), and a headset. Total power consumption is only three watts.

* * *

A jet flying motorcycle without wheels is being designed for the U.S. Army. The soldier will strap a miniature jet engine on his back, manipulate jet exhaust nozzles with handlebars at waist level, and scoot off at 60 miles per hour (96 km/hr).

The device is being developed by Bell Aerosystems Company of Niagara Falls, New York, which turned out a rocket belt successfully flown more than 2,500 times. But while the rocket belt operates for only 20 seconds with a maximum range of less than 900 feet (275 m), the jet belt's endurance may extend up to a full hour, affording a 60-mile (96 km) range. Built in quantities of 1,000 or more, Bell engineers estimate, the belt would cost about \$1,500 each.

The U.S. Army hasn't figured out exactly what jet-propelled soldiers will do, but it suggests the belt could be used by small commando units to penetrate far behind enemy lines on sabotage missions; a few men could slip behind a retreating enemy column to seal off a key mountain pass; or medical personnel could fly into a remote besieged area to care for wounded until a rescue force arrived.

Men could be launched from aircraft or helicopters. If the equipment could be made compact enough to be fitted into the cockpit of a combat fighter plane, it could enable the pilot to bail out of a disabled plane and scoot to safety.

Indications are the device will weigh about 150 pounds (680 kg). The operator would carry up to ten gallons (38 l) of fuel for the fanjet gas-turbine engine.

* * *

Two Convair F-106B Delta Dart jet fighters are being converted into highly advanced pilot trainers under a \$2,400,000 contract awarded to the Martin Company, Baltimore, Maryland, by the Air Force.

When modified, the two-seat jets will be able to simulate accurately the landing maneuvers of lifting-body spacecraft and the flight characteristics of a wide variety of high-performance aircraft including the General Dynamics F-111, Lockheed F-104, McDonnell F-4, and the rocket-powered North American X-15 research plane.

Called Variable Stability Trainers (VST) in their modified form, the aircraft will be assigned to the Aerospace Research Pilot School at Edwards Air Force Base, California.

"These aircraft will be extremely versatile and low-cost training tools," said James L. Decker, Martin's VST program manager.

"For training purposes, the two VST aircraft will take the place of a hangar full of different planes," Decker said. "In flight, the VST can be made to react like a completely different airplane, thus giving a pilot flight experience on a particular aircraft without his having to fly the actual plane."

(Continued on following page)

Celebrating its twentieth anniversary this year is the U.S. Navy Flight Demonstration Team, the Blue Angels, formed to "demonstrate precision techniques of naval aviation to naval personnel and, if directed, to the public." At right, the aerobatic team flies formation over New York Harbor and the Statue of Liberty in the supersonic F-11A Tiger, built by Grumman Aircraft Corporation.



The VST's most important mission at Edwards will be as a trainer for pilots picked to fly maneuverable lifting bodies—wingless aerospace vehicles which derive lift from their shape alone. Martin is currently building two such lifting bodies for the Air Force, an unmanned vehicle called PRIME, and a manned vehicle called SV-5P, under the PILOT program.

Heart of the Martin-designed VST system is an analog computer which will be programmed before takeoff with the desired flight characteristics of the vehicle to be simulated.

Once airborne, as the pilot performs a particular flying maneuver, commands from his control stick are sent to the computer which solves the equations of motion for that maneuver. This information is flashed to an autopilot which forces the F-106 to respond like the aircraft being simulated.

The bulk of the electrical equipment, including the computer, an electronic converter, and the autopilot, will be installed in the nose of the F-106 after its existing fire-control system has been removed.

The student's cockpit, in the rear of the two-place fighter, carries a completely new instrument panel which allows the student to see as well as feel the response of the aircraft being simulated. Standard F-106 controls will remain in the forward cockpit, occupied by the instructor.

* * *

Twenty years of military service usually means retirement in the U.S. military. But not for the Navy's Blue Angels aerobatic demonstration team, celebrating its 20th birthday this year. They're still flying high, fast, and handsome.

More than 80,000,000 people have seen the Blue Angels perform. Largest single audience was 1,500,000 at Mexico City's airport dedication in 1964.

The six-man team now flies the Grumman F-11A Tiger. It started out in 1946 with the F6F Hellcat, successively moved to the F8F Bearcat, F9F-2

and F9F-5 Panther (their first jet), F9F-8 Cougar, then to the supersonic F-11A. All are Grumman planes.

When the Korean War broke out in June 1950, the Blue Angels were ordered to combat aboard the USS PRINCETON. Lieutenant Commander Johnny Magda, then Blue Angel leader, lost his life when shot down off the north coast of Korea in March 1951. The team was reactivated late that year, with the original 1946 leader, Lieutenant Commander Roy M. "Butch" Voris, in charge.

The biggest year for the Navy's—and the nation's—good-will ambassadors was 1965 when they performed a record total of 87 times before more than 4,000,000 spectators in the U.S., Europe, Iceland, Bermuda, and the Caribbean. Highlight was their demonstration at the Paris International Air Show when they drew a standing ovation from a huge cosmopolitan crowd.

Commander Bob Aumuck, USN, leads the 1966 team. With him are Captain Fred Craig, U.S. Marine Corps, right wing; Lieutenant Red Hubbard, left wing; Lieutenant Frank Mezzadri, slot; and Lieutenant Commander Dick Oliver and Lieutenant Norm Gandia, solo pilots.

* * *

A new antisubmarine helicopter has been selected for the British Navy. Known as the SH-3D, it will be built by Westland Aircraft and will be the largest and most powerful helicopter to enter service with the Navy.

The SH-3D, which is expected to enter service in 1969, is a more powerful version of the Sikorsky Sea King, with two Bristol Siddeley Gnome engines and British antisubmarine equipment.

The new aircraft, with longer endurance, greater payload, and more advanced equipment, will be a considerable step forward from the Westland Wessex, now in service with the Navy, which carries 16 passengers or 4,000 pounds (1,815 kg) of cargo. The SH-3D, with a crew of four, can haul

25 troops or 5,000 pounds (2,265 kg) of cargo. For antisub missions, it will have homing torpedoes and sonar equipment manufactured by the Marine Systems Division of the Plessey Electronics Group. Ekco Electronics will be responsible for the radar and tactical coordination equipment. Marconi will provide the Doppler navigation equipment, and Louis Newmark the all-weather flight-control system.

Although the SH-3D is primarily designed to find and kill submarines in all weather, day or night, it will have a secondary role of providing transportation for troops and equipment and will be most effective for backing up the Navy's Commando helicopters.

* * *

The U.S. Army activated the 11th Infantry Brigade at Schofield Barracks, Hawaii, in July—last of the three new independent brigades announced for activation as part of the Army buildup.

The new brigade, with an authorized strength of 3,558, will initially have three infantry battalions, one cavalry troop, and one support battalion.

Other unit activations announced as part of the recent Army buildup are the 9th Infantry Division, activated in February 1966, at Fort Riley, Kansas; the 196th Infantry Brigade, activated in September 1965, at Fort Devens, Massachusetts; and the 199th Infantry Brigade, activated in June 1966, at Fort Benning, Georgia.

* * *

Direct cable communication circuits between the United States and Southeast Asia will soon be in operation. ITT World Communications, Inc., announced recently that it has filed application with the U.S. Federal Communications Commission to operate such a cable.

The service is intended to meet the accelerated demand for modern, coaxial-cable communications facilities in that area. The new circuits were to be available upon completion of the Guam-Hong Kong segment of the

British Commonwealth Seacom cable system in mid-August and were to provide 11 telegraph channels—seven from New York to Hong Kong and two each to Singapore and Malaysia.

Although the channels will be used initially for conventional message traffic, telex, and private-leased line communications, the system is designed to handle the transmission of alternate voice-data and computer-type information.

The Seacom cable, extending from Cairns (Australia) to Singapore and interconnecting en route with Kuala Lumpur, Madang (New Guinea), Guam, Hong Kong, and Jesselton (North Borneo)—is one of several submarine cable projects undertaken by the British Commonwealth in recent years. At Guam, it joins the facilities of the Hawaii-Japan cable system and the Guam-Philippines cable system. The final link in the chain, Guam to Australia, is still to be completed.

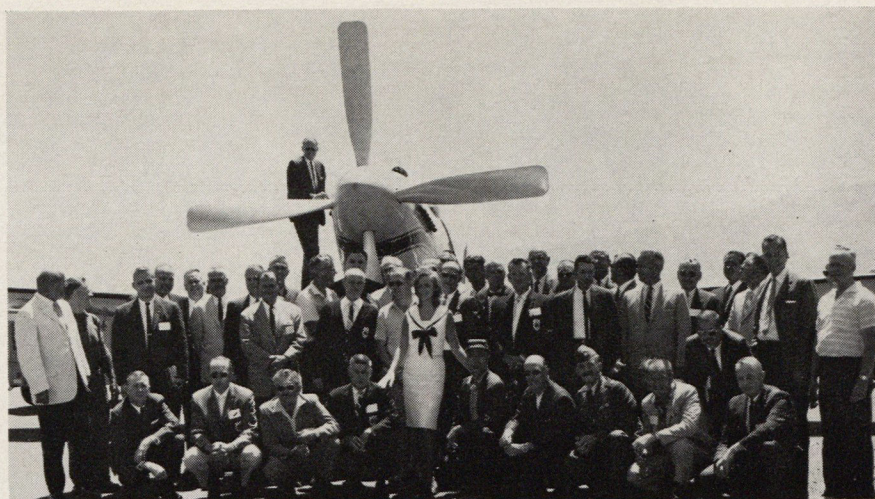
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As proof that the space age is truly worldwide, total U.S. aerospace exports achieved a record \$1,474,000,000 during 1965, a jump of 21.6 percent over 1964 exports.

In reporting the annual figures in late June, the Aerospace Industries Association revealed that jet transport sales increased 62.7 percent from \$211,000,000 in 1964 to \$352,800,000 in 1965.

Exports of the lighter utility aircraft were up 106.9 percent from \$33,300,000 in 1964 to \$68,800,000 last year. Helicopter exports gained 10.9 percent from \$14,600,000 in 1964 to \$16,200,000.

West Germany and Japan were major purchasers of large passenger transports, buying 11 each at a total cost of \$53,658,200 and \$58,677,400 respectively. Canada was the principal



Two beauty queens pose with some of the 400 men who gathered in Colorado this summer for a meeting of the American Fighter Aces Association. In the background is the North American P-51 Mustang fighter-escort which helped ensure Allied air superiority over Europe during World War II. In the foreground is Miss Colorado Springs of 1966. The Aces scored five or more fighter combat victories in both WW II and the Korean War.

buyer of American helicopters during the year, purchasing 49 at a total cost of \$4,096,000. Australia's purchase of 349 personal, utility-type aircraft totaling \$4,648,700 represented the largest export in that category.

* * *

A grant of \$90,000 to the Central American Air Navigation Service (COCESNA) has been awarded by the Agency for International Development (AID) to assist the Central American Republics in improving air navigation and communications facilities.

COCESNA represents the Republics of Guatemala, Honduras, El Salvador, Nicaragua, and Costa Rica.

The grant will be used in a project to provide a very-high-frequency, omnidirectional radio range at the La Mesa

Airport at San Pedro Sula, Honduras. Also included in the agreement are provisions for a nondirectional beacon, and ground-to-air communications for the San Pedro Sula area, and, under separate financing, training in fields connected with civil aviation activities—electronics, flight inspection, air traffic control, and communications.

AID will also finance the installation of air navigation aids for airways and airports in the Republic of Korea by the U.S. Federal Aviation Agency under a \$4,200,000 loan.

Part of the loan, \$1,300,000, will be spent by Korea for additional U. S. equipment such as various types of airport lights, emergency crash and rescue equipment, and heavy-duty machinery and trucks.

FAA will assist the Korean Government by providing technical guidance and by installing the equipment through its Civil Aviation Assistance Group (CAAG) office in Seoul. It also will assist Korea's Civil Aviation Bureau in training Korean personnel to operate and maintain the equipment. Korea will repay the loan in 30 years. Equipment to be purchased by the FAA includes airport surveillance and secondary surveillance radar systems, very-high-frequency omnidirectional radio range—tactical air navigation (VORTAC), communications equipment, and instrument landing systems.

Safe and efficient air transportation is vital to the development of Korea's economy, since its mountainous terrain makes rapid land travel virtually impossible in many areas.

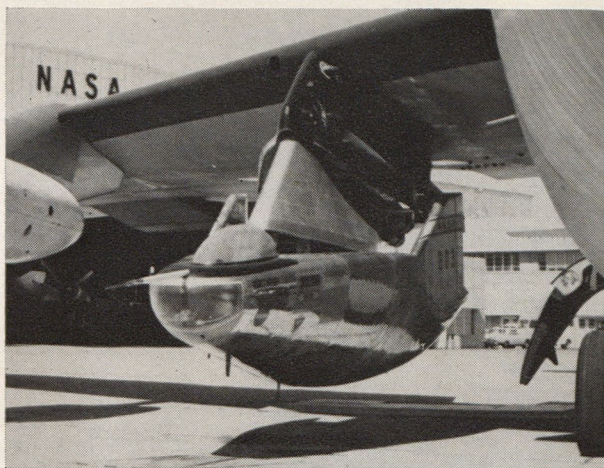
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The forerunner of future maneuver-
(Continued on following page)



—Wide World Photos

Jet airliners stack up at loading ramps at Philadelphia's International Airport after U. S. machinists' union, over wage controversy, struck five of the nation's major airlines—TWA, Eastern, Northwest, National, and United. Beginning in early July, the strike, biggest in airline history, cost airlines an average of \$7,000,000 a day in lost revenues.



NASA's M2-F2 heavyweight lifting body is shown mated to a B-52 launch aircraft at the Flight Research Center, Edwards AFB, California. The M2-F2 wingless research vehicle, forerunner of maneuverable spacecraft, made series of successful flight tests after being launched from B-52 at 45,000 feet (13,716 m).

able spacecraft, the M2-F2 lifting body, has made a series of successful flight tests. In its second flight, on July 19, the National Aeronautics and Space Administration's wingless 2.5-ton (2.3 mt) research vehicle was air-launched from a B-52 mother ship flying at 45,000 feet (13,716 m) above Boron, California. NASA pilot Milton Thompson glided straight ahead at approximately 450 miles per hour (724 km/hr) and then made a left turn as he passed through 27,000 feet (8,200 m). Four minutes after launch, Thompson made a 200-mile-per-hour (320 km/hr) powerless landing on Rogers Dry Lake Bed at Edwards Air Force Base, California.

The primary purpose of the flight was a complete systems check-out of the vehicle and evaluation of lateral stability. During the flight, Thompson performed several aileron maneuvers with some of the electronic-control dampers intentionally turned off.

The lifting-body concept is being investigated in flight by NASA to help establish the technological base for the design of future spacecraft. Wingless, the lifting bodies obtain their aerodynamic lift for flight from the shape of their bodies. Because of their higher lift and maneuvering capabilities, lifting bodies may offer greater advantages than the present manned spacecraft.

The M2-F2 lifting body was constructed for NASA's Flight Research Center by Northrop Corporation's North Division, Hawthorne, California.

* * *

Bristol Siddeley Engines, Ltd., of England; SNECMA, of France; and Pratt & Whitney Aircraft Corporation, in the U.S., have agreed to a joint program of work to be carried on in France and Britain on the Pratt & Whitney JT9D turbofan engine.

Bristol Siddeley and SNECMA have begun a development program for a high-pressure compressor within the framework of the development of the JT9D engine. The agreement includes

the application of the JT9D in large jet transport aircraft to be manufactured in Europe, such as the proposed airbus, and was the culmination of discussions that have been conducted by the firms for some time.

The JT9D turbofan is one of the most powerful jet engines in the world, developing 41,000 pounds (18,590 kg) of thrust. Four of these engines will power the 490-seat Boeing 747.

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An Apollo fuel-cell powerplant, operating in a simulated space vacuum, has successfully produced electricity and drinking water for 1,865 hours—more than equivalent to five 14-day missions to the moon.

The Powercel tested is similar to fuel cells to be used in the three-powerplant system aboard the Apollo spacecraft for U.S. astronauts' journeys to and from the moon. Built by Pratt & Whitney Aircraft, the fuel cells will supply the electrical needs and most of the drinking water for astronauts on lunar missions. Three similar powerplants are in the Apollo vehicle being prepared at Cape Kennedy for launch this summer.

J. S. Conley, Manager, Fuel-Cell Program, said Pratt & Whitney periodically operates powerplants for extended periods of time as part of the Apollo fuel-cell development program to demonstrate their capability to complete planned lunar missions.

The Powercells create electrical energy directly from oxygen and hydrogen without smoke, fumes, or vibration. Pure water is a by-product. More water than the astronauts need for drinking purposes will be produced and the excess will be used to cool spacecraft components.

In the 1,875-hour test, a total of 150 gallons (567 l) of water was produced, while generating 1,740 kilowatt hours of electric energy.

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COMSAT (Communications Satellite Corporation) has awarded Nippon Electric Company, Ltd., Japan, the

world's second largest telecommunications manufacturing firm, a \$441,412 contract calling for multiplex subsystems equipment to be installed in COMSAT's earth stations at Paumotu, Oahu, Hawaii, and Brewster Flat, Washington. It is the largest contract ever awarded by COMSAT to a non-American company.

Both stations are presently under construction and are expected to be completed and in operation by the end of the year. When in operation, the stations will serve as U.S. links for worldwide commercial satellite communications.

The multiplex system will modulate voice, TV, and high-speed data signals received from the U.S. terrestrial communications carriers for transmission over satellite links, and demodulate signals received from the satellite for relay to the land communications carriers in the U.S. NEC will supply order-wire equipment, test positions, and other auxiliary equipment, to be delivered this month. After the installation, over-all integration and COMSAT's acceptance tests will be completed by the end of November.

Dr. Susuma Okamura, General Manager of the NEC Transmission Division, has been appointed manager of this project.

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Evaluation of hydrocarbon fuels for use in future supersonic and hypersonic aircraft has begun at North American Aviation, Inc., under contract with the U.S. Air Force's Aeropropulsion Laboratories at Wright-Patterson AFB, Ohio.

The contract requires the company's Los Angeles, California, Division to modify and install an advanced aircraft fuel system simulator at Wright-Patterson AFB. It will duplicate many critical conditions encountered in the Mach 3 to 3.5 flight speed regions. After installation, engineers will conduct evaluation of nine different fuels.

Advanced hydrocarbon fuel technology is a vital factor in the design and development of future high-speed aircraft. Fuel characteristics may influence the entire design of an aircraft structure, as well as its fabrication techniques. Unlike pure chemicals, most hydrocarbon fuels cannot be completely evaluated by chemicals and physical analyses. Furthermore, there is not enough data available to make judgments on how this type of fuel may affect the design of advanced propulsion systems.

The advanced fuel-system simulator at the Ohio base will provide data which can be used to stabilize aircraft design criteria. It will also add to the knowledge of small-scale fuel quality control techniques.

☆☆☆



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