



Aerospace International

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



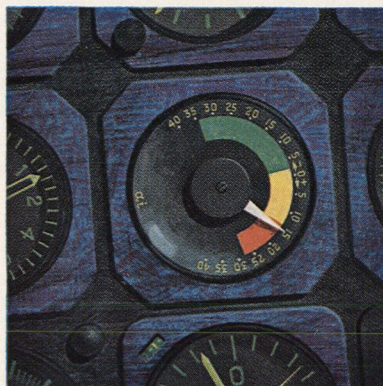
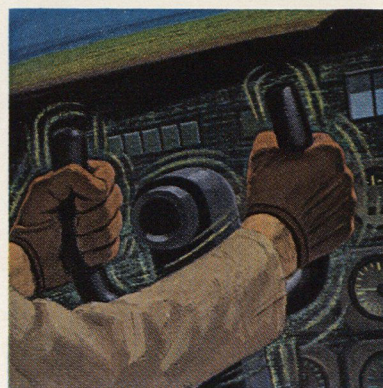
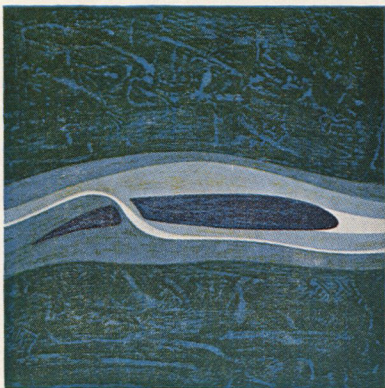
Photo shows an A-4 ready for takeoff from the USS HANCOCK off Vietnam.

U.S. NAVAL AVIATION -A Flexible and Mobile Force

A report on the third largest air force in the world—the aircraft it flies, its unique organization and training.

Also, special features on:

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- The versatile and durable F-4 Phantom II.
- Exploring and exploiting the world's oceans.



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Aerospace International

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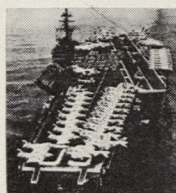
MEMORANDUM TO OUR READERS..... 4

By John F. Loosbrock, Editor

By the time you read this table of contents, a quick glance at either the cover or the masthead will have told you that our magazine's name has been changed to AEROSPACE INTERNATIONAL. This new name, we feel, is more descriptive of a unique editorial content and more in line with plans for our third year of publication.

HOW SEA-BASED AIRPOWER MEETS TODAY'S CHALLENGES..... 8

By Norman Polmar, Contributing Editor for Naval Affairs



With a current operating strength of about 8,400 aircraft, U.S. Navy aviation is the third largest "air force" in the world, surpassed only by the U.S. Air Force itself and the Soviet Air Force. Naval aviation is unique in that its bases can move across the seas, taking with them runways, fuel, munitions, maintenance equipment and personnel, and living quarters for pilots and aircrewmen. In the U.S. Navy its hallmarks are mobility, versatility, flexibility, and experience.

HOW THE PHANTOM II GOT THAT WAY..... 16

By J. S. Butz, Jr., Technical Editor

The McDonnell F-4 is today a multimission aircraft used—and highly praised—by both the Navy and the USAF. Its story began with a proposal to the U.S. Navy, continued with changes on the drawing board and assembly line, and offers a bright future with improvements in prospect that could make the F-4 a top performer into the 1980s.

OUT OF THE DEPTHS—A NEW WORLD OF WEALTH..... 26

By William D. Smith

The U.S. Government and industry are teaming up to explore the heretofore overlooked resources locked in the ocean depths. Exploitation of these treasures may well lead to new means of feeding the world's hungry, providing oil, and supplying needed minerals, chemicals, drugs, and living space. Scientists foresee that the oceans will become an integral part of man's living and working environment in the next generation.

LITTLE AIRFIELDS WITH A BIG FUTURE..... 34

The world's first operational training base for short airfields for tactical support (SATS) has been completed at a U.S. Marine Corps station in North Carolina. Under this system, aircraft are launched by catapult and stopped by arresting gear.

TARGET: DOWNED PILOT..... 37

By Norman Polmar, Contributing Editor for Naval Affairs



The responsibility for rescue of one's own forces is an inherent military capability. Hence, a major mission of the U.S. naval forces in the Vietnam War is search and rescue (SAR). When an airman is shot down over land or sea, his recovery becomes the top-priority objective of all operational aircraft and surface forces in the vicinity, often under fire from Communist guns. Navy ships and helicopters, aided by Air Force HU-16 amphibians, are responsible for rescues in the South China Sea.

AEROSPACE REVIEW..... 41

By Allan R. Scholin, Associate Editor

Both sides are girding for a step-up in the air war over Vietnam, as indicated by more frequent MIG encounters and a boost in U.S. orders for fighter planes . . . NASA scientists, puzzled over difficulties of working in space, hope to learn more from Gemini-12's flight in November . . . Guests at AFA's Fall Meeting in Washington included educators from 60 countries . . . Smokeless missile propellant, a laser gyroscope, and in-flight reconnaissance photo processing are among recent technical developments.

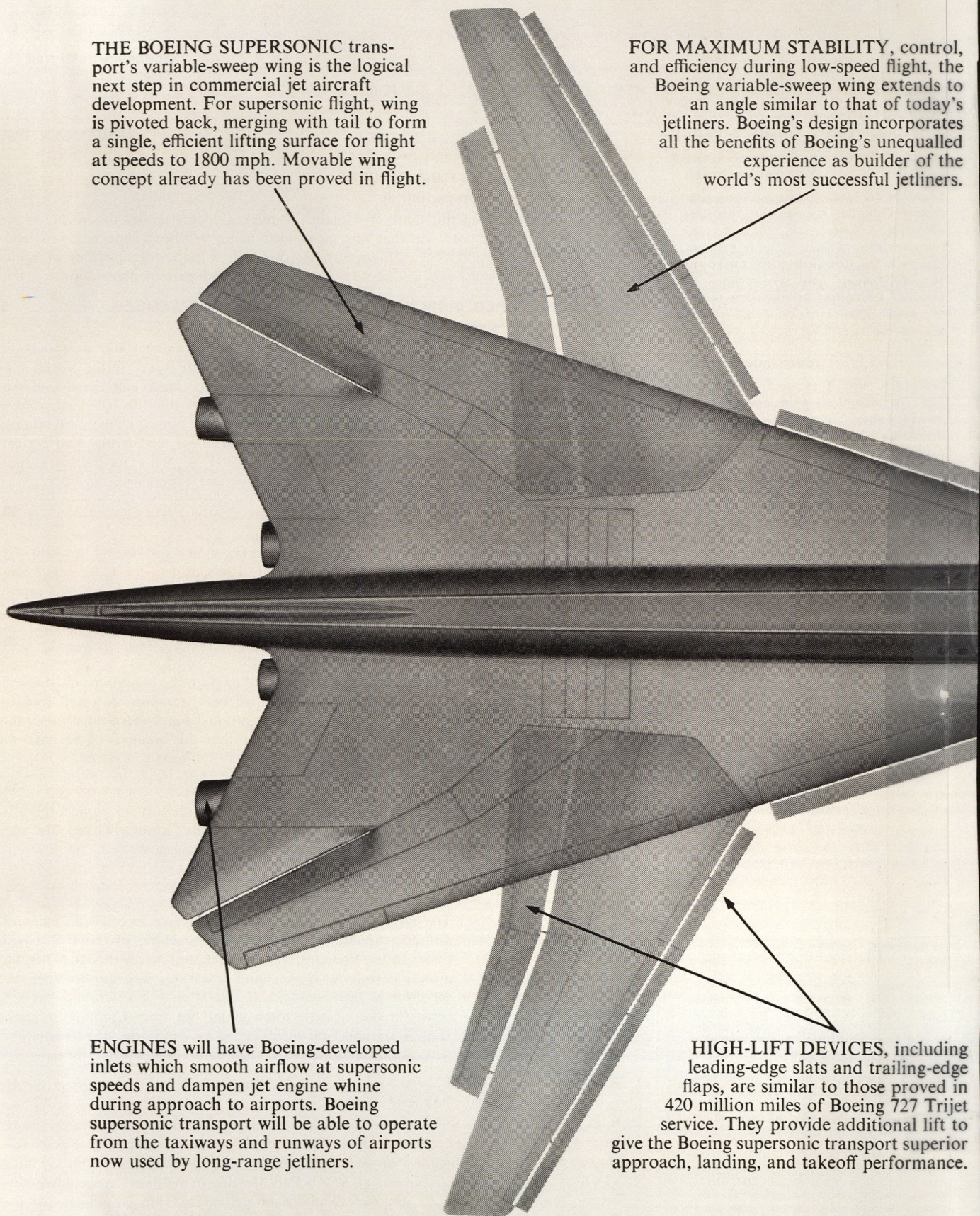
BPA AUDIT APPLIED FOR

THE BOEING SUPERSONIC transport's variable-sweep wing is the logical next step in commercial jet aircraft development. For supersonic flight, wing is pivoted back, merging with tail to form a single, efficient lifting surface for flight at speeds to 1800 mph. Movable wing concept already has been proved in flight.

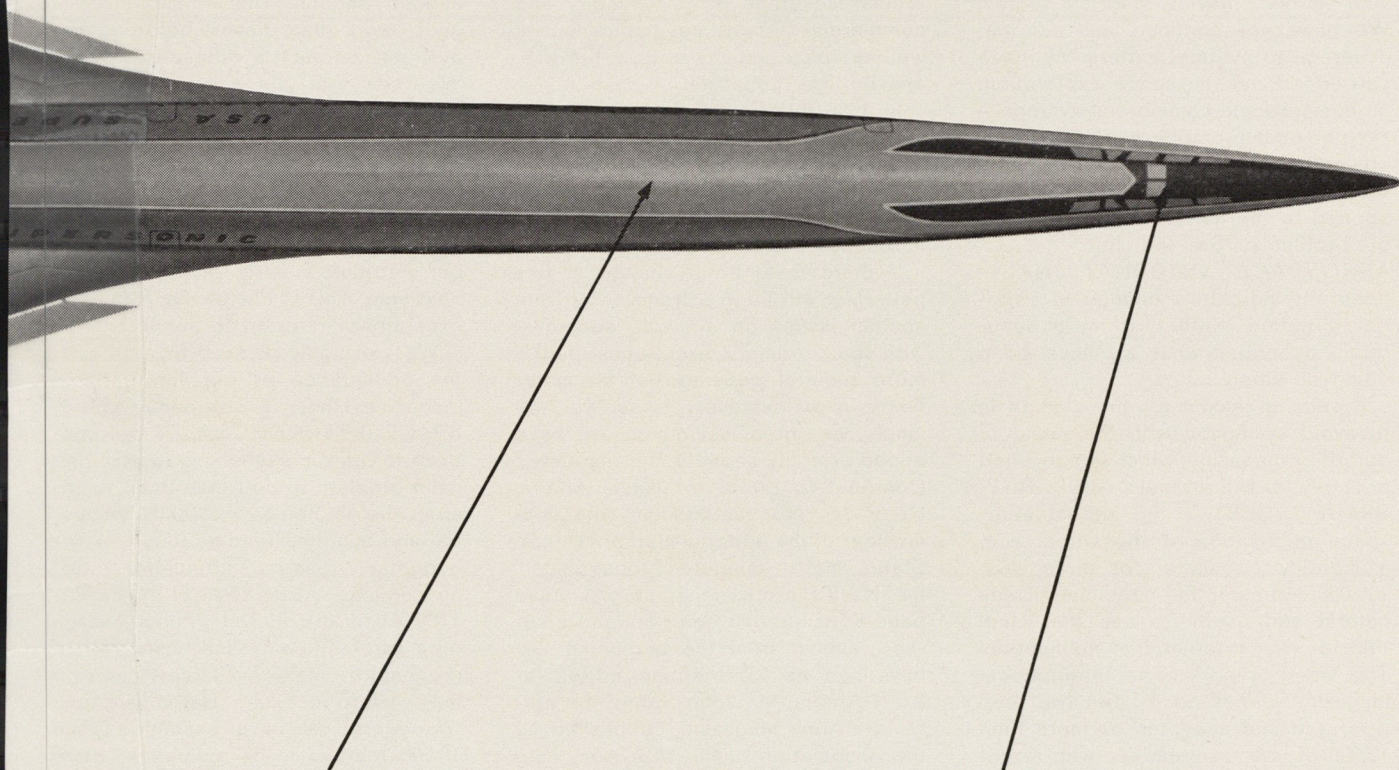
FOR MAXIMUM STABILITY, control, and efficiency during low-speed flight, the Boeing variable-sweep wing extends to an angle similar to that of today's jetliners. Boeing's design incorporates all the benefits of Boeing's unequalled experience as builder of the world's most successful jetliners.

ENGINES will have Boeing-developed inlets which smooth airflow at supersonic speeds and dampen jet engine whine during approach to airports. Boeing supersonic transport will be able to operate from the taxiways and runways of airports now used by long-range jetliners.

HIGH-LIFT DEVICES, including leading-edge slats and trailing-edge flaps, are similar to those proved in 420 million miles of Boeing 727 Trijet service. They provide additional lift to give the Boeing supersonic transport superior approach, landing, and takeoff performance.



The Boeing supersonic transport by the builder of the world's most successful jetliners.



BOEING SST WILL CARRY over 300 passengers from New York to London in 2 hours, 40 minutes. Cabin is wider than those of today's airliners, more spacious than any other supersonic transport under construction or proposed. This design, Boeing's entry in Federal Aviation Agency's supersonic transport competition, can be in service by the mid-1970's.

PILOT TECHNIQUE will require no new skills—the Boeing SST will take off and land like a present-day jetliner, and actual flight experience has shown that changing wing sweep is as easy as operating conventional wing flaps. The Boeing SST's step-ahead design could assure America's continued leadership in jet transportation.

BOEING SST

MEMORANDUM

TO: Readers of INTERNATIONAL FROM: John F. Loosbrock, Editor

Beginning with this November 1966 issue, your magazine has a new name. It is now called AEROSPACE INTERNATIONAL.

There are several basic reasons for making this change. First, the name AEROSPACE INTERNATIONAL is more descriptive of the editorial theme of the publication. From the beginning, we have covered activities and technological developments of interest to all three kinds of military service—armies, navies, and air forces. We have not confined our editorial coverage to military matters. We have carried articles on space exploration, on business and commercial aviation—even on oceanography, hydrofoil development, and other advanced projects where aerospace technology is being applied to the solution of many kinds of problems. So the new name—AEROSPACE INTERNATIONAL—does not indicate a change in editorial direction. Rather, it more accurately describes what we have been doing all along.

A second reason for the change is to avoid confusion with the name of our other magazine, which is published primarily for U.S. readers. AIR FORCE/SPACE DIGEST is the largest aerospace publication in the world, with a monthly circulation of more than 100,000 copies. In the beginning, it was natural and useful to use the same title for your International publication. This need is gone. The International magazine stands on its own two feet. It is read and accepted by more than 12,000 of you, our readers, who represent 68 nations of the Free World. It is no longer a "little brother" of AIR FORCE/SPACE DIGEST but a full-fledged, separate, and, you tell us, an important publication in its own right. Hence it is only proper that the International magazine should have its own name, descriptive of its unique editorial content—AEROSPACE INTERNATIONAL.

A brief review of some of our past issues indicates the breadth of the coverage which has led to the new name. Our first issue, in January 1965,

featured a report on "The Coming Revolution in Aeronautics," citing new advances in materials, engines, and aerodynamics which will affect aviation ten years and more from now. In June of 1965 we published a special edition for the Paris Air Show. In December of 1965 a special edition covered all aspects of tactical air war—past, present, and future—by leading authorities of the Army, Navy, and Air Force. In addition, there has been regular coverage of new military and commercial aircraft developments, as well as space activity both in the U.S. and in other countries.

In 1966 thus far we have published special issues on business and commercial aircraft, on the aerial aspects of military mobility, on naval aviation, on international cooperation in various aerospace projects and activities.

If there is to be a change in this pattern it will lie in a trend away from special issues on a single subject—with some dramatic exceptions—and a more general coverage of all major fields in almost every issue. For example, as noted last month, we have added a highly capable and respected Contributing Editor for Naval Affairs. He is Mr. Norman Polmar, who is a member of the editorial staff of "United States Naval Institute Proceedings," the Navy's professional journal. (See page 8 for his first contribution.) Likewise, almost from the beginning, we have had as Contributing Editor for Army Affairs, Mr. John Spore, the editor of "Army Magazine," published by the Association of the U.S. Army. We expect to add a Contributing Editor for business and commercial aviation in the near future. When these talents are combined with those of our own prize-winning editorial staff, a formidable team has been assembled.

Next month we will publish a special report on the U.S. Air Force itself—how it is organized and equipped to perform its many missions. The issue will be packed with useful information.

To begin our third year of publication we are proud to announce a unique publishing event. We have

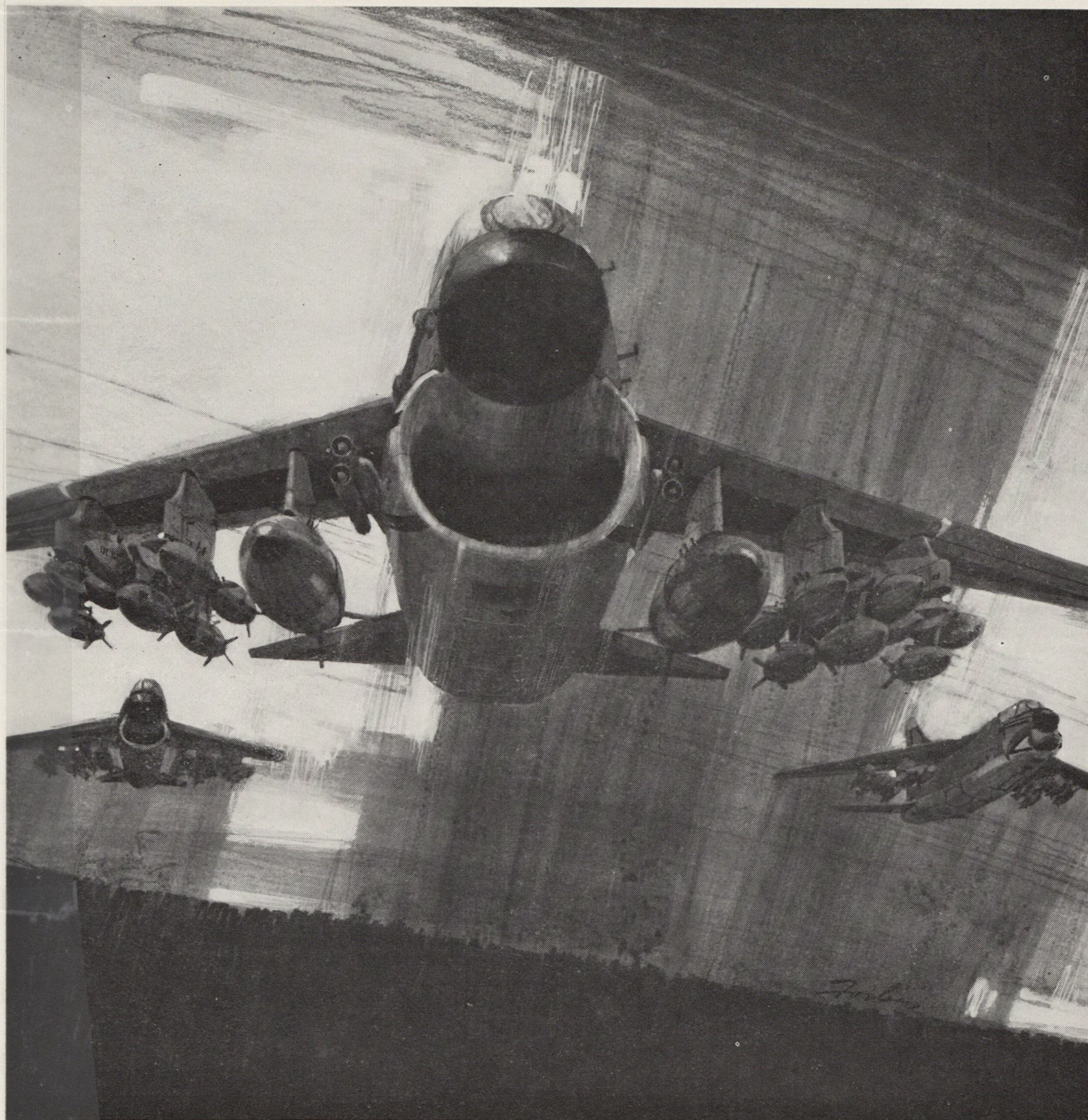
made special arrangements with the Institute of Strategic Studies in London to publish, in magazine form, the complete text of the Institute's annual analysis of the military forces of the world. Entitled "The Military Balance," the study examines the size, organization, and equipment of the armies, navies, and air forces of some 49 countries. Included are the countries of the Warsaw Pact, of NATO, CENTO, SEATO, China, and the major non-aligned nations. This valuable reference work has never before been available on such a widespread basis. We know that you will want to keep your copy near you. Because the report is so complete, we are combining our January and February issues so as to bring you your copy of "The Military Balance" in a single issue of AEROSPACE INTERNATIONAL. It will be distributed early in February of next year. This is one of the "dramatic exceptions" referred to above.

We are highly pleased thus far with the acceptance of our International magazine. Under its new name, AEROSPACE INTERNATIONAL, it will continue to grow in usefulness to you. Our main problem to date has been to restrict distribution to the really influential and qualified readers to whom, for budgetary reasons, circulation must be confined. AEROSPACE INTERNATIONAL is distributed without charge on a carefully controlled basis. Hence it cannot be made available to all who may wish to receive it. But in less than two years, we have expanded from 10,000 readers in 53 nations to more than 12,000 readers in 68 nations. And additional requests come in daily.

In our first literature we promised that every month we would "analyze and interpret U.S. aerospace power in terms of its impact on the Free World community. The audience is the military and civilian policy-makers of the Free World. AF/SD INTERNATIONAL will be edited and written with their special needs and interests in mind...."

Under its new name, AEROSPACE INTERNATIONAL will continue to do just that.

☆☆☆



Here Come the Corsairs!

Again . . . again . . . and again

First one . . . Then three . . . And suddenly a sky full of A-7 Corsair II's streak over the horizon . . . on the deck. They slip swiftly and neatly under radar . . . and SAMs.

The A-7 carries its own weight in bombs, rockets and missiles. Making ground hugging runs at over 500 knots, the Corsair can accurately deliver as much as 15,000 pounds of armament payload . . . twice that of any existing light attack

jet aircraft in its class . . . and at twice the distance.

The A-7 can be over troops for hours . . . on call for devastating close support.

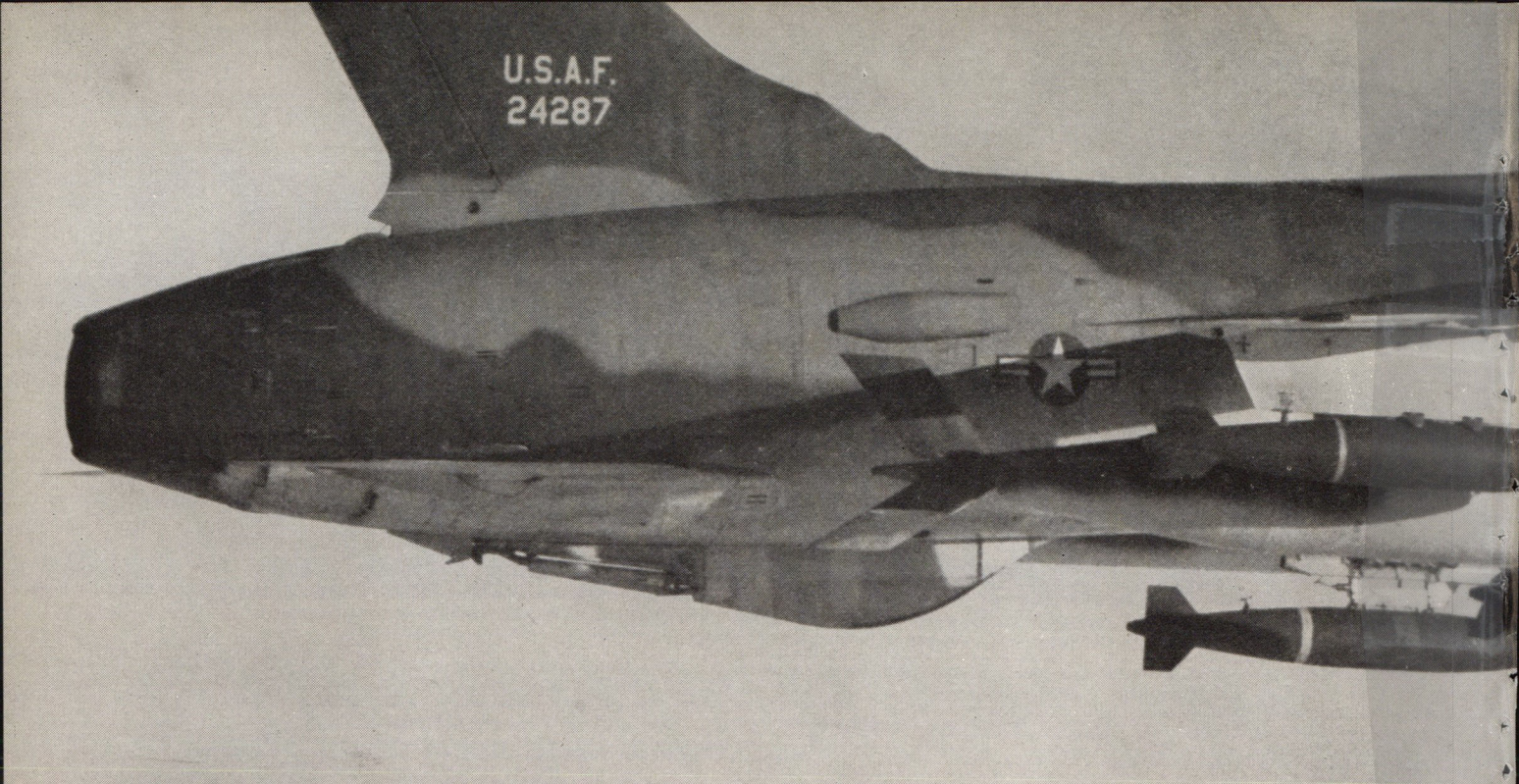
When jumped in its environment the highly maneuverable Corsair is capable of taking care of itself . . . versatile . . . rugged . . . this is the A-7 Corsair II . . . now in quantity production by the LTV Vought Aeronautics Division.

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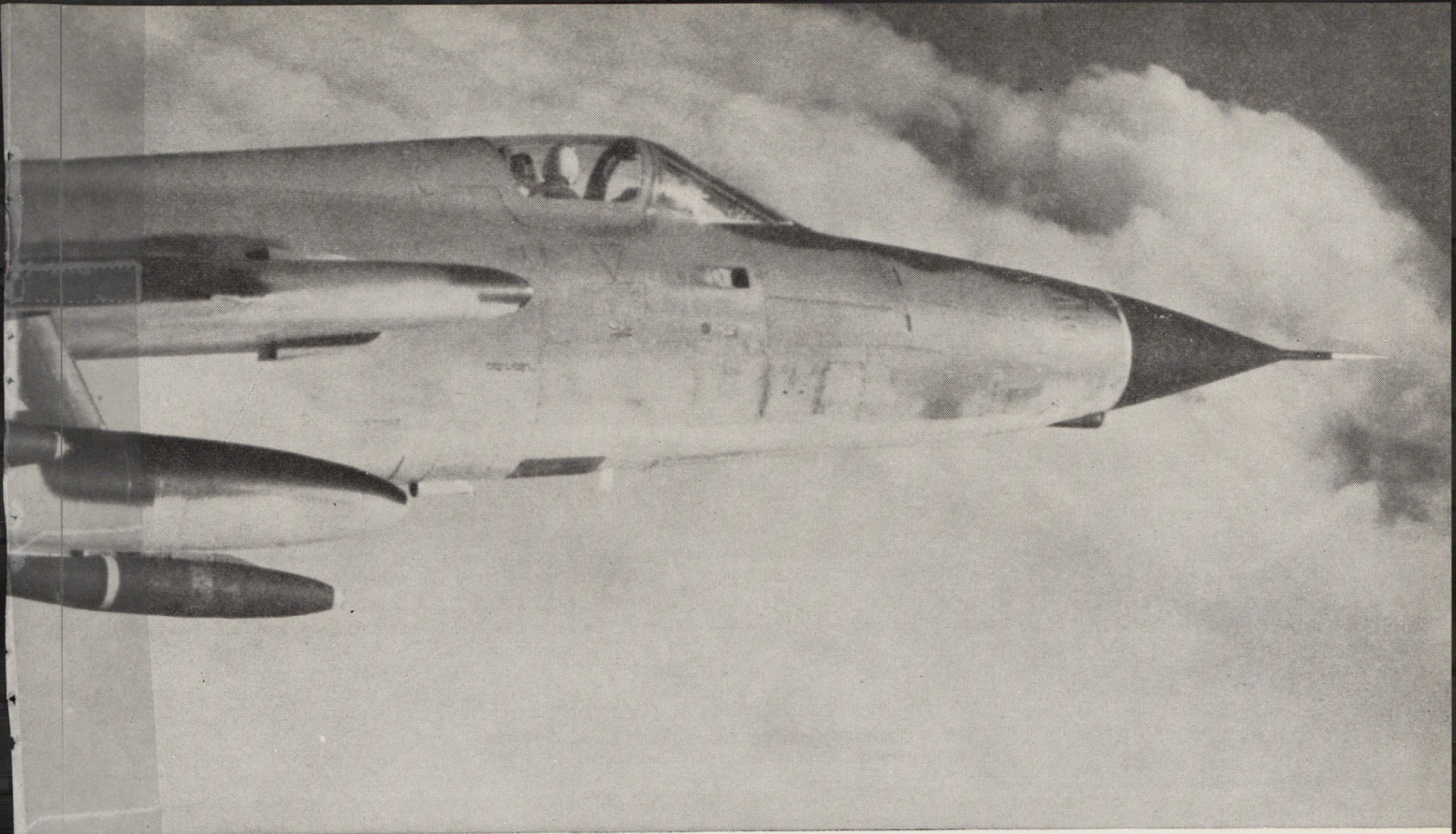
Air Force/Republic F-105—workhorse fighter-bomber in South East Asia.*

Think of a fighter-bomber lighter than the
F-105... with a better payload radius than

THAT WILL TAKE

The people at Republic who created the
thinking about it. We're designing one, as
in the United States/Federal Republic of

*The F-105 has flown more than 75% of the U.S. Air Force strike missions against North Vietnam.



F-105...more maneuverable than the
the F-105...and greater strike capability...

OFF VERTICALLY!

F-105 are doing more than
part of a joint-nation team effort
Germany program.



FAIRCHILD HILLER
REPUBLIC AVIATION DIVISION

Mobility, versatility, flexibility, and long experience in the successful deployment of sea-based airpower as well as the U.S. Marine Corps aviation that operates under U.S. Navy direction are the hallmark of U.S. naval aviation—second in numbers of aircraft only to the U.S. Air Force and the Soviet Air Force. Here is a comprehensive report by a naval specialist on . . .

How Sea-Based Airpower Meets Today's Challenges

BY NORMAN POLMAR

Contributing Editor, Naval Affairs

U.S. naval aviation is a large and unique organization. With a current operating strength of approximately 8,400 aircraft, U.S. naval aviation is larger than any other "air force" except the U.S. Air Force (with 12,400 aircraft) and the Soviet Air Force (with some 10,500 aircraft). In addition to size, U.S. naval aviation has the distinctive characteristics of (1) control, (2) flexibility, (3) versatility, and (4) mobility.

The U.S. Navy has control of U.S. land-based maritime reconnaissance aircraft, fleet logistic aircraft, and naval training planes in addition to ship-based aircraft. At no echelon are naval air commanders responsible to officers outside of their own service except in the unified commands, in which a single officer commands all U.S. forces within a given area. For example, all U.S. forces in Europe—including the Sixth Fleet in the Mediterranean—are in a unified command under an Army general; all U.S. forces in the Pacific are in a unified command headed by a Navy admiral.

Within the generic term of naval aviation is Marine aviation. The U.S. Marine Corps is a separate service under the Secretary of the Navy and is the only marine corps in the world to have its own aviation organization. The employment of Marine air (and ground) units is under Navy direction. Marine combat forces in the Atlantic and Pacific areas operate as "type commands" under the respective Navy fleet commands. That is, the admiral commanding the U.S. Atlantic Fleet is

responsible for the employment of Marine forces in the Atlantic area in the same manner that he is for Atlantic Fleet submarines or destroyers.

This Navy control of all aspects of naval aviation ensures the most potent naval air arm possible and the best possible coordination between naval

and air forces in an era when much of the surface of the earth—dry and wet alike—can be controlled mainly from the air.

Flexibility in naval aviation is personified by the naval aviator himself. All student pilots—Navy and Marine—receive the same basic flight instruc-



For the past two years the U.S. Navy has employed UH-6 Sea Knight helicopters to cut sharply the time needed for transfer of supplies. One is shown here carrying fuel tanks from the USS SACRAMENTO, at right, to the USS HANCOCK off Vietnam.

tion, which includes qualification in carrier operations. Thus, Marine fighters and attack aircraft can operate from regular airfields, special Short Airfields for Tactical Support (SATS) (see page 34), or from aircraft carriers. Navy carrier aircraft can, when the occasion demands, operate from SATS installations.

U.S. naval aircraft have traditionally been developed to possess a maximum degree of versatility, essentially beginning with the famed Grumman F6F Hellcat and Chance-Vought F4U Corsair of World War II. (Both of these planes were among the top performing fighters of the war, and as fighter-bombers could each carry two 1,000-pound [453.5 kg] bombs or a similar weight in rockets and smaller bombs. The F6F could also carry a torpedo. The F4U—which first flew in 1940—was a first-line fighter in the Korean War and as late as 1964 a squadron flew in French colors.)

The Douglas AD (now designated A-1) Skyraider, which first flew in 1945, has flown in 28 variations. Skyraiders still serve a useful purpose in Vietnam, and one of these propeller-driven A-1s even shot down an unwary MIG-17 in an aerial encounter.

The A4D (now A-4) Skyhawk, another Douglas plane, was developed more than a decade ago as the world's smallest plane capable of delivering a nuclear weapon. Today the single-jet Skyhawks are winning laurels over Vietnam in the close-support and

general-attack roles. The Navy-McDonnell F-4 Phantom II (see page 17) is the best operational fighter in the U. S. arsenal today, being employed as a fighter, reconnaissance plane, and attack aircraft (in the last role capable of carrying more than twice the bomb load of a World War II-era B-17 Flying Fortress).

Versatility is a key characteristic of the Navy's aircraft carriers as well as aircraft. Carriers which in World War II launched strikes against the Imperial Japanese Fleet are now sending strikes against the Viet Cong and North Vietnam. The speed of their fighters has increased from 375 to 1,120 miles per hour (604 to 1,802 km/hr) and the weight of their bombers from 9,000 pounds to 70,000 pounds (4,082 to 31,751 kg), but the ships are holding their own in operations with the Navy's newest carriers in the South China Sea.

Coupled closely with this versatility of naval aviation is mobility. Naval aviation is unique in that its bases can move across the seas, taking with them runways, fuel, munitions, spare parts, machine shops, maintenance personnel, and living quarters for pilots and aircrewmembers.

Obviously, any combat aircraft can travel faster than an aircraft carrier with her "cruising" speed of about 26 knots. The aircraft carrier and her air wing can move 700 miles (1,127 km) in a single day compared to a plane's ability to cover that distance in an

hour. But when the carrier arrives in the trouble area, her aircraft and pilots are rested and ready to fly. They can take off as soon as the carrier arrives within range of the target area, or the planes and men can stand waiting on deck, observing at relatively close range, the changing military situation.

These attributes of control, flexibility, versatility, and mobility combine to make U.S. naval aviation a viable and powerful military force.

Naval aviation's striking power consists of attack-carrier air wings, anti-submarine air groups, patrol squadrons, and Marine aircraft wings.

Attack Carrier Air Wings

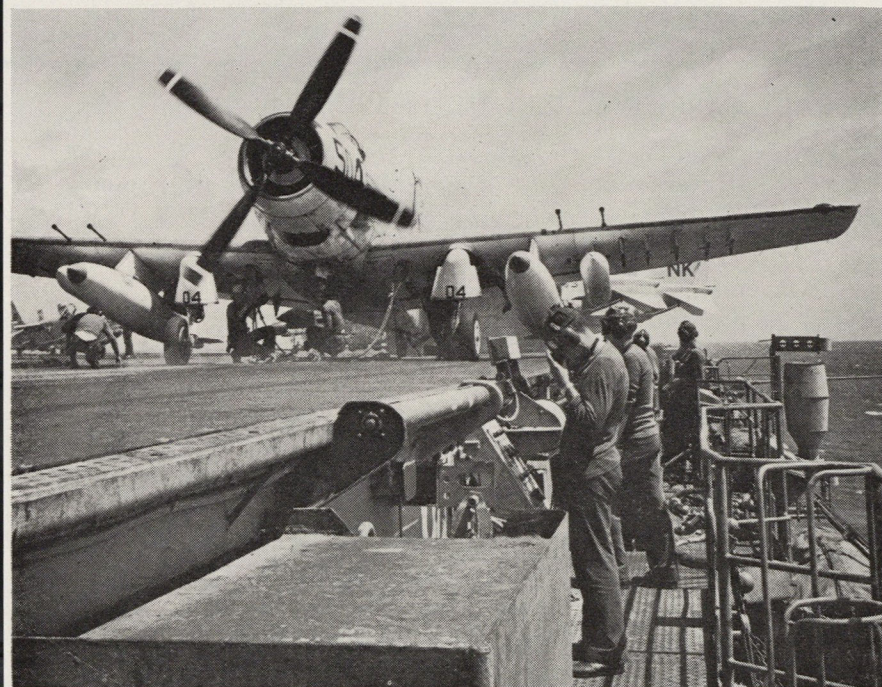
The attack carrier air wing is a balanced force of fighters, attack planes, and special-mission aircraft. Within the wing is the capability to gain control of the air and strike at any kind of surface target with 20-mm cannon fire, thermonuclear weapons, or any ordnance in between. The U.S. Navy currently operates 15 carrier air wings with one assigned to each of the Fleet's 15 operational attack or strike carriers. (The term "wing" was substituted for "group" in December 1963 to better equate Navy and Air Force tactical striking power.)

Carrier air wings vary in size from 70 to 90 aircraft, depending upon the class of carrier in which embarked. For example, a FORRESTAL-class carrier (see table on page 10) may have two 12-plane fighter squadrons flying McDonnell F-4B Phantoms, two 14-plane attack squadrons with Douglas A-4 Skyhawks, an attack squadron with nine Grumman A-6A Intruders, and a reconnaissance-attack squadron with six North American RA-5C Vigilantes.

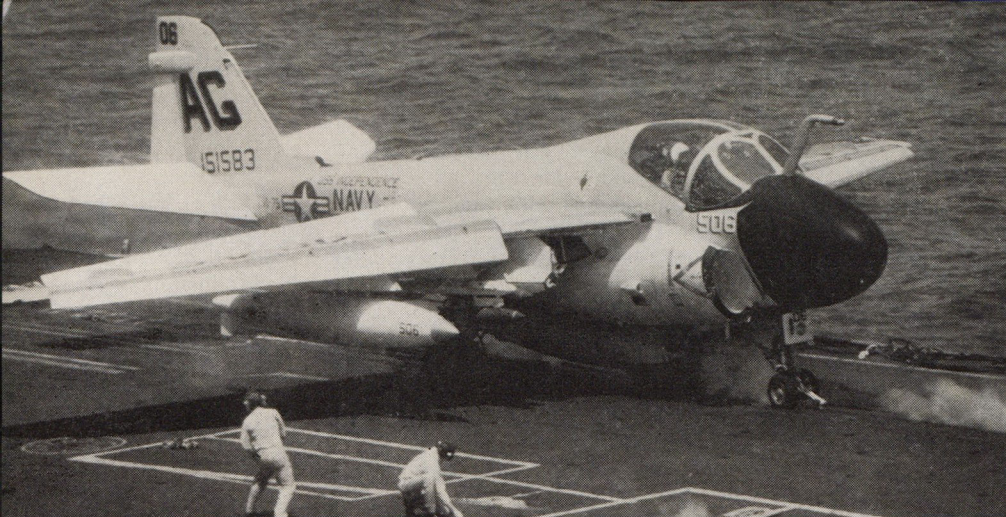
The F-4 Phantoms, which are also going aboard British carriers in the F-4K variant, are twin-jet, Mach 2+ aircraft, with the primary mission of air superiority. But they are equally capable of long-range escort and ground-attack missions. In the latter role they can still carry air-to-air missiles while loaded with bombs, air-to-ground missiles, or rockets for a maximum weapons load of 13,320 pounds (6,042 kg).

The small A-4 single-place, single-jet Skyhawks are used mainly for visual attack missions, having a limited all-weather/night capability. The larger Grumman A-6 Intruders (two-place, twin-engine) are equipped with a complex electronics system for all-weather, day/night, high- or low-level attack.

Multisensor reconnaissance requirements on the Navy's larger carriers are fulfilled by the big 70,000-pound (Continued on following page)



The A-1 propeller-driven aircraft, here being prepared for launch by the catapult crew of the USS CONSTELLATION, is one of 28 versions of the Douglas Aircraft Company's Skyraiders, which first flew in 1945 and is still performing capably in Southeast Asia.



Equipped with a complex electronics system for all-weather, day/night, high- or low-level attack, the two-place, twin-engine A-6 Intruder, built by the Grumman Aircraft Engineering Corporation, is now going aboard the U. S. Navy's larger aircraft carriers.

(31,751 kg) North American Vigilante. The RA-5C version now in the Fleet is equipped for electronic, infrared, and photographic reconnaissance, and is capable of speeds in excess of Mach 2.

There is also a three- or four-plane detachment of twin-turboprop Grumman E-2A Hawkeye early-warning aircraft and three Kaman UH-2 utility helicopters on each FORRESTAL-class carrier.

ESSEX-Class Carriers

The smaller ESSEX-class carriers have fewer and generally smaller aircraft. The fighters aboard this class are Ling-Temco-Vought F-8D or F-8E Crusaders, in lieu of Phantoms. There are two squadrons of A-4 Skyhawks, but the third attack squadron in an ESSEX-class ship flies the propeller-

driven A-1 Skyraiders instead of the twin-jet Intruder now going aboard the larger carriers. Carriers of the ESSEX class and some of the larger carriers operating in the Western Pacific frequently carry a four-plane detachment of Douglas A-3B Skywarrior heavy attack planes. These twin-jet bombers, weighing up to 84,000 pounds (38,100 kg) at takeoff, are used in the strike, pathfinder, and aerial-tanker roles.

Three RF-8G Photo Crusaders perform the photo-reconnaissance missions for the ESSEX-class carriers, in lieu of the larger Vigilantes, and the older Grumman E-1B Tracers (two piston engines) are used for airborne early warning. Utility and plane-guard helicopters are also assigned to these ships.

Thus, these air wings are heavily weighted in favor of attack, with three

to five attack squadrons embarked, compared to two fighter squadrons. And both the Phantoms and Crusaders of the fighter squadrons can be employed in the attack role. This loading balance reflects the Navy's efforts to make the aircraft carrier a major part of the nation's nuclear striking force in the post-Korean period and the lack of major enemy air opposition in the limited-war conflicts since the Korean War.

Although not a part of the air wing, an electronic countermeasures reconnaissance version of the Skywarrior (EA-3B) sometimes comes to roost on carriers in the Mediterranean and Western Pacific. Based at Rota, Spain, and Atsugi, Japan, two fleet air-reconnaissance squadrons use these planes to keep an electronic eye on the edges of the Communist world.

Each attack carrier normally has at least one twin-engine cargo plane (Grumman C-1A Trader or Grumman C-2A Greyhound) for flying personnel, mail, and high-priority parts between carriers and shore bases. These planes are known familiarly as CODs—an acronym for Carrier Onboard Delivery.

ASW Air Groups

The Navy's eight antisubmarine air groups are all assigned to ESSEX-class carriers which serve as the nuclei for highly mobile hunter-killer groups. Each ASW air group has two fixed-wing squadrons flying a total of 20 Grumman S-2 Tracker aircraft and a helicopter squadron with 16 Sikorsky

(Continued on page 13)

U.S. AIRCRAFT CARRIER STRENGTH, 1966

Number of Ships in Class	Class	Full-load Displacement	Over-all Length	Speed (knots)
1	CVAN <i>Enterprise</i>	86,000 tons (78,000 mt)	1,123 feet (342 m)	30
7	CVA <i>Forrestal</i>	approx. 78,000 tons (70,800 mt)	approx. 1,047 feet (319 m)	34
3	CVA <i>Midway</i>	approx. 63,000 tons (57,200 mt)	979 feet (298 m)	33
5	CVA <i>Essex/Hancock</i>	approx. 42,600 tons (38,600 mt)	approx. 899 feet (274 m)	33
9	CVS <i>Essex/Hancock</i>	approx. 42,000 tons (38,100 mt)	approx. 899 feet (274 m)	33
3	LPH <i>Essex</i>	38,000 tons (34,500 mt)	888 feet (271 m)	33
5	LPH <i>Iwo Jima</i>	18,000 tons (16,300 mt)	592 feet (180 m)	20

CVAN—nuclear-powered attack carrier; CVA—attack carrier; CVS—ASW support carrier; LPH—helicopter carrier (amphibious assault ship); one Midway-class carrier is now in the yard undergoing a three-year modernization; in addition to the class totals above, one improved Forrestal-class and one Iwo Jima-class carrier are currently under construction; plans call for three additional nuclear-powered attack carriers by mid-1970s.



The new Douglas A-4F: all Skyhawk.

What is new? A lot is new about the Douglas A-4F, latest in the proud line of combat-proved Skyhawk attack fighters. Its new P&W J52-P8A engine develops 9,300 pounds of thrust for improved short field take-offs and for greater load-carrying ability. A new, steerable nose wheel improves ground maneuvering and deck handling. New wing lift spoilers give better performance in

crosswind landings. New, too, are its updated avionics, and its standard, zero-zero Escapac ejection seat. Best of all, the new A-4F is all Skyhawk: multi-mission versatility, fast re-arming and turn-around time, simple maintenance needs, and a cost/effectiveness unequaled by any airplane in its class.

DOUGLAS

AIRCRAFT DIVISION
Long Beach, California, U.S.A.

C-141 STARLIFTER

LARGEST OPERATIONAL FANJET AIRLIFTER IN THE WORLD



The C-141 StarLifter is a plane of many missions. Heavy airdrops. High speed casualty evacuation. Strategic personnel and cargo airlift. It is easily maintained, quickly deployed, and able to react rapidly to nearly any mission requirement.



The C-141 StarLifter has already been successfully tested—and proven—in a long, arduous program. Now in military service, it offers a short takeoff and landing capability, excellent slow speed handling characteristics, optimum high altitude performance, and on-board emergency ground power.



The C-141 StarLifter is just one of a family of famous airlifters designed and developed by Lockheed-Georgia—the versatile C-130 Hercules; the utility personnel and cargo C-140 JetStar transport; and tomorrow's giant C-5A, the largest plane in the world.

LOCKHEED

LOCKHEED-GEORGIA COMPANY, MARIETTA, GEORGIA, U.S.A.
A DIVISION OF LOCKHEED AIRCRAFT CORPORATION

SH-3As. The twin-engine Trackers provide a long-range search and attack capability. The Tracker's equipment includes magnetic anomaly detection (MAD) and electronic countermeasures (ECM) equipment, passive acoustic search (Jezebel) and active echo ranging (Julie) devices, radars, wing-mounted searchlight, parachute flares, and an internal bomb bay and wing stations for rockets, depth bombs, and homing torpedoes.

The inability of fixed-wing aircraft to remain in one spot brings into focus the value of the SH-3A helicopters which, although they are slower and have shorter ranges than the Trackers, can hover over the water to lower a sonar head into the depths. These twin-turboprop helicopters can hover on automatic control and are armed with homing torpedoes. (Both the Tracker and the SH-3A Sea King can carry nuclear depth charges.)

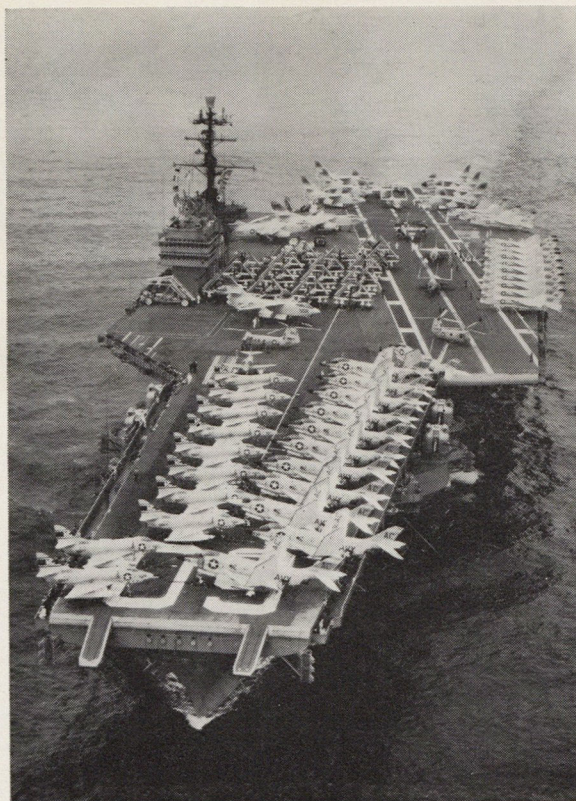
All-Weather Capability

Both the S-2 Tracker and Sea King are day/night, all-weather aircraft. They are complemented aboard the ASW carriers by an airborne early-warning detachment flying four E-1B Tracers and a COD cargo plane. As additional Kaman UH-2 helicopters become available, two are scheduled to go aboard each ASW carrier for utility work.

The ASW carriers operating in the Western Pacific are also assigned four A-4 Skyhawks armed with two 20-mm cannon and Sidewinder air-to-air missiles. These fast (647 mph/1,041 km/hr for the A-4C) light attack planes thus provide a limited air-defense capability for the ASW carriers.

The absence of air and submarine opposition to U.S. Navy forces in the Vietnamese War has allowed the ASW carrier planes to fly other missions. Their A-4 Skyhawks—some flown by Marine pilots—have operated from nearby attack carriers for brief periods to fly strikes against the Viet Cong. Similarly, the SH-3A Sea King helicopters have been employed in search-and-rescue missions. The SH-3As are not normally armed except for ASW weapons, but on search-and-rescue missions each helicopter is fitted with two flexible 7.62-mm machine guns. Special armor plating has also been installed, and sonar equipment is temporarily removed to reduce the gross weight and enable the helicopters to hover in mountainous areas or under high-density altitude conditions.

The versatility of these ASW carriers, which cannot operate the Fleet's newer fighters or attack aircraft, is now being demonstrated in the South China Sea where the ASW carrier INTREPID is operating as a "limited



The USS SARATOGA is representative of the FORRESTAL-class of aircraft carriers, which may have two 12-plane fighter squadrons flying McDonnell F-4B Phantoms, two 14-plane attack squadrons with Douglas A-4 Skyhawks, an attack squadron with nine Grumman A-6A Intruders, and a reconnaissance-attack squadron with six North American RA-5C Vigilantes.

attack carrier." She offloaded her ASW aircraft and, with only minor changes, she is now supporting flying missions over North and South Vietnam with two squadrons of A-4 Skyhawks and two of A-1 Skyraiders.

Patrol Squadrons

Shore-based maritime patrol/ASW aircraft are larger than carrier-based aircraft and consequently can remain aloft longer and travel further than the Trackers and Sea Kings. These land- and sea-based planes are also roomier and more comfortable than the carrier planes, both important factors in long maritime patrols. But they are dependent upon suitable bases, are more expensive, and must travel further to reach their patrol areas. Here again, the mobility of the ASW carrier places the base closer to the patrol area, greatly reducing the number of aircraft required to cover a given area.

Still, because land-based patrol aircraft are very cost/effective when operating within certain distances from their bases, the U.S. Navy maintains 30 patrol squadrons—27 flying Lockheed P-2H Neptune or P-3A Orion land planes and three with Martin P-5B Marlin flying boats. About half of the land squadrons now have the four-engine, turboprop Orion (Navy version of the Electra commercial airliner). Eventually, the Orions will replace both the Neptunes (powered by two piston

engines with two auxiliary turbojets) and Marlins (with two piston engines and single-jet booster). The Orion's capabilities and costs are far above the older planes' and will thus replace them at a rate of nine Orions for 12 of the others in each squadron.

All three patrol planes have extensive submarine-detection equipment and can carry bombs, rockets, depth charges, and torpedoes. The Orions now coming off the production line are being fitted to carry up to four Bullpup air-to-surface missiles. No guns are normally mounted in the patrol planes; the Marlin flying boats, however, which have been patrolling South Vietnam's coastline in search of craft carrying supplies to the Viet Cong, have been armed with 7.62-mm machine guns.

Marine Aircraft Wings

The fourth segment of naval aviation's striking power are the Marine aircraft wings. One wing is normally assigned to support each Marine division. There have been three active wings working with the three active divisions since the Korean War. A fourth Marine division was activated this summer, but to date no plans have been announced to form a supporting aircraft wing, although some squadrons will work with the division.

Each of these aircraft wings nor-

(Continued on following page)

mally includes some 15 to 20 aircraft squadrons to provide all types of aerial support required by Marine ground forces. Marine aviation now has an aggregate strength of 15 fighter and fighter/attack squadrons, 12 attack squadrons, three composite reconnaissance squadrons, four observation squadrons, 18 helicopter transport squadrons, and three refueling/transport squadrons. These 55 units fly some 1,200 aircraft, about 15 percent of the naval aircraft inventory.

Marine fighter squadrons fly either 15 F-4B Phantoms or a similar number of F-8E Crusaders, with the former squadrons being designated fighter/attack squadrons. The Phantoms predominate and will replace the Crusaders completely within the next couple of years. Marine attack squadrons fly either A-4 Skyhawks (20 aircraft) or A-6A Intruders (12 aircraft), with the older plane filling the majority of the units. All of these aircraft are, of course, capable of carrier operations.

Spotter Aircraft

Each observation squadron has recently been equipped with 24 Bell UH-1E helicopters, replacing Cessna O-1B and O-1C fixed-wing aircraft and the Kaman OH-43D helicopter. The UH-1Es may be supplemented by the North American OV-10A LARA counterinsurgency aircraft, which is now under development. The Marine reconnaissance squadrons fly RF-4B Phantoms and EF-10B Skyknights. The latter (formerly designated F3D-2Q) are two-place Douglas aircraft used for electronic countermeasures and reconnaissance work. They are being replaced by an ECM version of the A-6 Intruder attack plane.

Three refueling/transport squadrons in the Marine aircraft wings fly the Lockheed C-130F Hercules. This four-engine turboprop plane is used as both transport and aerial tanker, in the latter role being equipped with external fuel tanks and pods containing drogue hose reels.

While not a carrier aircraft, during recent tests a Navy-manned C-130 successfully landed and took off from the aircraft carrier FORRESTAL. These tests were conducted without special equipment or an arresting hook being fitted to the C-130.

Each Marine aircraft wing also has a couple of Douglas C-47 "Gooney Bird" and C-54 transports for logistics, administrative, and utility work.

The 18 existing Marine helicopter squadrons are being reequipped with Boeing CH-46 and Sikorsky CH-53 helicopters capable of carrying up to 17 and 33 troops, respectively. Their



A Marine Corps F-4 begins its takeoff run on the CEI-3 aircraft catapult, part of the SATS (Short Airfields for Tactical Support) program now in service at the Chu Lai Air Base in Vietnam. The system was developed by All American Engineering Company. For more on the SATS system, see the article beginning on page 34 of this issue.

cargo capacities, at a range of about 225 miles (362 km), are 4,000 and 8,000 pounds (1,814 and 3,629 kg), respectively. Previously these squadrons flew Sikorsky UH-34 and CH-37 helicopters. Some new Marine helicopter squadrons are being formed.

Marine helicopter squadrons operate with combat troops ashore and regularly go aboard the Navy's helicopter carriers. They are not, however, integral parts of the Marine divisions in the manner that U.S. Army divisions—notably the 1st Cavalry Division (Airmobile)—have helicopters within their normal tables of organization.

A helicopter carrier can operate up to a full squadron of 20 to 24 medium cargo helicopters (UH-34 or CH-46), plus a few heavy helicopters and observation aircraft. These ships provide another aspect of naval aviation's versatility by being able to operate ASW helicopters with a minimum of preparation. (They lack the catapults, arresting wires, and, in the case of the newer, built-for-the-purpose ships, the speed to operate fixed-wing aircraft.)

Detachments of Marine helicopters are also temporarily assigned to the smaller amphibious transport docks and dock-landing ships, both types having space for six medium helicopters. Operating in amphibious squadrons with tank landing ships and attack cargo ships, these smaller helicopter-carrying ships provide even battalion-size landing teams with the capability of landing on an alien shore by helicopter, landing craft, or tracked vehicle, or any combination of these, depending upon the geographical and tactical situations.

Support Aircraft

Backing up this Navy-Marine Corps striking power are a variety of Navy fixed-wing and helicopter support squadrons. Five Fleet tactical-support

squadrons provide worldwide transport service for personnel and high-priority equipment in support of the Fleet. Four of these squadrons, operating from bases on the U.S. East and West Coasts, Hawaii, Japan, Spain, and Italy, fly some 80 aircraft, mostly the four-engine C-130F Hercules. The fifth squadron controls about 35 C-1A/C-2A cargo planes, which perform COD chores aboard carriers and at advanced bases.

At this writing, three Navy-manned transport squadrons are in the Military Airlift Command, which provides airlift for all U.S. services. During the first half of 1967 the three squadrons will disband and their 48 C-130s will go to the Air Force.

Returning to naval aviation support squadrons, there are nine Fleet composite squadrons which perform a myriad of services for the Fleet. These missions range from target towing to training controllers and technicians to operate unmanned drone antisubmarine helicopters (DASH) aboard destroyer-type ships.

Helicopters

Three large helicopter combat support squadrons provide helicopters to the Fleet: the Kaman UH-2 Seasprites to amphibious ships, cruisers, and carriers for rescue and utility work; Boeing UH-46A Sea Knights to replenishment ships for carrying cargo; UH-2s, Sikorsky H-19s, and small Bell H-13s to icebreakers; and Sikorsky RH-3A Sea King helicopters, which are especially fitted for minesweeping, to the mine forces.

Three Navy air development squadrons test new weapons and help develop tactics for the Navy and Marine Corps. These also fly a number of different aircraft types, some old and some new, and periodically some which the Navy does not even own or

want to own (e.g., three Lockheed F-104 Starfighters were flown by the Navy to test the Sidewinder air-to-air missile).

A fourth air development squadron services U.S. operations in the Antarctic, flying from bases in the frozen continent and from Christchurch, New Zealand. This unit's equipment includes helicopters and fixed-wing aircraft which range in size from single-engine de Havilland U-1 Otters to four-engine, ski-fitted Lockheed LC-130F Hercules.

A few additional naval flying units provide services to the Fleet: The Naval Air Test Center at Patuxent River, Maryland, tests new aircraft for the Fleet, both ashore and aboard carriers; a Marine helicopter development squadron at Quantico, Virginia, tries out new vertical assault tactics and equipment; and an oceanographic air survey unit, also based at Patuxent River, flies four instrument-packed Lockheed NC-121K Super Constellations and a Douglas NC-54K Skymaster as part of the Navy's continuing quest for data about the seas.

Beyond these Fleet and support aviation units, there is a large naval training establishment with 40-odd squadrons capable of teaching novices to fly or preparing an experienced pilot for the latest model of Fleet aircraft.

Direction

The Joint Chiefs of Staff are responsible for the employment of U.S. military forces, including naval aviation. The Navy and Marine representatives on the JCS, the Chief of Naval Operations, and the Commandant of the Marine Corps, respectively, are responsible for organization, personnel, training, equipment, and support of naval aviation.

Their "senior aviators" are the Deputy Chief of Naval Operations (Air) and Deputy Chief of Staff (Air). The post of DCNO (Air) was established in 1943 to direct and coordinate all naval aviation matters at the Navy

planning and policy-making level. The current DCNO (Air) is Vice Admiral Thomas F. Connolly.

The senior aviation post at Marine Corps Headquarters began as Officer-in-Charge, Aviation, in 1919 and has progressed to the current Deputy Chief of Staff (Air). Because Marine air and ground forces are considered "type commands" within the Navy's fleet structure, the DCS (Air) also holds the positions of Head, Marine Aviation Division, and Assistant Chief of Naval Operations (Marine Aviation) within the DCNO (Air) organization. The Marine Aviation Division coordinates management and planning of Marine aviation "to ensure that Marine aviation is developed in concert with the over-all Naval Aviation Program." As the ACNO (Marine Aviation), the senior Marine aviator acts as direct liaison between the Chief of Naval Operations and the Commandant of the Marine Corps. Major General Keith McCutcheon is the current holder of these three posts—DCS (Air), ACNO (Marine Aviation), and Head, Marine Aviation Division in DCNO (Air).

On the operational level, essentially all U.S. Navy forces are assigned to either the Atlantic Fleet or Pacific Fleet. The "type commands" within each fleet include a Commander, Naval Air Force, and a Commander, Fleet Marine Force. These type commanders have administrative control of all air units in the Atlantic or Pacific areas, and prescribe or recommend organization, training, personnel, and equipment complements; inspection standards; and other administrative matters. Also, the Commander, Naval Air Force, has administrative control of the aviation ships—carriers and seaplane tenders—within his fleet.

This administrative control of the type commanders is distinct from the operational control of the tactical commanders. While a ship or squadron remains within a given type command wherever it operates, there is a tactical commander who directs its operations. For example, the U.S. Fleet in the Mediterranean Sea is designated

the Sixth Fleet. The Sixth Fleet is a tactical command which includes several task forces, among them TF 60, the Attack Carrier Force with two attack carriers and some 160 aircraft; TF 62, a Marine battalion landing team with its own helicopters embarked in amphibious ships; and TF 67, a patrol-plane squadron which normally operates from the island of Sicily. Periodically, a hunter-killer group built around an ASW carrier and her squadrons operates in the Mediterranean as TF 66. All of these aviation units—at times three carriers and some 250 aircraft—are under the operational control of Commander, Sixth Fleet, but remain under the administrative control of Commander, Naval Air Force Atlantic.

Material Support

Material support for naval aviation—Navy and Marine components alike—is provided by the Naval Material Command. This organization, under the Chief of Naval Operations, has six systems commands: air, ship, electronic, ordnance, supply, and facilities engineering. These systems commands (reorganized in March of 1966 from four material "bureaus") are responsible for the research, test, evaluation, development, design, procurement, and modification of material within their respective purviews. They are equally responsive to Navy and Marine Corps requirements, with officers from the latter service assigned to those systems commands which provide direct support to Marine aviation.

In general, the Marines use aircraft developed for the Navy. However, this does not prevent the Marines from obtaining aircraft which are beyond the Navy's interest, as evidenced by the procurement of aircraft such as the Cessna O-1 observation plane, the Sikorsky CH-53 helicopter, and (before Navy acquisition) the C-130 transport. The Marines have almost always accepted Navy carrier-type fighter, attack, and reconnaissance aircraft, in part because of the mission of Marine aviation:

"To participate as the supporting air component of the Fleet Marine Forces in the seizure and defense of advanced naval bases and for the conduct of such land operations as may be essential to the prosecution of a naval campaign; and, as a collateral function, to participate as an integral component of naval aviation in the execution of such other Navy functions as the Fleet Commanders so direct."

These concepts of control, flexibility, versatility, and mobility have made the U.S. Navy's aviation units a powerful air force and a vital component of U.S. seapower. ☆☆☆



A variety of helicopter support squadrons back up the Navy-Marine Corps striking power, including three large combat-support squadrons serving the Fleet.

It is not always easy to say what was done "right" when a successful aircraft is built. This is the case with the McDonnell F-4, which began as a proposal to the U.S. Navy and has been changed and improved on the drawing board and on the assembly line until, today, it is a multimission aircraft used—and highly praised—by both the Navy and USAF. And the F-4's future is bright. The addition of advanced engines, the use of more titanium, and variable-sweep wings could make the Phantom a top performer into the 1980s . . .

How the Phantom II Got That Way

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

Winston Churchill once wrote, "No one can guarantee success in war." He contended that all one can do is work hard enough to deserve it.

High-performance airplane designers, perhaps even more than soldiers, must live with this harsh truth. Hard work, perseverance, and technical brilliance are not uncommon virtues among designers, and if these were enough to ensure a winner, the aircraft business would be quite different than it is. Most new aircraft could be expected to set records in performance and in the hearts and pocketbooks of their operators. They all would be produced in the thousands, and each would leave a big mark on more than two decades of flight.

But history shows that the probability of producing such an outstanding airplane is quite low. It hasn't been done very often, even by the best designers.

Consequently, any airplane that moves into this "highly successful" class becomes intensely interesting. The inevitable questions are: "How did it get there?" and "What makes the aircraft so attractive?"

These are complex questions with dozens of possible answers, and it is not facetious to say that the manufacturer of a "highly successful" airplane spends as much time as do his competitors in trying to nail down the exact answers.

F-4: Most Successful Jet Ever?

The F-4 Phantom II, built by McDonnell Aircraft Corporation, is the latest of the "highly successful" airplanes. The F-4 deserves an especially close review because it could become the

most versatile and widely used jet fighter to date. And there is a possibility of its becoming the most successful jet-powered airplane ever, in terms of numbers built and length of service.

Just one statistic is sufficient to establish the F-4 as a "highly successful" airplane and as a contender for the title of the most successful jet-powered airplane in history. This is the number of aircraft produced and planned for production.

Piecing together data from the U.S. military services and from Great Britain, it is clear that the total production run now planned for Phantom IIs is approaching the 4,000-aircraft mark. Around 1,500 already have been delivered, and more than 2,000 still are on order. Production today is proceeding at the rate of about 50 per month and could apparently be increased by the same amount.

The U.S. Navy, which gave birth to

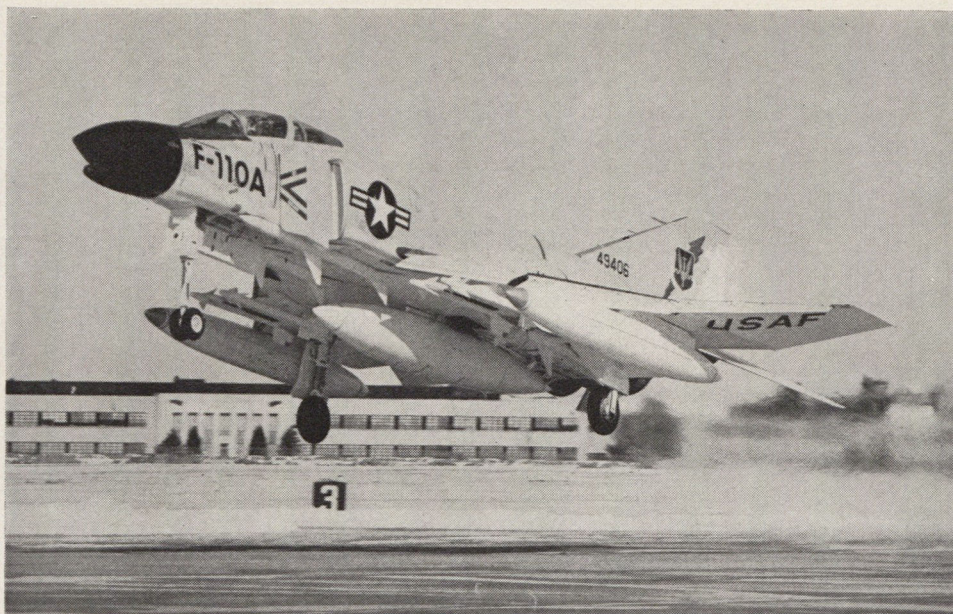
the airplane, paid the larger share of its development, and began to operate it in squadron service in 1960, plans to purchase a total of more than 1,000. The U.S. Air Force, which selected the F-4 for the Tactical Air Command about three years ago, already has taken delivery on several hundred and now schedules a total buy of more than 2,000—a total at least twice the Navy's.

The Royal Navy and Royal Air Force, according to the authoritative British magazine "Flight," will purchase 290 Phantom IIs, the first of which will be the 2,534th off McDonnell's line in St. Louis, Missouri. It is due to roll out on October 1, 1967.

The total dollar figure for the F-4 program is scarcely less impressive than the production run. Today, a brand-new F-4, equipped with the U.S. Air Force avionics package and four Raytheon Sparrow III missiles, costs between \$1,700,000 and \$1,800,000. On



USAF guard and his sentry dog companion watch a Phantom II land in Vietnam. The Phantom II is compiling an excellent record in Southeast Asia as it did during peacetime operations in the U.S.



The Phantom II is one of the best short-field aircraft in service today due to its original design as a carrier fighter. It has a boundary-layer control system that blows air over the leading and trailing edges of the wing to increase lift. A high amount of excess thrust at low speeds shortens the takeoff distance. Shown left is the first USAF version, then designated F-110.

this basis a production run of 4,000 would be worth at least \$7,000,000,000—maybe more.

To put these numbers in perspective, North American Aviation's F-86 has been the most numerous jet fighter in USAF service to date. More than 6,200 were produced (and this did not include the FJs for the U.S. Navy). Dollar value of this fleet was a good bit less than that scheduled to be spent on the F-4, because the average F-86 sold for less than \$1,000,000.

One of the larger Century-series fighter production runs was for North American Aviation's F-100. Nearly 2,300 were produced.

A total of 742 Boeing Company B-52 bombers were manufactured at an average cost of approximately \$8,000,000 each. This production run totaled about \$6,000,000,000.

To date, Boeing has produced, or has orders to deliver, about 1,250 707, 727, and 737 transports at an average price of around \$5,000,000 each. The total value of this transport fleet is less than that of the F-4 force contemplated.

Obviously, the F-4 already has carved itself a broad niche in aviation history. However, there is a high probability that the airplane has just begun to roll and that many more orders will be received.

The Phantom II and other established Mach 2 to 2.5 aircraft, such as Lockheed Aircraft Corporation's F-104, have an unusual technical advantage not enjoyed by fighters of the past. That is, they are not going to be slower than the next generation of Navy carrier-based and Tactical Air Command fighters. Technology will not

allow a Mach 3 to Mach 4 fighter with adequate range and load-carrying ability to be built under 110,000 pounds (49,900 kg) or so. Such an aircraft would require a totally new heat-resistant structure and subsystems. Its configuration would be poor for short landings and takeoffs and during low and slow weapons delivery.

Next Generation of Fighters

The new generation of fighters that the U.S. Air Force and Navy are looking at most closely today are called the FX and VFAX, respectively. Apparently these aircraft will have a top speed of less than Mach 2.5 to avoid excessive high-temperature problems, will weigh around 50,000 pounds (22,680 kg), and will be about the size of the F-4, or maybe smaller. Technology offers three excellent opportunities for making these aircraft substantially better performers than anything now flying. Giving the FX and VFAX twice the range and payload capability of the current F-4s is a distinct possibility.

One of the opportunities is the variable-sweep wing. Top technical people in both the U.S. Air Force and Navy appear to be convinced that the technology of the variable-sweep wing is firmly established. It is considered to pay off well if one is designing a multimission airplane and not concentrating on a single task, such as a point-defense interceptor.

The second opportunity is to reduce structural weight by replacing aluminum with titanium. Using a heavy percentage of titanium in the load-bearing structure will pay off handsomely in a

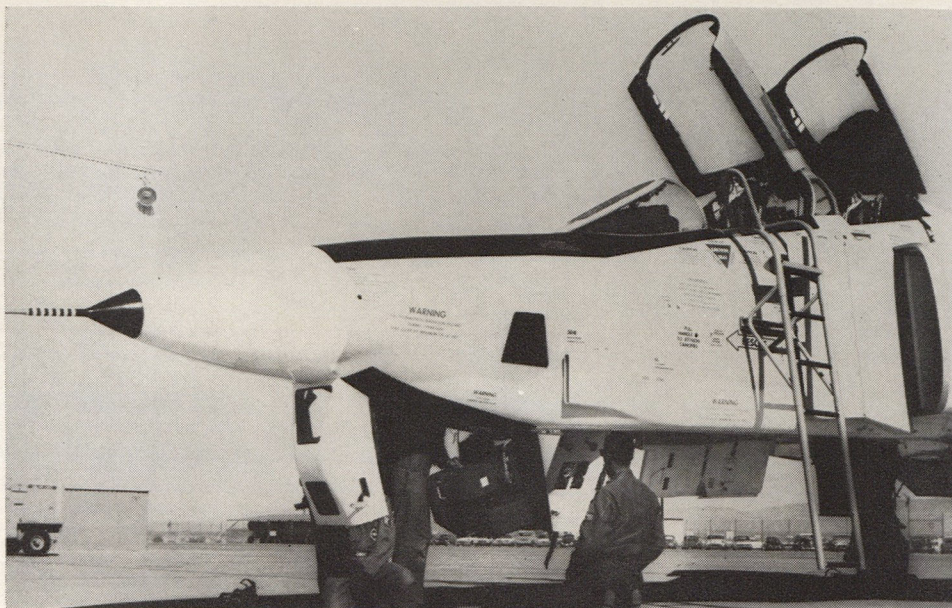
reduction in structural weight percentage for tactical fighters designed for high maneuver "G" limits. The reduced dead weight improves just about every performance parameter—range, payload, acceleration characteristics, climb, etc. About seven and one-half percent of the F-4's structural weight today is titanium. Studies show that further weight savings would be achieved if 60 percent of its structure were switched from aluminum to titanium. A higher percentage of titanium weight might not be worthwhile, except to improve durability, for there is strong evidence that titanium airplanes will last longer than aluminum ones.

The third opportunity is perhaps the most important. New gas-turbine powerplants with about twice the thrust-to-weight ratio and half the specific fuel consumption of current operational engines are in the advanced stages of development. If these engines were the only new technology available, a new generation of fighters would be warranted. Put all three of these advances together and the opportunity is extremely compelling.

A powerful new option has been thrown into the "next-generation" airplane problem, however, because no one is pushing for necessarily higher speeds. For example, it is possible to put the new engines in the F-4 and improve its performance substantially. It also is possible to increase the percentage of titanium in the F-4 and to make other structural improvements. Putting a variable-sweep wing on the F-4 also is another option. McDonnell is making proposals to the U.S. Navy on such improved F-4s.

(Continued on following page)

Technicians service an RF-4C at right. A Fairchild camera that scans 180 degrees to provide horizon-to-horizon terrain coverage is mounted in this aircraft. Film is processed automatically in flight to provide finished prints as soon as the aircraft lands.



Undoubtedly it would be ideal to start from scratch and tailor a new wing, structure, and engine combination. Such an aircraft could be expected to wring the maximum performance out of the new technology. But the F-4 is a proven Mach 2.5 aerodynamic configuration, and it could be modified, using the new technology, to nearly match a new fighter for most missions. Perhaps this course would result in significant dollar savings.

The F-4's Growth Potential

The main point is that the F-4, and other established Mach 2-plus fighters, have a growth potential that no previous generation of military aircraft has enjoyed.

Exploitation of the growth potential already is in progress. The F-4K for the Royal Navy and the F-4M for the Royal Air Force will be powered by Rolls-Royce Spey 25R turbofans. These engines are of later vintage than the General Electric J79s that power U.S. versions of the Phantom II. The Speys deliver a maximum of 21,500 pounds (9,752 kg) of thrust with afterburner, about 12 percent more than the GE J79s. According to "Flight," the Spey fuel consumption will be 30 percent less than the U.S. engines.

If the Spey meets its performance predictions, then the British F-4s that start coming off the McDonnell lines in 1967 will be substantial improvements over U.S. models. The increased thrust will improve takeoff and landing performance and top speed. Most important, it will improve acceleration and shorten the time and decrease the fuel needed to reach fighting speed at around Mach 2.

The 30-percent reduction in fuel

consumption can be translated into a 30-percent improvement in range for most missions. A performance boost of this magnitude has always been considered a significant achievement and is still impressive today.

New U.S. Phantom IIs due out in the next few years will be powered by newer versions of the J79. The thrust and specific fuel consumption improvements are about five percent in each case. These engines will narrow the gap between the U.S. and British models, but certainly not close it.

Potent new U.S. engine technology is available, however. As an example, the General Electric GE-1 series of turbojets has nearly doubled the thrust-to-weight ratio of the J79. The GE-1 now running, and which will serve as the gas generator for the large fan engine on the Lockheed C-5A transport, is too small for the F-4. But this is a family of engines, and one properly sized could make a dramatic improvement in F-4 performance.

Pratt & Whitney's TF30 turbofan in the General Dynamics Corporation F-111 is larger than the Spey, but a slightly smaller engine of this type could boost the Phantom II performance significantly.

Another reason that more orders can be expected is that the F-4 is coming to be regarded as a "bargain-basement" high-performance airplane. It is quite far down on its manufacturing learning curve now, and the flyaway price can be expected to dip below \$1,700,000. This is a substantial price for a fighter, but in terms of effectiveness it is far from being out of line. One F-4, for instance, will do the bomb-carrying work of at least four F-84s of Korean War vintage, and the F-4 is useful in far worse weather.

Since the F-4 does not cost more than four F-84s, a cost/effectiveness improvement can be chalked up.

In the air defense role, the missile-armed F-4 also represents a great cost/effectiveness improvement because it can protect far more airspace than a subsonic interceptor carrying only guns.

Looking to the future, the F-4 may remain a bargain for many years to come. The U.S. Navy gave a strong clue in recent U.S. Congressional testimony. The Navy stated that the unit cost of the missile-equipped F-111B, slated for air defense of the fleet, has jumped from \$3,400,000 to \$8,000,000 in three years. If this price holds, the Navy apparently plans to cut its order and buy more Phantom IIs because one F-111B cannot do the air defense work of four F-4s.

Vietnam Losses

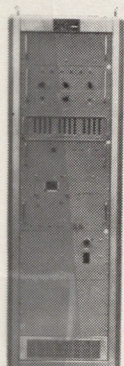
Certainly the greatest impetus for more Phantom II orders will come from the Vietnam War, which already has been a factor in the big U.S. Air Force buy to date. U.S. Air Force and Navy losses over North Vietnam totaled more than 170 aircraft of all types in 1965. The total will rise substantially in 1966, if the first six months are an accurate indication. Since April, an average of more than one high-performance aircraft per day is being downed over the North.

Even if the war stopped tomorrow, there is a strong possibility that increased F-4 orders would be placed. The capacity of the Tactical Air Command to respond to emergencies is being seriously questioned in the Air Force and in the Congress. Losses of
(Continued on page 21)



How does a ship rendezvous at an exact spot in the ocean?

Shipboard Transceiver



Ocean Bottom Transponder



Easily—with the Bendix-Pacific Acoustic Navigation System. It enables ships and submarines to occupy any selected point in the ocean or follow a given track over the ocean floor. And accuracy of the Bendix-Pacific system is unaffected by currents or surface conditions.

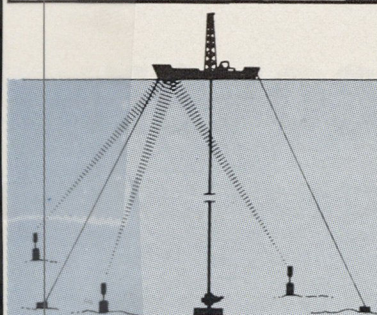
The system operates by means of shipboard equipment that interrogates an array of transponders on the ocean floor. Response time from each transponder permits the ship's location to be computed with great accuracy.

Bendix-Pacific transponders in the Atlantic Missile Range, put into operation in June, 1963, were interrogated recently and all were still operating.

Its reliability and accuracy make the system particularly useful for underwater drilling and mining, oceanic surveys, missile and satellite tracking, and locating submerged objects.

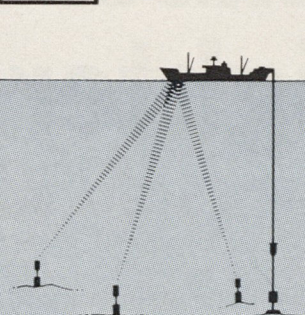
For more information, write Bendix International Operations, Dept. Q116-74, 605 Third Ave., New York, N.Y. 10016.

Bendix International Operations



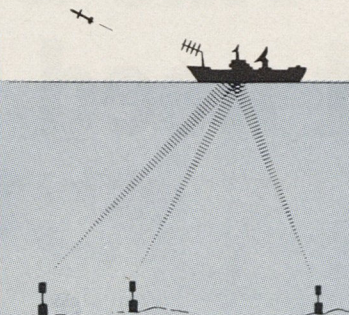
DEEP-WATER DRILLING OPERATIONS

Bottom-mounted acoustic transponders enable drilling ships to maintain a position directly over a hole being drilled in the ocean floor, regardless of depth.



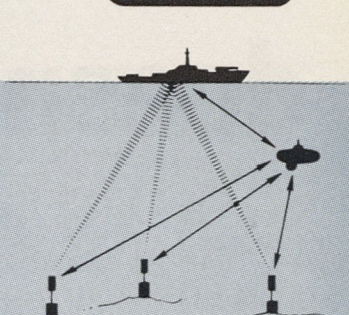
OCEANOGRAPHIC SURVEYS

Acoustic navigation permits survey ships to reoccupy oceanographic stations and to conduct fine-grained bottom surveys beyond the range of shore-based navigation aids.



MISSILE/SATELLITE TRACKING SHIPS

The accuracy of tracking data depends on the known position of the tracking ship. Acoustic navigation provides accurate position determination over a wide area in deep water.



POSITION LOCATION, DEEP SUBMERGENCE VEHICLE

Acoustic navigation system is used to determine the exact position of a deep operating vehicle with respect to a tending vessel as well as the position of both vessels with respect to the transponder array.



This bomber doesn't need fighter cover.

Unescorted F-5's on a ground-support mission may look like a tempting target to hostile fighters.

But attacking them can be suicide.

The F-5's won't just drop their loads and run. They'll turn and fight.

With its short turn radius the F-5 can quickly get on the tail of its attacker. Then, even if it is not carrying air-to-air missiles, its tremendous acceleration and rate of climb will put it within cannon range before the opponent can run away.

F-5's are built to survive in the air over tactical battlefields. Small, fast and agile, with twin engines and redundant systems, they can absorb a lot of damage and come back fighting.

So, while it's comforting to an F-5 pilot to have friendly fighters overhead, he can get along fine without them.

Provided he checks the sky now and then.

NORTHROP F-5

NORTHROP CORPORATION, BEVERLY HILLS, CALIFORNIA, USA

tactical fighters have been exceeding new deliveries. The Defense Department's recent boost in plane orders is certain to include F-4s.

Few aircraft have equaled the F-4 in across-the-board acceptance by the services. It is virtually impossible to hear serious criticism about the Phantom II in either the United States or Vietnam.

Service pilots seldom admit to disliking the airplane they are flying, but F-4 pilots are exceptionally enthusiastic. The Phantom is regarded as one of the more forgiving supersonic aircraft, with none of the major idiosyncracies of the Century-series fighters that sprang from an earlier technology.

From the standpoint of maintenance the F-4 is also outstanding. It has one of the lowest maintenance man-hour per flight-hour requirements of any supersonic aircraft in either U.S. Navy or Air Force service.

The Phantom II's first-line performance is verified by the fact that it holds or has held more than 12 world records including eight time-to-climb marks; the 100- and 500-kilometer (62 and 311 miles) closed-course records (an indication of the aircraft's maneuvering capability, for the pilot sustained more than three Gs through a 360-degree turn at Mach 2); sustained altitude record of 66,443.8 feet (20,252 m); and the absolute world's speed record of 1,606.3 miles per hour (2,585 km/hr) when the aircraft hit peak speeds in excess of 1,650 mph (2,655 km/hr)—more than Mach 2.5. These records were set from 1960 to 1962, and they were subsequently broken by a Russian aircraft, but most of the records returned to the U.S. on May 1, 1965, when two Lockheed YF-12As set nine records in the single day.

One record of importance in the attack field is still held by the Phantom II. It is the low-altitude speed record of Mach 1.2 (902.77 mph or 1,452.83 km/hr) for four passes over a three-kilometer (1.8 miles) course at

an altitude of less than 300 feet (91 m).

In the important range/payload department, the F-4 can hold its own with the best jet operational aircraft. In operations against North Vietnam, the Air Force hangs a basic load of eight 750-pound (340 kg) bombs under the F-4's wings and, with aerial refueling, operates the aircraft well over 500 miles (805 km) from its base.

Among operational fighters today, the F-4 has few peers at any task. It has proven highly effective in the diverse roles of air superiority, air defense, including the all-weather role, close air support, interdiction, and long-range attack. The Phantom is the best existing evidence that highly effective multimission aircraft can be designed. Both the U.S. Navy and Air Force consider it to be first-line equipment for all air-to-air and air-to-ground missions, and apparently this rating will continue well past 1975.

How the Phantom Began

Since the Phantom II began life as a single-place, all-weather, air-to-air weapon, it is interesting to trace its evolution into a multiman, multimission aircraft.

The Phantom II began as an unsolicited proposal from McDonnell Aircraft Corporation to the U.S. Navy in September 1953. It was a single-place, twin-J65-powered, all-weather fighter, armed with four 20-mm guns. The basic layout was similar to that of the Phantom I (the first jet-powered carrier fighter), the F2H Banshee series, and the Air Force F-101 Voodoo. Twin engines were expected to improve reliability and reduce the aircraft's attrition rate in war and peace. These were located in the fuselage and fed by shoulder inlets. Many structural and aerodynamic refinements were worked into this design as a result of experience with the previous aircraft.

One example was an attempt to move the horizontal tail down low on

the fuselage to prevent the pitch-up problems that the F-101 had experienced. This proved to be one of the most difficult tasks in the whole design effort.

Another major improvement was the installation of a variable-geometry engine air inlet to give good engine performance at all speeds and altitudes and to allow the top speed to go above Mach 2. The F-101 had a fixed inlet that held the maximum speed well below Mach 2.

The proposed aircraft was recommended for procurement by the Navy's Bureau of Aeronautics in August 1954 with a production changeover from the J65 to the J79 engine as soon as it became available. By the time the contract was let in October 1954, the designation was changed from the F4H-1 to the AH-1. Navy officials report that the attack designation was more an administrative point than a basic change in mission.

General Electric made better progress than expected with the J79, and early in 1955 it replaced the J65. By June 1955, the airplane was again designated the F4H-1, and the basic concept was changed from gun armament to all-missile armament. This brought the addition of the second man to the crew because it was believed that he would materially improve the aircraft's over-all efficiency in all-weather intercept operations.

A mockup review was held in November 1955, and the F4H-1's first flight took place in May 1958.

During this period the Navy was just recovering from its most serious technical setback of the jet age. Complete reliance had been placed on the J40 engine. All of the Navy's transonic aircraft were originally planned around this one large turbojet engine, which was predicted to have outstanding performance for its time. But the J40 didn't come up to expectations, and finally had to be canceled while the

(Continued on following page)



The British are scheduled to receive 290 Phantom IIs for the Royal Navy and Royal Air Force. They will be powered by Rolls-Royce Spey turbofan engines and will have substantially better range than USN and USAF versions.

Navy used Air Force engines and initiated some crash development programs to fill the gap.

After this crisis the Navy's top leaders decided not to take any more chances. So in August of 1955, Chance-Vought (now part of Ling-Temco-Vought, Inc.) was asked to submit a proposal for an all-weather, missile-only, single-seat, single-engine fighter that would be an improved version of the company's successful F8U-1 and would be powered by the new J75 built by Pratt & Whitney Aircraft Division of United Aircraft Corporation. In virtually every way this project was protection in case of the collapse of the J79, or the F4H-1, or the subsequent discovery that their basic concepts were not sound. The Navy intended to bring both designs into operational service with the fleet if they warranted it.

As it turned out the Navy won both bets in a big way. According to Navy sources, flight tests, pitting one aircraft against the other, showed that the designs were of equally high quality, and both represented a major advance in fleet air-defense capability. However, the U.S. Department of Defense would not grant the funds to

produce both. The Navy chose the Phantom II primarily because of the two-man crew, which was judged to be more effective. The second engine was considered a secondary advantage. Navy civilian engineers who participated in the evaluation believe that the canceled F8U-3 actually would have set higher performance records than the Phantom II.

The Air Force Contribution

In 1962 the Air Force selected the F-4 for the Tactical Air Command. The primary reason was to obtain the aircraft's air-to-air capability. To expedite the introduction of this aircraft, called the F-4C, into operational service, most of the Navy's systems were adopted intact and great effort was made to keep changes to a minimum.

One major change was the installation of a full set of flight controls in the rear cockpit. The Air Force chose to man the F-4 with two pilots instead of a pilot and a radar operator as the Navy does.

The other major change was the addition of a Litton Industries inertial-navigation system. This unit tells the pilot his latitude and longitude at any

given moment. It is very accurate and allows the crew to navigate right to a target. In strange country, such as North Vietnam, this system eliminates circling or hunting for targets, which would give enemy anti-aircraft time to get ready. The F-4C can hit its target in the first pass through an area, and it has a much greater probability of surprising the enemy than aircraft not equipped with the inertial-navigation system.

Most of the few changes in the F-4C were made to increase its air-to-ground capability. This policy also was adhered to during the design of the "D" model, which already is being delivered. The major improvement there was a further addition of a General Electric lead computing sight and an AiResearch central air-data computer to handle bombing and navigation chores. These systems are similar to the ones in the F-105 and in all bombing modes—dive, level, and night/all-weather—they allow the computation problem and weapon release to be handled automatically. These systems are superior in several respects to the Navy systems used in the F-4C, which are largely manual. Bombing accuracy

(Continued on page 25)

MAJOR SUBCONTRACTORS AND SUPPLIERS FOR THE F-4 PHANTOM II

Important to every successful aircraft, in addition to the prime contractor, are the hundreds of subcontractors and suppliers who contribute to the finished product. For, if the assemblies they supply are not "quality" products, neither is the aircraft. Below is a necessarily limited list of main F-4 subcontractors and suppliers, with the elements and components they provide.

F-4 MAJOR AIRFRAME SUBCONTRACTORS AND ASSEMBLIES

ASSEMBLY NAME	SUBCONTRACTOR
Aft Fuselage	Republic
Stabilator	Republic
Engine Doors	Republic
Outer Wing	Douglas
Doors and Surfaces	Beech
Forward and Aft Canopies	Goodyear
Windshield	Goodyear
Center Line Stores Rack	Cessna
Missile Pylon and Ejection Racks	Cessna
Wing Tank Pylon	Cessna
Landing Gears	Bendix
Radome	Brunswick-Balke-Collender
Ejection Seats	Martin-Baker

F-4 MAJOR GOVERNMENT-FURNISHED AIRCRAFT EQUIPMENT SUPPLIERS

SUBSYSTEM NAME	MODEL AIRCRAFT	SUPPLIER
Engine J79-GE-8/15	All	General Electric
Radar APQ 72/100	F-4B & F-4C	Westinghouse
Radar APA 157	F-4B & F-4C	Raytheon
Bombing System AJB-3A	F-4B	Lear Siegler and Texas Instruments
C.N.I. System ASQ 19	All	Collins and Stewart Warner
Electrical Power System	All	Bendix, Red Bank Div.
Guided Missile Launcher	F-4C	Martin
Bullpup Missile Control System	F-4C	Martin
Wheels and Brakes	F-4C & RF-4C	Goodyear
Cartridge Starter	F-4C & RF-4C	Sundstrand
Radar Altimeter APN 22	F-4B	Electronics Assistance Corp.

F-4 MAJOR EQUIPMENT SUPPLIERS

SUBSYSTEM NAME	MODEL AIRCRAFT	SUPPLIER
Autopilot	All	General Electric
Central Air Data Computer	All	AiResearch
Cabin Refrigeration	All	AiResearch
Equipment Refrigeration	All	AiResearch
Navigation Computer	All	Eclipse Pioneer
Emergency Power (Ram Air Turbine)	All	AiResearch
Hydraulic Power Control	All	Weston Hydraulics
Engine Inlet Air Control	All	Eclipse Pioneer
Radar Altimeter	F-4C (GFAE on F-4B)	RCA
Bombing System	F-4C (GFAE on F-4B)	Lear Siegler
Inertial Platform	F-4C & RF-4C	Litton Industries
Infrared Seeker	F-4B & F-4C	American Car & Foundry
Side-Looking Radar	RF-4B & RF-4C	Goodyear Aircraft
Infrared Mapper	RF-4B & RF-4C	Texas Instruments
Forward-Looking Radar	RF-4B & RF-4C	Texas Instruments
High-Altitude Panoramic Camera	RF-4B & RF-4C	Hycon Mfg. Co.
Low-Altitude Panoramic Camera	RF-4B & RF-4C	Fairchild Camera
Framing Cameras	RF-4B & RF-4C	Hycon Mfg. Co.
Data Annotation	RF-4B & RF-4C	Fairchild Stratos
Photo Control	RF-4B & RF-4C	Electronics Specialty
Camera Stabilization	RF-4B & RF-4C	Fairchild Camera
High-Altitude Radar Altimeter	RF-4B & RF-4C	Stewart Warner
Boundary-Layer Control System	All	Solar, San Diego; Arrowhead; Stainless Steel Products



Overwater hunter of underwater mines

Minesweeping has taken to the air. Sikorsky's twin-turbine RH-3A brings helicopter speed, agility and hover capabilities to the mine countermeasures mission.

The RH-3A is a modified SH-3A, the U. S. Navy's proved anti-submarine helicopter. It can cruise to a station up to 60 miles from base, accomplish a 3-hour sweeping mission (including retrieval of gear) and return to base. The tow hook can be lowered 50 feet during transfer, permitting the air-

craft to fly safely above rough seas. There are bubble windows to enable the crew to observe sweeping operations, and rear view mirrors to aid both the pilot and co-pilot.

Like other helicopters in the Sikorsky twin-turbine S-61 family, the RH-3A can make water landings in an emergency. Nine of these aircraft are scheduled for delivery to the U. S. Navy, four of them for service aboard ships, including minesweepers.

Once again the helicopter demon-

strates its value in military uses. For more information, contact the United Aircraft International representative named below.

**United Aircraft
International**

**U
A**

SUBSIDIARY OF UNITED AIRCRAFT CORP.

EAST HARTFORD, CONN. 06108, U.S.A.



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The off-the-shelf bird for "swivel-chair" pilots.

Military flying proficiency is never "on-the-shelf" . . . transition to tactical/strategic aircraft comes quickly . . . when administrator-pilots whose primary duty is currently a desk job, maintain their flying skills in versatile, high performance JET COMMANDERS!

Twin-turbine powered Jet Commanders feature highly sophisticated systems simple enough to operate to safely accommodate the capabilities of pilots who fly infrequently.

Jet Commanders operate easily from fields too short for bigger jets . . . cruise at 45,000 feet and better than 425k. With either engine out and at full gross weight, a Jet Commander can climb at 1,900 fpm, maintain 20,000 feet and retain full cabin pressurization and air conditioning.

FAA certified to the same standards of SAFETY and RELIABILITY as commercial jet liners; Jet Commanders are unparalleled in multiple back-ups for all systems, including fail-safe 4g structure.

A "forgiving" airplane, the Jet Commander has a conventional empennage with no deep stall characteristics

. . . there's easy, precise control from stall speed to max speed with full aileron control throughout a stall.

Automated electrical systems and computerized autopilot-navigation systems relieve crews of many of their aircraft management tasks . . . keeps them familiar with similar systems of tac/strategic aircraft, and guarantees all-weather capability.

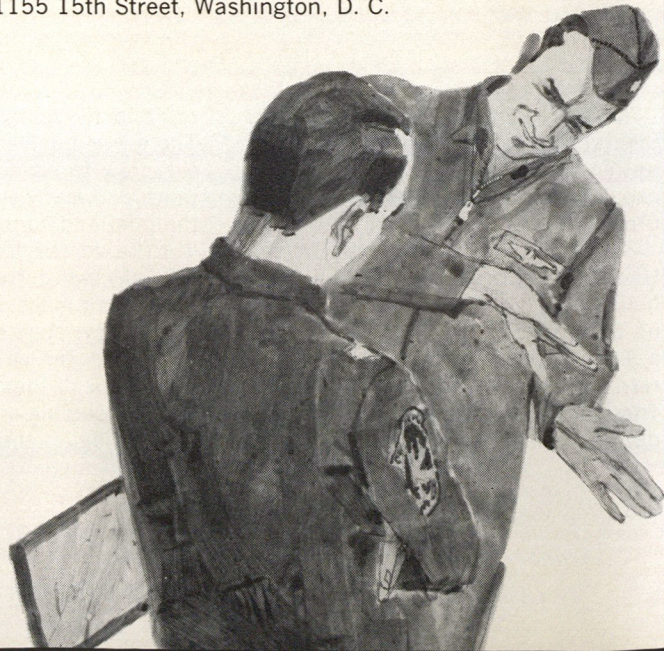
The Jet Commander can be changed quickly from a pilot proficiency trainer to a "hot" cargo, personnel or command transport with a minimum of modification. Its operationally proven, maintenance-free characteristics—its global capability—and its ability to operate independent of ground support, make it the ideal aircraft to easily and economically accomplish the important objectives of the Mission Support System.

FOR COMPLETE DETAILS ON THE JET COMMANDER,
WRITE AERO COMMANDER, Suite 810, Madison Building,
1155 15th Street, Washington, D. C.

JET COMMANDER®

A PRODUCT OF ROCKWELL-STANDARD CORPORATION

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





Boom operator in a tanker aircraft has this view of the Phantom II during refueling. The F-4 is large for a fighter, grossing above 50,000 pounds (22,600 kg).

with the automatic systems is up to three times better than with the manual equipment.

The Air Force has planned still another model, the F-4E, which will incorporate all of the features of the "C" and "D" plus a 20-mm General Electric Vulcan cannon of the type used in the F-105. The aircraft will have a nose similar to the RF-4 reconnaissance aircraft, and the gun will be fired out of the forward camera port.

The normal Sparrow III missile armament allows the F-4 to engage aircraft at distances of eight miles (13 km) or so, well beyond gun range. Under the

special rules laid down for the Vietnamese operations, however, no aircraft can be engaged without first being positively identified visually. This maneuver brings the F-4 inside the minimum range of its missiles and into gun range. Since the F-4s have no guns and their enemy does, this puts some U.S. aircraft at a significant disadvantage at the beginning of any air-to-air engagement. Still the current record is 14 MIGs downed by U.S. Navy and Air Force F-4s over North Vietnam, including three MIG-21s. The total number of MIGs shot down by the U.S. to date is 21 confirmed and one probable. Two F-4s are believed to have been downed in air-to-air action.

In any event, the gun in the F-4E is considered to be worthwhile for ground attack even if it's never used in air-to-air combat.

Multimission vs. Single Mission

Theoretically and philosophically, the F-4 has had far less impact on the military aviation community than it has had on the operational forces. One might think that the F-4 made a lasting point in favor of the multimission fighter and the two-place, two-engine concept. But this is far from true. The diversity of opinion is as wide as ever in industry and the Government.

If anything, controversy is growing, and all organizations are taking a hard new look at the requirements of the 1970s and 1980s and the extensive opportunities offered by the new technology. Once you could expect to hear a strong defense of the multi-

purpose idea from the Air Force while the Navy adhered to the single-purpose airplane concept. Today all the barriers seem to be down, and strong proponents of each concept and variants of the concepts can be found in almost any office in either service. Past experience certainly has not unified thought on fighter operations.

Perhaps the F-4 has only one clear message on which everyone can agree. It is an old message which always provides a great payoff. That is to build quality hardware. It's an easy goal to talk about. Everyone tries for it, but it is extremely difficult to achieve with high-performance machines.

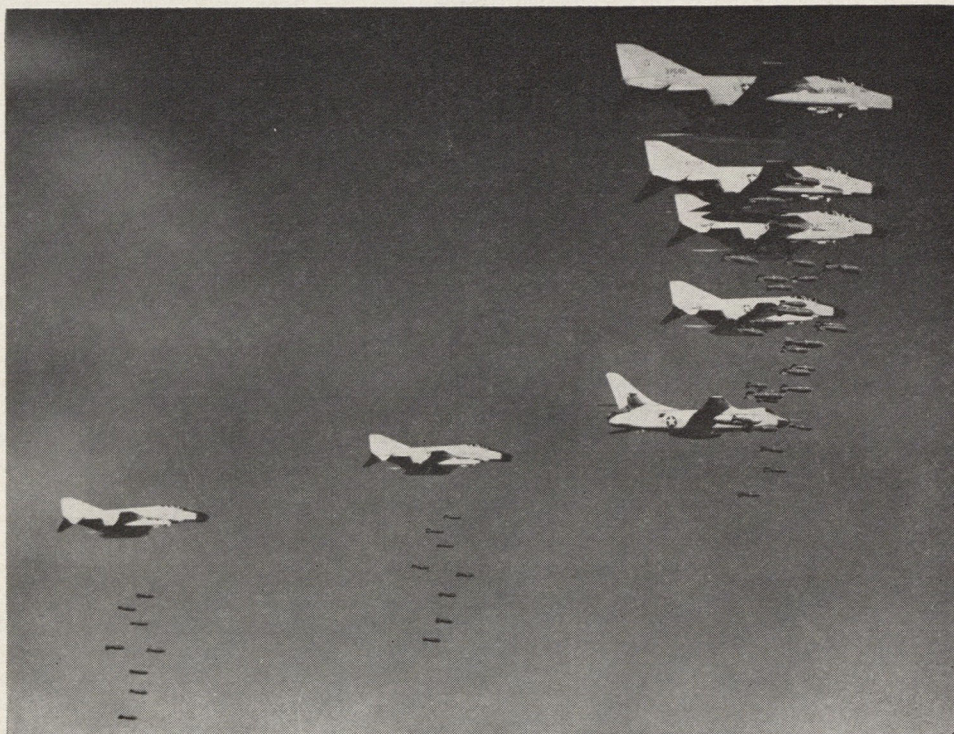
The F-4 concept was right for its time, but it is vitally important that the airplane actually does what it was designed to do.

The Phantom II is complex. It is loaded with sophisticated electronic equipment. It has a sophisticated, automatically controlled inlet for engine air. It has an elaborate boundary-layer control system that blows air out of high-lift devices on both the leading and trailing edges of the wing. The key point is that these systems and all others work the way they are supposed to. The aircraft performs as advertised. The customers are happy and think they made a good bargain.

To paraphrase and elaborate on Sir Winston Churchill, nobody could have guaranteed that the F-4 would have become one of the most widely used and successful jet aircraft ever built, but it would be difficult to say that those involved didn't work hard enough to deserve it.

☆☆☆

Air Force versions of the Phantom II are shown above during a level bombing run in North Vietnam with a Douglas RB-66 electronic warfare aircraft leading the formation. This operation was undertaken to determine how effective radar bombing through the clouds would be so that the air offensive could be maintained, if necessary, during bad weather.



Mankind is just beginning to realize the vast resources that for eons have been locked up in the ocean depths. Exploitation of these treasures may well lead to new means of feeding the world's hungry, providing oil, supplying needed minerals, chemicals, drugs, living space, and even solving the unemployment problem. The U.S. Government is currently spending 36 times more on exploration of space than on oceanography. But now, with Government and industry teaming up, scientists foresee the oceans as becoming an integral part of man's living and working environment in the next generation . . .

Out of the Depths— A New World of Wealth

BY WILLIAM D. SMITH

The following article is reprinted from the July 17, 1966, issue of "The New York Times." Copyright 1966 by The New York Times Company. Reprinted by permission.

The sea, man's first frontier, has become his last major earthbound challenge. It has also become an important goal in the search for investment opportunity and profit.

The oceans are capable of feeding the world's hungry, providing vast quantities of oil, and supplying needed minerals, chemicals, and drugs, according to even the most pessimistic exponents of oceanography.

"Within 50 years, man will move onto and into the sea—occupying it and exploiting it as an integral part of his use of this planet for recreation, minerals, food, waste disposal, military and transportation operations, and, as populations grow, for actual living space," says Dr. F. N. Spiess, head of the Marine Physical Laboratory of the University of California's Scripps Institution of Oceanography, at San Diego.

Many oceanographers would say that Dr. Spiess was being far too conservative.

The challenge of extracting the sea's wealth is a mighty one but the potential rewards for both Government and private enterprise are monumental.

Return Estimated

The National Research Council of the U.S. National Academy of Sciences, in a deliberately conservative

study, concluded that the direct return on a 20-year investment in oceanographic research will be more than three times larger during those 20 years alone than if the same money had been invested at ten percent compound interest.

The opportunities have not been lost on industry. John H. Clotworthy, Vice President of the Westinghouse Electric Corporation's Defense and Space Center and general manager of the company's underseas division, recently told a U.S. Congressional subcommittee:

"A major thrust into the ocean could be expected to become a recognizable element in our Gross National Product and help satisfy the future need for new employment opportunities in both the professional and labor markets."

U.S. industry and Government already have a substantial stake in the oceans. Current spending on all things connected with the seas has been estimated at nearly \$10,000,000,000 a year. This figure includes about \$4,000,000,000 for military projects, \$2,000,000,000 for offshore oil and gas, \$2,000,000,000 for marine recreation, and \$400,000,000 for commercial fishing.

Undersea mining and extraction of chemicals from seawater is a \$250,000,000 business. Nonmilitary research accounts for another \$250,000,000, with

\$141,000,000 of this total coming from the Government, and the remainder from U.S. industry and the universities.

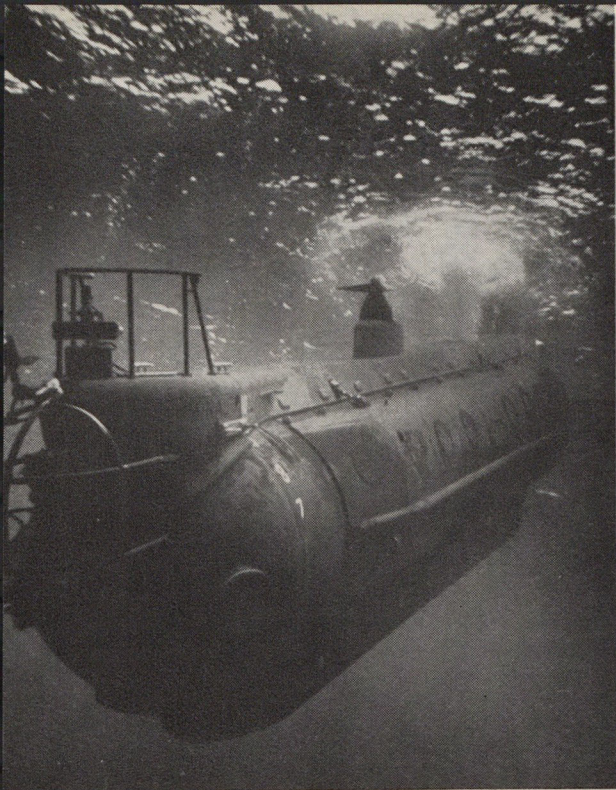
Unfortunately, the bulk of this huge stake in ocean activities is contributing very little toward increasing knowledge of the seas. With the major exception of the U.S. Navy's antisubmarine warfare studies and Deep Submergence Systems Project, much of the military spending is along rather prosaic lines.

Vacuum vs. Ocean

In terms of actual funding for research purposes, U.S. expenditures are on the frugal side. According to U.S. Senator Warren G. Magnuson, a Democrat from the state of Washington, the Federal Government "is spending 36 times more on vacuum (space) than it is on the ocean."

The Government's interest would seem to be picking up, however. President Johnson, speaking recently at the commissioning of an oceanographic research vessel in Washington, D. C., called for greater efforts to extract the riches from the world's oceans.

At the same time, the President's Science Advisory Committee issued a report on "Effective Uses of the Sea" that recommended a doubling of Federal support for marine science and



Sixty percent of the world's ocean floor can be explored by man with the use of this first all-aluminum submarine, built by General Dynamics Electric Boat Division for Reynolds International, Inc. Called the "Aluminaut," the craft is designed to operate at depths of 15,000 feet (4,570 m), displaces 150,000 pounds (68,040 kg), and has an operating range of about 80 miles (130 km).

nies are presently devising ways to eliminate the familiar platform drilling rig and locate the wellhead, and possibly the production equipment, on the ocean bottom.

Difficult Technology

Drilling of wells on the ocean floor has been tried on an experimental basis under very special conditions. Lowering and installing of equipment on the ocean bottom requires sophisticated techniques, including underwater television to guide the operators. This is just the beginning, though, for once the well has been installed it must be controlled through remote devices.

Lack of the proper tools is also holding back the mining of the ocean, although there are some notable exceptions. An exotic one is off the coast of South Africa where an enterprising Texan dredges more than 700 tons (635 mt) of diamond gravel daily from the ocean floor. Yields average five carats a ton, compared with one carat a ton from land ore, and most of the stones from the ocean are gem quality.

All of the United States supply of manganese and 75 percent of the nation's bromine now come from the ocean.

Treasure in the Deep

This again is just a prologue of what is to follow. As with oil, most of the minerals now being wrested from the sea come from the Continental Shelf. The real treasures, however, lie beyond on the continental slope and in the ocean depths.

Oceanographers have estimated that the sea holds some 5×10^{13} metric tons of minerals. Included in this total are 2×10^{12} tons of magnesium, 1×10^{11} tons of bromine, 7×10^{11} tons of boron, 2×10^{10} tons of uranium, 15×10^9 tons of copper, 15×10^9 tons of manganese, 1×10^{10} tons of gold, and 5×10^8 tons of silver.

The question of when man goes after this treasure is primarily one of when does the cost of getting these metals from land sources exceed the cost of obtaining them from the sea.

Dr. John Mero, Vice President of Ocean Resources, Inc., and a leading authority on undersea mining, said recently, "It would be profitable to mine materials such as phosphate, nickel, copper, cobalt, and even manganese from the sea at today's costs and prices.

"And I firmly believe that within the next generation, the sea will be a major source not only of those metals but molybdenum, vanadium, lead, zinc, (Continued on page 29)

technology over the next four years.

Spending by U.S. private industry is contributing far more, comparatively, to solving the problems of the ocean than it has to space. In terms of actual money spent, however, it is still no great sum by today's standards.

As with all frontiers, there are pioneers trying to get in on the ground floor, or, in this case, the ocean floor. There are, at present, more than 600 U.S. companies involved in one way or another in probing for the ocean's riches.

They range in size from such corporate giants as the Standard Oil Company (New Jersey), the General Dynamics Corporation, and Litton Industries to a host of small specialty concerns such as Alpine Geophysical Associates, Inc., and Ocean Resources, Inc.

Money is already being made, both by companies extracting the sea's riches, and by concerns making the equipment needed to get at these riches.

More than \$1,000,000,000 in oil, seafood, and minerals was taken from the sea by U.S. companies in 1964, according to the latest U.S. Bureau of Mines Minerals Yearbook. This is just the trickle before the flood, according to every informed source.

Much Research Needed

To increase the flow, a great deal of basic research is needed in materials, undersea vehicles, instruments, communications, and tools, as well as

looking into the physiological and psychological problems man will face under the sea.

The U.S. oil and gas industry has reaped the greatest harvest from the sea, but it has also put in the most money and energy. The United States oil industry invested about \$2,000,000,000 in offshore leases, exploration, drilling, and production facilities last year alone.

The oil industry recognized the value of the minerals below the ocean floor about 30 years ago. Although considerable oil was recovered from below the ocean floor in the late 1950s, it was not until this decade that major recoveries were made.

In 1960, some eight percent of the Free World's oil supply was pumped from beneath the ocean. Last year, offshore oil wells pumped 16 percent of the Free World's supply. Informed industry sources predict that this figure may increase to 40 percent by 1975.

All Oil from Shelf

All of the oil from the sea so far has come from that area called the Continental Shelf. This is the area, contiguous to all major land masses, that formerly was dry land itself. It varies in width and depth of water, but in many ways still resembles dry land.

Before the oil companies push into deeper waters and begin trying to tap the ocean's depths for petroleum and gas, whole new families of equipment must be developed.

Oilmen from all the major compa-

SCIENCE/SCOPE

A "window shade" array of solar cells is being developed by Hughes for the U.S. Air Force as a power source for space. It will be designed to withstand launch requirements for a Titan III type booster in a stowed condition...will unfurl in a manner loosely comparable to unrolling a window shade. Demonstration model will have a 50-square-foot array; modular design allows larger arrays for extra solar power.

"Large array" microcircuits and high density packaging techniques are features of the HCM-205, new microminiature airborne computer designed by Hughes. It has a 4,096 18-bit word memory, expandable to 32,768 words; can perform about 125,000 operations per second; weighs 13.3 lbs. including power supply; occupies 1/5 of a cubic foot. It will be integrated into a multimode radar data processing system for flight test early next year.

A prototype radar system, most powerful ever built by Hughes, is called ADAR (Advanced Design Array Radar). The reduced-size prototype city defense system will be used to demonstrate new long-range phased-array techniques for the U.S. Air Force prior to defining the best type of full-scale system.

The first four Mark 1B satellite ground-link terminals, now on duty for the U.S. Army to communicate with the random-orbit military satellites launched in June, will play a significant role in the world's first global military satellite communications network. Three of the air-transportable terminals are located in Hawaii, the Philippines, and West Germany. The fourth, now being erected in Ethiopia, will soon be ready for test operations.

Voice of America broadcasts soon will pierce the "Bamboo Curtain". Ten giant, 250,000-watt Hughes radio transmitters will beam U.S. Information Agency programs deep into Red China from the Philippines on a round-the-clock schedule.

A 30-megabit laser communication system, sponsored by NASA's Manned Spacecraft Center, employs polarization-modulation techniques. It has been demonstrated between stations a few miles apart in the Los Angeles area. This system has a 30-million-bit-per-second capacity. It simultaneously transmits a 5-megacycle TV channel, a 4-kc voice channel, and a 1-kc telemetry channel. Big potential of laser communications is its ability to handle very high data rates with one installation. Thus, laser technology and systems have moved closer to being practical long-range, high-data-rate space communications systems.

A new joint-venture firm called Satellite Telecommunications Company (Satelco) has been formed by Nippon Electric Company Ltd. and the Hughes Aircraft Company for worldwide marketing of satellite communications ground terminal stations and equipment. The activities will also include systems and applications engineering, site surveys, test installation, maintenance, spares provisioning of terminal stations under contract, and other field service and support functions.

HUGHES INTERNATIONAL
HUGHES AIRCRAFT COMPANY

CULVER CITY, CALIFORNIA, U.S.A.

titanium, zirconium, and several other metals."

The corporate pioneers are already at work. Lockheed Aircraft Corporation is working in a joint venture with the International Minerals and Chemicals Corporation and the U.S. Bureau of Mines to study ocean mining methods.

The Reynolds Metals Company has an all-aluminum submarine to study the depths. It is also considering private development of a whole system of underwater work capabilities, including undersea barges for mining.

Using the Desalting Process

W. R. Grace & Company is actively studying methods of recovering a variety of minerals from seawater in conjunction with the operation of desalting plants.

Union Carbide Corporation is employing Ocean Systems, Inc., in which it owns a 65-percent interest, in a substantial study of the sea's opportunities.

Although lack of proper equipment is retarding underwater oil and mining activities, it is not because there is any lack of thought being given to the matter.

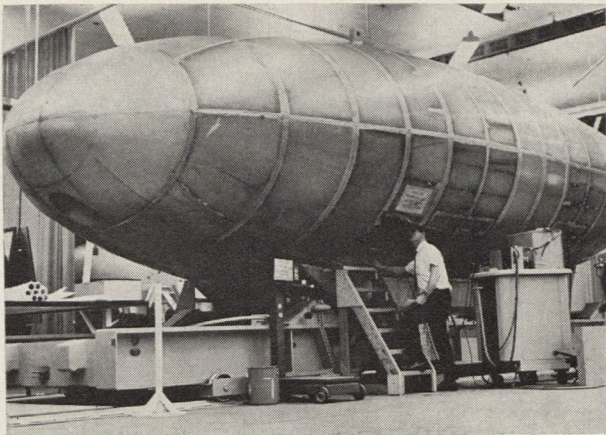
One of the most active areas is submersibles. The General Dynamics Corporation has for years been a leader in this field. This spring it launched two small research submarines. The first, the Star II, is equipped with an ultrahigh-strength hull for operations to a depth of 1,200 feet (365 m). The other, the Star III, can descend to 2,000 feet (610 m) and has an external mechanical arm that can cut wire, close its grip, pick up a pencil or a 200-pound (90 kg) weight, and manipulate valves.

General Dynamics is now working on the first nuclear-powered research submarine. The vessel, which is being built for the U.S. Navy, is expected to become operational by 1968.

Westinghouse Electric Corporation, which also has a long history in underwater activity, operates a charter service that hires out a submersible, a surface support ship, oceanographic equipment, and technical personnel, including divers.

Built by Cousteau

The Diving Saucer, designed and built by Jacques-Yves Cousteau, is now operated by Westinghouse and is the forerunner of the company's Deepstar family of submersibles. The Deepstars, each capable of holding two or three men, will be able to submerge to hoped-for depths of 20,000 feet (6,096 m).



"Deep Quest," undersea research submarine built by Lockheed Missiles & Space Company, can take a 7,000-pound (3,000 kg) payload more than a mile (1.6 km) beneath the ocean's surface. Two crewmen and two observers test materials needed in exploiting the depths.

North American Aviation is designing an underwater vessel called the Beaver, which will be equipped with manipulators capable of using a number of tools.

Possibly the most famous of the research submarines operating is the Alvin, which located the hydrogen bomb that fell into the Mediterranean Sea off the coast of Spain. It was built by Litton Industries for the Woods Hole Oceanographic Institute, Woods Hole, Massachusetts.

While man is learning about the sea by moving about in submarines, he is also trying to develop stationary submerged shelters suitable for human habitation. The U.S. Navy's program, called Sealab, got under way in the summer of 1964, when a four-man crew spent ten days in a large cylindrical chamber submerged 192 feet (58.5 m) deep off the coast of Bermuda.

This was followed by Sealab II, in which teams of ten men each spent 15 days under water. Astronaut Scott Carpenter was one of the men, and he stayed down for a total of 30 days.

Plans for Sealab III are well under way.

In addition, the Navy is looking ahead to the construction of an advanced underwater facility for work at a depth of more than 600 feet (183 m). It is tentatively called the Seafloor Habitat Complex. The complex will consist of a combination of modular units, including living quarters, a research laboratory, and power sources.

The applications of such shelters to undersea drilling and mining are obvious. Their success will also make the day of the underwater city considerably closer.

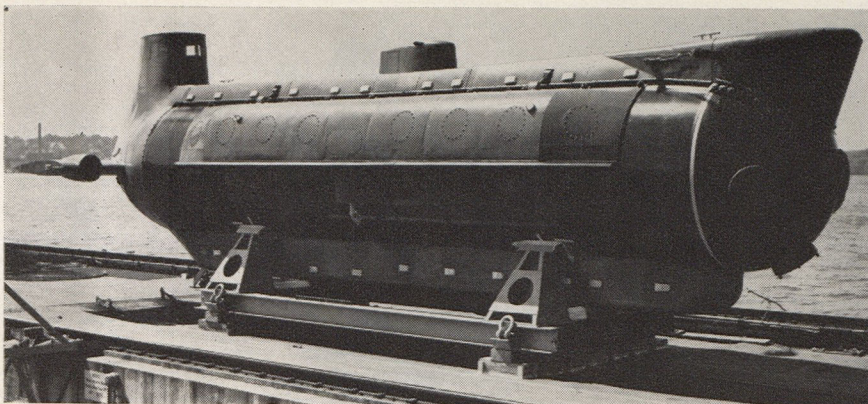
Fight for the Market

Producers of titanium, glass-reinforced plastics, higher-strength steels, aluminum, and nickel are fighting it out for the market for undersea materials. The Republic Steel Corporation and the United States Steel Corporation have both developed special high-strength steels for the undersea market.

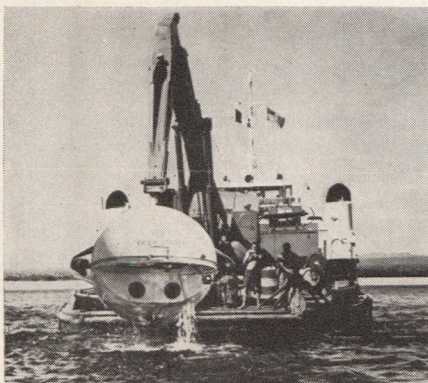
Besides pressure, the sea presents
(Continued on following page)

Undersea mining research is conducted by this vessel of the U. S. Department of the Interior's Bureau of Mines. The 65-foot (20 m) boat carries equipment for investigating ways of recovering minerals from the ocean floor. Cooperating in the program are Lockheed Missiles & Space Company and International Minerals & Chemical Corporation.

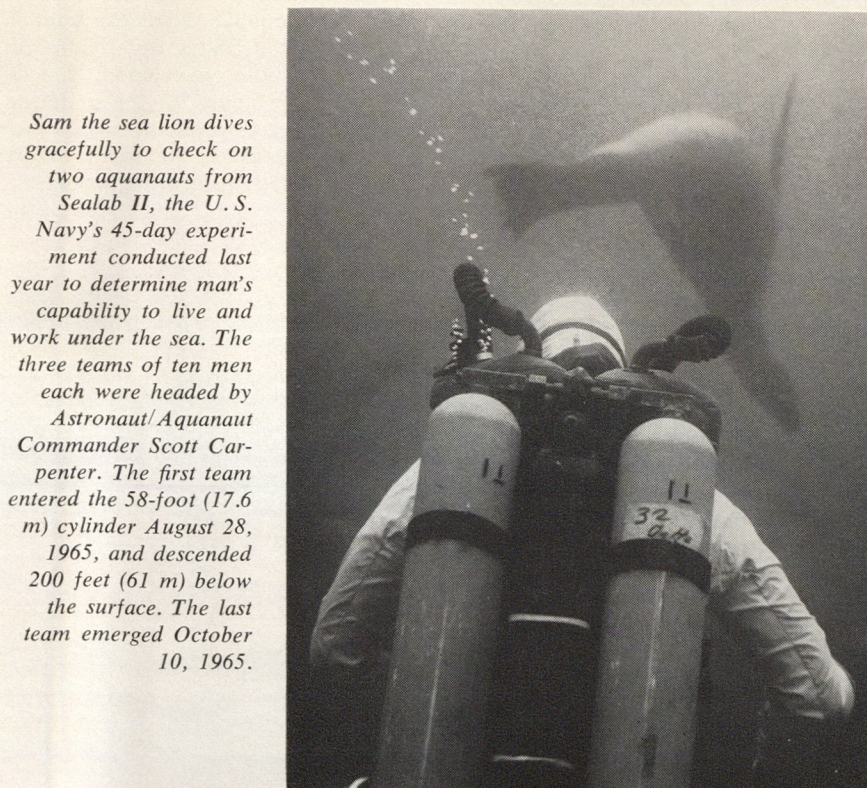




The Aluminaut, the world's deepest-diving submarine to date, represents an investment of five years of research and development and more than \$3,000,000 by Reynolds International, Inc. The craft is equipped with sonar, television cameras for detailed observation of the ocean floor, and robot hands to obtain specimens. It carries a crew of three.



Westinghouse Electric Corporation has designed a research submersible which it hopes will be able to dive to 20,000 feet (6,096 m). The "Deepstar," above, has been successfully tested, diving to a depth of 4,000 feet (1,200 m), exploring the ocean floor for 90 minutes, and demonstrating its maneuverability by picking up samples of animal life.



Sam the sea lion dives gracefully to check on two aqualungs from Sealab II, the U. S. Navy's 45-day experiment conducted last year to determine man's capability to live and work under the sea. The three teams of ten men each were headed by Astronaut/Aquanaut Commander Scott Carpenter. The first team entered the 58-foot (17.6 m) cylinder August 28, 1965, and descended 200 feet (61 m) below the surface. The last team emerged October 10, 1965.

the problem of corrosion. Several of the chemical companies are working on protective coatings at present, and it is likely that more will join the study.

Several companies, such as the Goodyear Tire and Rubber Company, are presently involved in a research program to develop anticorrosion compounds.

Another major tether on man's thrust into the sea is the lack of proper instrumentation. Instruments of all sorts are needed to test, explore, and control the ocean environment.

Many of the instruments presently being used in oceanographic research have been transferred directly from space and other uses. They are doing the job, but far from perfectly.

Companies such as Honeywell, Inc., Beckman Instruments, and Sylvania Electric Products, Inc., are working on devices specifically designed for the water environment, but a great deal more effort is needed in this direction.

It is not just coincidental that many of the companies participating in oceanography are also active in aerospace. The race in space and the challenge of the ocean are similar in many ways.

"Aerospace research has much in common with ocean research. Materials, propulsion, auxiliary power units, guidance, and communications systems are as vital to marine vehicles as they are to aerospace vehicles, and pose many of the same problems. It is logical, then, that the aerospace industry should turn its research attention to the fields of the ocean," according to Daniel J. Haughton, President of Lockheed.

Antisubmarine Warfare

The best example of aerospace companies participating in "inner-space" operations is the U.S. Navy's antisubmarine warfare program. Since 1961, the percentage of the Navy's research, development, testing, and evaluation budget that is devoted to antisubmarine warfare has climbed from 18 percent to more than 28 percent at the present. By the end of the decade, it will account for at least a third of the total budget.

The names participating in this all-important program read like a roster of the U.S. aerospace industry. Not only is most of the technology being put together by aerospace concerns, but the Navy has picked TRW, Inc., an aerospace company, to coordinate and do the systems work on the entire program.

In the Deep Submergence Systems Project (DSSP), another aerospace company, the Northrop Corporation, (Continued on page 32)



tactical air support training systems?

BUT I THOUGHT DEL MAR MADE TOW TARGETS!

Del Mar has specialized in complete weapons training systems for more than thirteen years. Many of these have been aerial weapons training systems that have been used extensively for the realistic in-flight training of the air forces and naval air services of the United States and the other Free World nations. However, Del Mar's unique capability has not been limited to such aerial weapons training systems alone.

Case in point: firing ranges completely instrumented by Del Mar for the military services . . .

fully equipped with Del Mar targets that simulate tanks, trucks, personnel, and gun emplacements. With the use of Acoustiscore — a Del Mar breakthrough in the development of reliable miss-distance indicators — hits and near-misses, within a preset

radius of the targets, are instantaneously measured, counted, and telemetered to a field control station. There, they are displayed for the real-time observation of the tactical effectiveness of the weapons, and the data may also be recorded for future study and evaluation.

DEL MAR

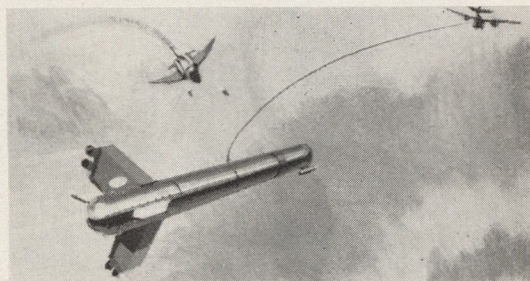


Del Mar Engineering Laboratories

6901 West Imperial Highway
Los Angeles, California 90045

Of course, we still make tow targets . . .

Our newest DF-14 Series consists of center-of-gravity, non-rotating tow targets that perform in subsonic and supersonic environments. The DF-14 (shown below) is equipped with four radar lenses to simulate an enemy aircraft, four infrared flares, and an Acoustiscore transducer for the accurate measurement of the miss-distances of the attack projectiles. These DF-14's are part of one Del Mar aerial system for such high-performance aircraft as the F-104, F8U, and F4 Series. In addition to the targets, this Del Mar system offers a tow reel and launcher for the in-flight launching, towing, and recovery of the targets.



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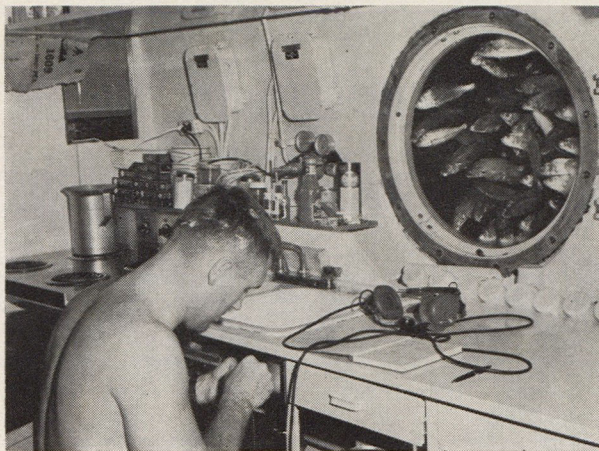
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Curious visitors at the porthole do not divert engineer Berry Cannon from his task of repairing the headset for helium unscrambler in Sealab II. Forty-seven different experiments were conducted by Sealab II's aquanauts during their 45 days under the sea.



has been given the job of assisting the Navy in management and systems integration. The program was created in reaction to the April 1963 loss off the U.S. East Coast of the nuclear sub THRESHER, with 129 men aboard.

DSSP has been planned to give the Navy four major capabilities: the ability to locate stricken submarines and their crews; to recover small objects down to 20,000 feet (6,096 m); to salvage large objects, including submarines and ships, downed on the Continental Shelf; and to expand man's capability to work in the sea.

Commercial interest in this program is perhaps greater than in any other program of similar size, in terms of funds available, to emanate from the Federal Government in recent years. More than 400 companies have sought information on business possibilities in the operation.

The hostile environments of space and the hostile environment of the sea have many technical requirements in common, but the transfer of technology from one to the other is neither easy nor automatic.

As far as business is concerned, ocean and space are even more unlike. In space, there is only one customer, the Government. Prime contracts are let in huge sums.

In contrast, a very large number of customers make up the ocean market, and prime contracts may be both large and small. The research-and-development contract, so familiar in the aerospace business, is not common in oceanics.

As a result, more of a burden has been placed on private capital.

The nation's over-all program in conquering the seas has been moving ahead, but in bits and starts. Part of the problem has been lack of funds and the other has been lack of central control and direction.

The prime example of this lack of direction is Project Mohole, the U.S.'s most ambitious project in the earth

sciences. The primary goal of the project was the scientific exploration by core drilling of the earth's deep crust and mantle beneath the ocean basins. The secondary goal was to provide a prototype national facility for heavy work at sea, such as mining, satellite tracking, and handling equipment.

Despite its obvious importance, the program, sponsored by the National Science Foundation, met trouble repeatedly in the U.S. Congress, and after alternate periods of slowdown and speedup, has now been canceled.

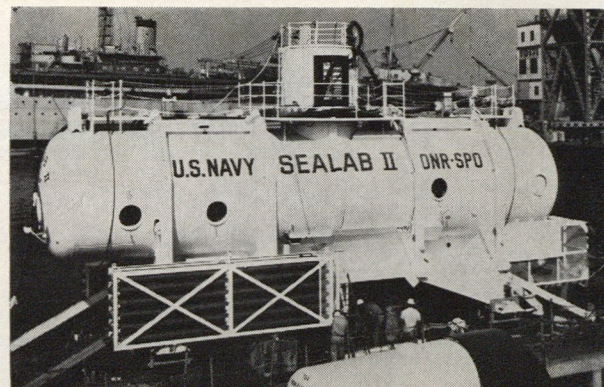
Research Expansion

This period of lack of direction may, however, be coming to a close. In June, President Johnson signed the Marine Resources and Engineering Development Act.

The act calls for the expansion of research and development and the establishment of a National Council on Marine Resources and Marine Development. The council is headed by Vice President Hubert Humphrey. It also established a Commission on Marine Science, Engineering, and Resources, which will be composed of 15 men knowledgeable in the oceanographic field.

The bill is not as strong as similar

Sealab II, the U.S. Navy's underwater laboratory, reclines on a barge at the Long Beach Naval Shipyard, California, shortly before being towed to its undersea station, 200 feet (61 m) below the surface off the coast of California near La Jolla.



space laws, but it should provide some over-all guidance to what has been a fairly disconnected effort.

The United States is not acting in an international void in its oceanographic efforts. France has made significant contributions to the understanding of the seas. Britain is also active. Even the tiny state of Monaco has made significant contributions to the field, and, in fact, houses the world's greatest oceanographic museum.

The big competitor, of course, is the Soviet Union. Russia has by far the world's largest fleet of submarines and its modern fishing vessels roam the world even to the fishing banks off Cape Cod.

Rival Techniques

These are just the Soviet Union's most obvious oceanographic activities. Their accomplishments in space make it not unlikely that they are presently performing experiments and research that rival anything the U.S. is doing in technique and sophistication.

Recently, President Johnson called upon the Soviet Union to join the United States and all other maritime nations in exploiting the seas for mankind's benefit.

He asked that nations avoid a new form of colonial competition for the ocean's riches. "We must be careful to avoid a race to grab and hold the lands under the high seas. We must ensure that the deep seas and the ocean bottoms are to remain the legacy of all human beings."

Many years ago, Sir Walter Raleigh said, "Whoever commands the seas, commands the trade, whoever commands the trade . . . commands the riches of the world."

Similar words were spoken more recently: "The nation that first learns to live under the seas will control them. And the nation that controls the seas will control the world." The speaker was G. V. Petrovich of the Soviet Union.

☆☆☆

**If it's an operational inertial
navigation system, chances are
Litton makes it.**



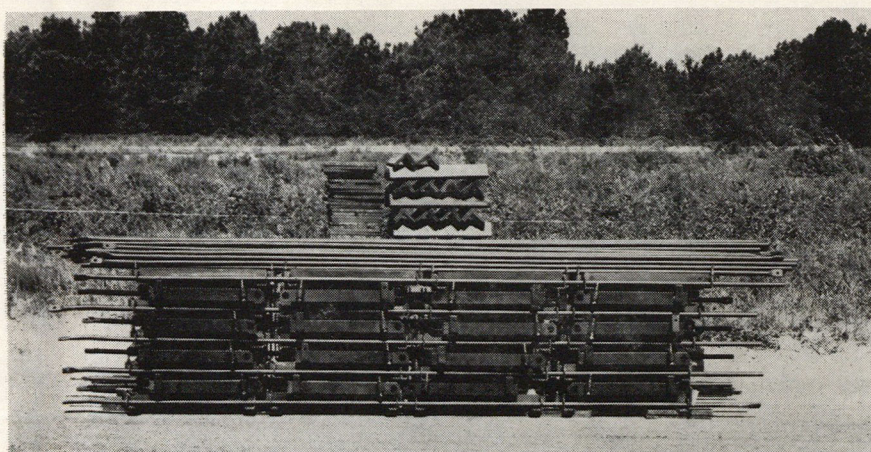
**One is guiding this
all-weather Grumman A-6A
to target.**

The world's first operational training base for short airfields for tactical support (SATS) has been completed at a U.S. Marine Corps base in North Carolina. The SATS system is similar to having an aircraft carrier on dry land, with aircraft launched by catapult in a little over 2,000 feet (610 m) and, on landing, stopped by arresting gear. Such a system is also in daily use at the Marine Corps base at Chu Lai in Vietnam . . .

LITTLE AIRFIELDS WITH A BIG FUTURE



Airfield in the making—Marine Corps engineers clear away trees and underbrush for construction of the world's first SATS operational training site, Bogue Field, N. C.



When the site of the new field has been cleared and leveled, the aluminum mat sections are on hand and waiting to be laid and joined together to make the airfield's runway.

Construction of the world's first operational training base for short airfields used in tactical support (SATS) has just been completed at Bogue Field, North Carolina. In addition to training pilots for SATS, the site will also provide Marine Corps pilots with simulated carrier training, except for the pitch and roll of the sea.

A SATS field, consisting of portable, mobile, and reusable runways, is designed to be operational 72 hours after the start of amphibious operations.

The success of the SATS system in actual operations can be measured daily at the Chu Lai Air Base in South Vietnam. Fighting aircraft have been launched and arrested there on a SATS runway since May of this year. The runway matting in use in the Far East war zone was originally at Bogue Field before being shipped to Vietnam.

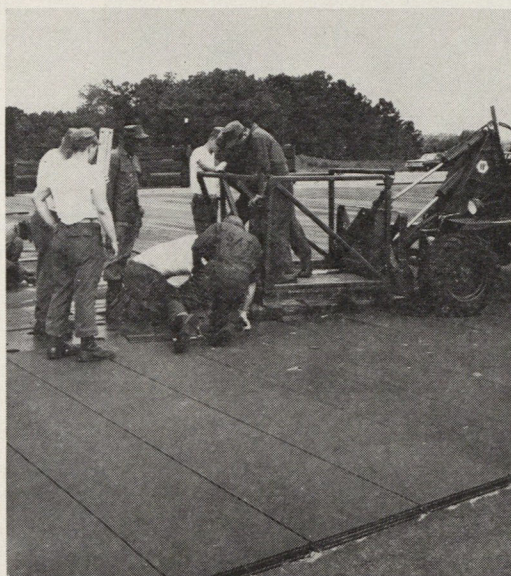
Work, meanwhile, has continued at the North Carolina training site. Bogue Field contains many of the SATS concepts and elements which should make it an ideal training site for pilots and equipment personnel. It was used during World War II as a training base for pilots and crew members of the 3d Marine Aircraft Wing. Aircraft using the field at that time were the F4U Corsair and the B-26 twin-engine bomber.

Thus Bogue Field's airstrip, undeveloped for jet operations due to the length of its runways and operating support facilities, has precisely the conditions SATS personnel are expected to encounter during their deployments.

The concept was born in 1953 when Marine Corps initiative set out to solve a crucial jet-age problem: how to



Members of naval construction battalion, "Seabees," begin laying the aluminum mats that, when finished, will make up the SATS runway 72 feet (21 m) wide and a little more than 2,000 feet (610 m) long. Sections hook onto each other.



Construction personnel drive shearing stakes into the new field as the runway takes shape. Such stakes prevent individual sections of the aluminum matting from wobbling and twisting out of place.

quickly install a jet airstrip under combat conditions and how to utilize existing prejet runways not equipped to handle supersonic aircraft.

Work began on the training site near the Marine Air Station at Cherry Point, North Carolina, on August 22, 1966, with approximately 250 military personnel taking part in the construction process.

The completed SATS runway is 72 feet (22 m) wide by 2,210 feet (673 m) long, made up of mats two feet (.6 m) wide and 12 feet (3.6 m) long which weigh 144 pounds (65 kg) each.

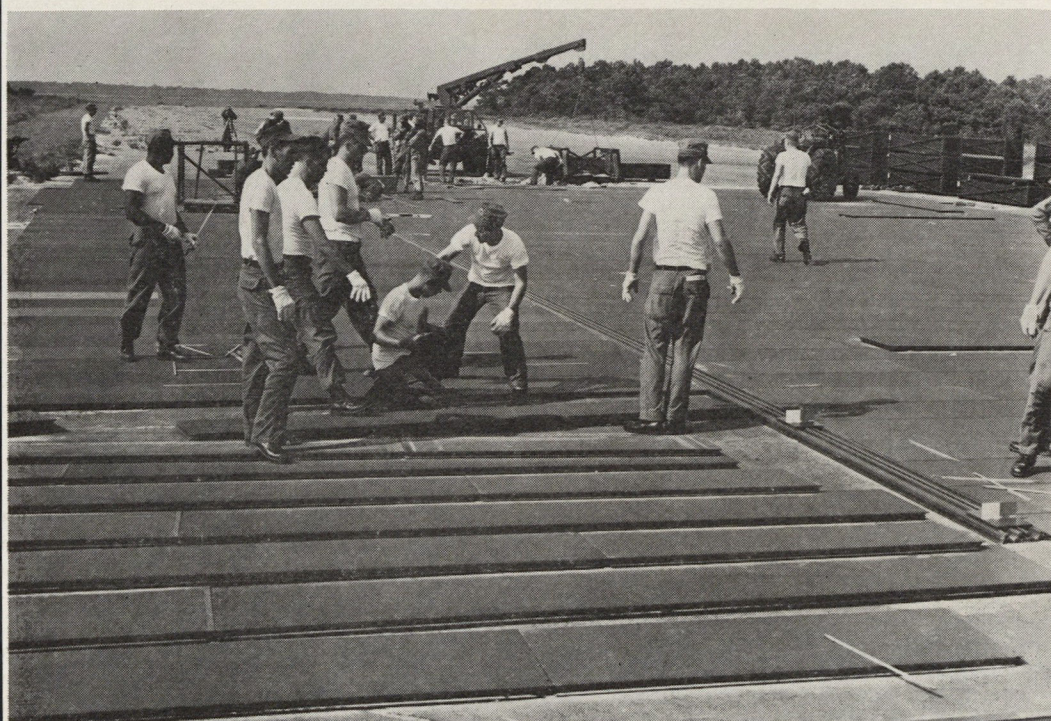
The Seabees, or naval construction-battalion personnel, working two six-hour shifts, are able to lay 400 feet (122 m) of matting a day.

Both the catapult and the arresting systems used in SATS operations have evolved from the systems used aboard aircraft carriers. A portable tower houses all the normal functions of an Air Station Control Tower.

At each end of the runway a CE-1 MOD-3 catapult is installed; one is employed as a backup to the other. The catapult is powered by two J79 turbojet engines, which give the aircraft the added thrust necessary for liftoff from the short airfield.

An expeditionary SATS is an all-weather site permitting operations under reduced visibility and total blackout if necessary. A returning aircraft locates the small base through a navigation beacon called the Tactical Air Navigation System (TACAN). This beacon emits a signal picked up by the antenna of an aircraft and gives

(Continued on following page)



As the work progresses, what had been scrub forest takes on the look of an airfield. Here the Seabees lay the matting and the catapult track simultaneously during construction of the new SATS runway at Bogue Field, North Carolina.



As the new runway nears completion, Marine launch and recovery technicians install the dolly-arrester assembly. Nylon rope is reeved through the sheaves on this assembly and on an identical assembly at the other end of the runway to stop the catapult dolly.

the pilot a readout on his instrument panel of magnetic heading and distance to the field.

Within a hundred miles of SATS, the pilot contacts his Marine Air Traffic Control Unit (MATCU), which controls the site radar. This unit vectors the aircraft on line until ground control approach radar (GCA) can pick it up and talk the pilot in by radio.

Finally the pilot follows a vertical row of orange lights shining from a Fresnel Lens. The lens appears as a single round ball. There are several in succession, making up the vertical row. By centering these lights, the pilot can reach his touchdown point.

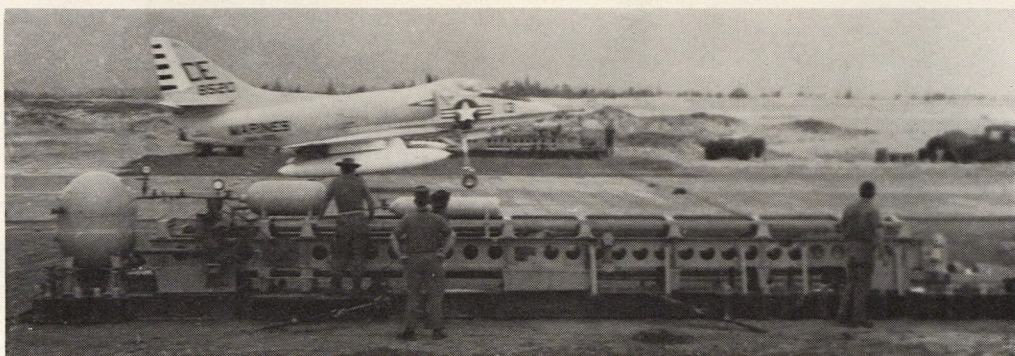
In the middle of the airstrip are two M-21 arresting gear units used to assist the aircraft in landing. Two units are installed as safety measures.

The M-21 is a newly developed arresting gear that utilizes a turbine wheel in a fluid-filled tub. The turbine wheel spinning at high speed in the fluid creates a braking force sufficient to stop heavy F-4 aircraft in 600 feet (183 m).

Another SATS site is being planned for West Coast training at El Toro, California. ☆☆☆

HOW THE SATS LAUNCH CATAPULT WORKS

An A-4B Skyhawk of the Marine Air Group at Chu Lai in Vietnam lands and hooks up with the portable arresting gear, foreground, used to shorten the ground roll during landing. Since last May the full SATS system has been in use at Chu Lai, using procedures and equipment similar to that at the Bogue Field site.



The catapult used in the SATS system employs a closed-loop cable and capstan method of launch. An "endless" 6,000-foot (1,829 m) steel wire rope is driven through a guide rail in the runway by two gas generators coupled through a reduction gear in the capstan.

An aircraft launch dolly is attached to this cable. The aircraft is pulled up to this dolly, using the catapult hooks built into all U.S. Navy and Marine Corps tactical aircraft for use on carriers. The guide rail is designed to protect the launch cable and help in directional control of the dolly and the aircraft during launch.

The aircraft is positioned at the launch end of the runway with its nose wheel on the dolly. A nylon bridle is applied to the aircraft and dolly. The dolly is fastened to the launch cable. A specially designed "holdback" assembly is fastened to the tail of the aircraft. This assembly is designed to release when the designed power of the air-

craft and the catapult exceeds the designed breaking strength.

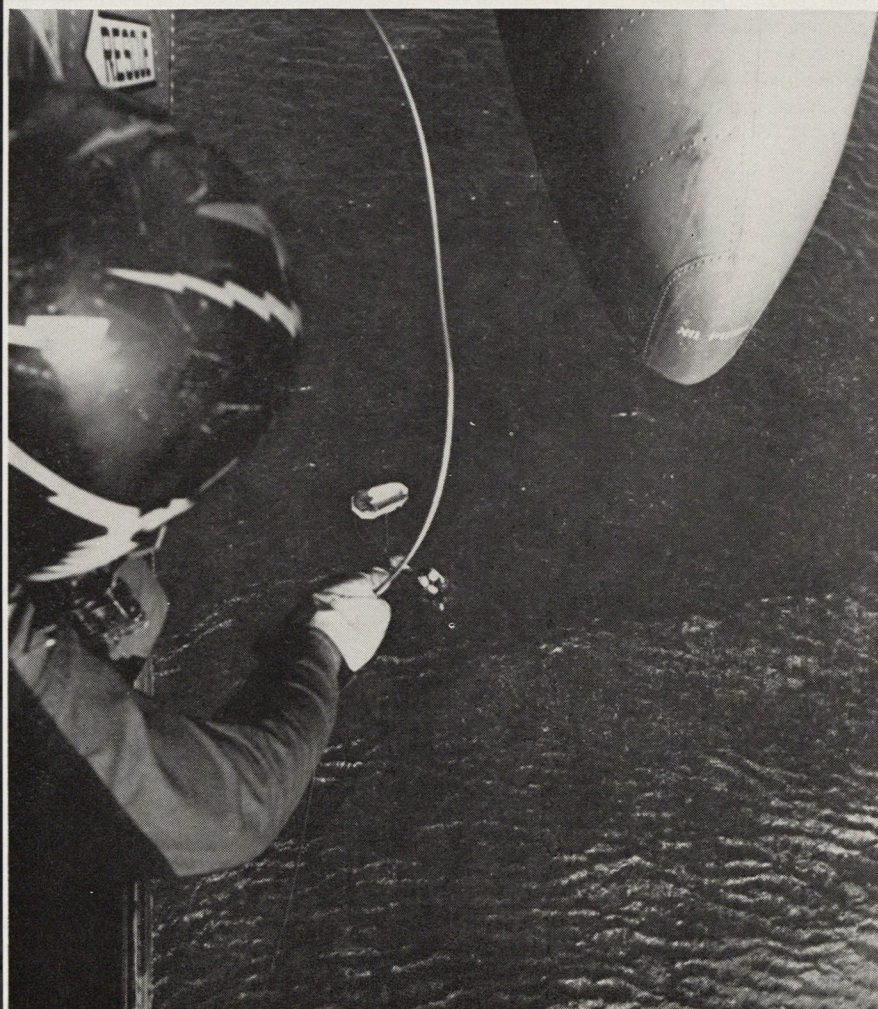
After the holdback assembly releases the aircraft, the catapult accelerates it to flying speed. The distance needed to launch an aircraft varies depending on the type and weight of the aircraft, temperature, and wind velocity. All this information is fed into a computer in the launch control system. The computer programs the catapult engine runup to ensure adequate power to launch the aircraft.

When the aircraft reaches its precomputed flying speed, the catapult engines are returned to idle power, allowing the aircraft to drop the bridle attaching it to the dolly and to proceed with its mission. The dolly continues down the runway until it contacts a dolly-arrester system. This system, using elastic nylon rope, unlocks the dolly from the launch cable and returns it, "slingshot" fashion, to where another aircraft is waiting to repeat the cycle.

Primary responsibility for rescuing U.S. aircrews who bail out over the South China Sea is exercised by Navy ships and helicopters, aided by Air Force HU-16 amphibians. When an airman is shot down over land or sea, his recovery becomes the top-priority objective of all operational aircraft and surface forces in the vicinity, often under fire from Communist guns . . .

Target: Downed Pilot

BY NORMAN POLMAR, Assistant Editor, "U. S. Naval Institute Proceedings"
Contributing Editor for Naval Affairs, AEROSPACE INTERNATIONAL



A most welcome sight to a downed pilot is this U. S. Navy SH-3A Sea King helicopter hovering overhead as a crew member guides a recovery line toward the pilot's raft. If the pilot were injured, a rescue team member would drop into the water to aid him.

A vital mission of the U.S. naval forces in the Vietnam War is search and rescue (SAR), especially for U.S. fliers whose planes are shot down or severely damaged on missions over North Vietnam. With U.S. aircraft losses over North Vietnam averaging six a week during 1966, and increasing by virtue of the growing number of strikes against the North, the number of SAR missions is continually increasing.

The Navy SAR role in the Vietnam War may be divided into essentially two categories: (1) responsibility for rescue of its own forces in naval operations and (2) responsibility for the rescue of anyone—military, civilian, friendly, and unfriendly—at sea.

The responsibility for rescue of one's own forces is an inherent military capability. Every air base has its own rescue helicopters, crash trucks, and specialized equipment. Army and Marine ground forces have their own troops, helicopters, and tactics for rescuing an isolated unit or a pilot downed nearby. So, too, do Navy ships have men designated as rescue swimmers, ready lifeboats or rafts, and helicopters.

During air operations a carrier will fly off one or two of her helicopters—referred to as "angels"—to hover just to starboard of the ship while she launches or recovers aircraft. These helicopters, generally Kaman UH-2 Seasprites, are ready to dash in and pick up a pilot who ditches during landing or takeoff. In addition, a destroyer frequently trails close behind

(Continued on following page)



Though normally employed for antisubmarine patrol, Sikorsky SH-3A Sea King helicopters, with ASW gear removed, are now operating from U.S. Navy carriers in the Gulf of Tonkin to assist in rescuing aircrews who bail out of disabled aircraft.

a carrier on plane guard duty during flight operations. When flight operations aboard the carrier are concluded, the "angels" will come back to the flight deck and the destroyer will drop back from the carrier to take her normal position in the carrier's protective screen.

Such operations are normal, everyday occurrences in carrier work and have been since the U.S. Navy got its first aircraft carriers in the 1920s. Helicopters came on the scene to supplement destroyers in plane guard duties in the late 1940s. Today the "angels" often pluck an aviator from the water seconds after his plane ditches.

The massive employment of U.S. naval forces in the Vietnam War has made the Navy a partner with the Air Force in the rescue of Air Force, Navy, Army, Marine, and South Vietnamese fliers who crash in Vietnam or off-shore.

The over-all responsibility for SAR in the Vietnam area rests with the Joint Rescue Coordination Center at Tan Son Nhut Airfield in Saigon. This Center is an activity under the U.S. unified commander in Vietnam, Army General William C. Westmoreland, who commands all U.S. military forces in the war. His agent for SAR is the Air Force which has the 3d Aerospace Rescue and Recovery Group at Tan Son Nhut. This group operates the Joint Rescue Coordination Center, which includes Army and Navy liaison officers. Ironically, there are no representatives of the U.S. Coast Guard at the Center. That service, traditionally a maritime rescue agency for the United States, is being employed in a strictly naval role in the Vietnam War, and the Coast Guard patrol boats being used in the war are under Navy operational control.

There is a coordination subcenter at the large U.S. military complex at Da Nang. (Both Tan Son Nhut and Da Nang serve as bases for Air Force

squadrons flying rescue helicopters and fixed-wing aircraft.) The two coordination centers keep track of which rescue aircraft are available, how soon they can reach a specific location, how soon protective fighters or attack aircraft can be en route, etc.

When a U.S. or South Vietnamese plane is hit by enemy fire or suffers mechanical trouble over Vietnam, another pilot, generally his wingman, becomes the self-appointed, immediate on-scene rescue commander. During major strikes against the North an Air

Force HC-130H four-engine transport is airborne to serve as the rescue command aircraft. Using special, pre-arranged SAR radio circuits, the on-scene commander puts out a call for the nearest rescue aircraft, apprises the Joint Rescue Coordination Center or subcenter of the situation, and, if necessary, puts out a call for a rescue combat air patrol.

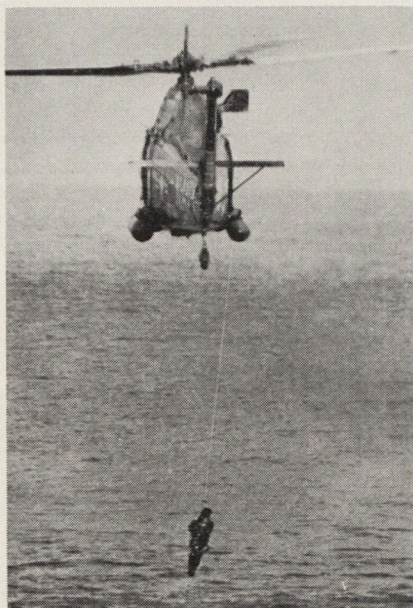
Basically, the Air Force has responsibility for rescues over land and the Navy for overwater operations. If at all possible, the pilot of a damaged plane will try to get out to sea before he parachutes or ditches. At sea, his chances of escaping capture by the North Vietnamese or Viet Cong are immensely greater, and at the same time he will be easier to rescue. "At sea" here can mean in Haiphong Harbor, just 100 yards (90 m) from shore—where at least one rescue helicopter has picked up a downed U.S. pilot.

Whether he comes down on land or water, the downed pilot has Personal Locator Beacons attached to his parachute and person. These are small electronic homing devices which put out a signal to guide rescue aircraft. In addition, voice communications can be carried on by most of the homing sets carried by the pilot.

The land-water division of rescue



Rare photo of pilot actually ejecting from his doomed aircraft was taken by fellow pilot in formation off Vietnam. Flier, still in ejection seat, appears above and behind his wingman as his abandoned F-8 Crusader begins dive into Gulf of Tonkin. The pilot was in the water only 80 seconds before he was rescued by a carrier-based helicopter.



responsibility means that fliers ditching or parachuting into the sea will generally be picked up by a Navy helicopter or an Air Force seaplane. Strangely enough, all rescue flying boats used by the United States in Southeast Asia are Grumman twin-engine HU-16 Albatross aircraft operated by the Air Force. However, the effort to get the downed flier out as soon as possible often brings Air Force helicopters over water and Navy helicopters over land.

If there is any sign of enemy opposition to the rescue, the on-scene commander will call for a rescue combat air patrol. A RESCAP mission takes precedence over any other mission, and aircraft in the area—Navy, Marine, or Air Force—will abort other missions to come to the aid of the downed pilot. Aircraft returning to their airfield or carrier will, if fuel permits, turn around. Aircraft which have expended their bombs, rockets, and ammunition will turn back even if only to make dummy runs on enemy forces attempting to interfere with a rescue. Aerial tankers—already airborne, at land bases, and on carriers—will stand by for in-flight refueling of RESCAP aircraft, if necessary.

U.S. Navy destroyers or patrol boats in the area of a water rescue will steam toward the scene to assist in whatever way possible. Often this means firing on Communist coastal positions which are attempting to interfere with a rescue. The first U.S. naval bombardment of North Vietnam came when a U.S. destroyer blazed away with her own 5-inch (127 mm) guns at a North Vietnamese gun battery shooting at U.S. rescue aircraft.

The smaller patrol boats—generally of the 50-foot (15 m) SWIFT class, armed with machine guns and an 81-

mm mortar—have proved particularly useful in searching coastal waters and suspected Communist junks for downed U.S. fliers.

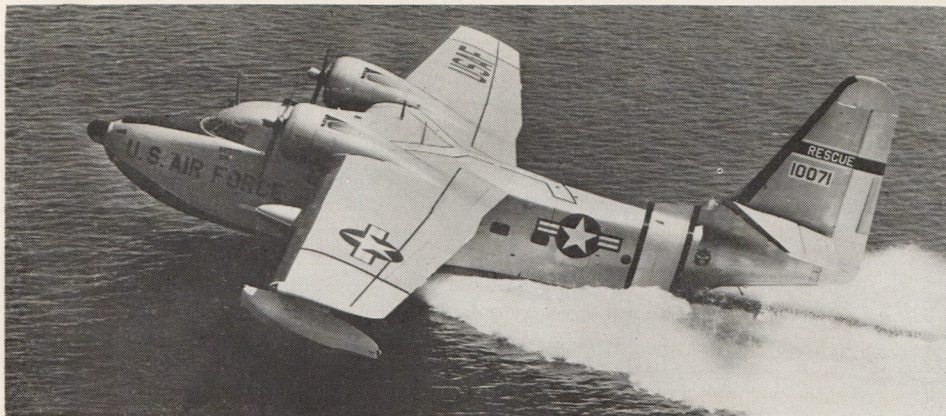
The destroyers and larger frigates (destroyer leaders) also serve as advanced bases for Navy rescue helicopters. The Navy SH-3A and UH-2A-2B helicopters are based aboard aircraft carriers which operate well offshore in the South China Sea. The smaller UH-2 Seasprites can land on and operate from the frigates, which are as large as some World War II-era light cruisers (5,350 to 8,700 tons/4,852 to 7,892 mt full load). The larger SH-3A Sea Kings cannot operate from the frigates, and neither helicopter can land on the smaller destroyers (about 3,000 tons/2,721 mt full load). However, the destroyers are fitted with small flight decks, hangars, and other aviation facilities to operate small, unmanned antisubmarine helicopters. The Sea Kings can hover over the destroyers and, while the ship is under way, take on fuel, using their rescue hoists to hold the fuel line. No special equipment is required by the helicopters except for a device to prevent their rescue hoist from pinching the fuel line. Ship-to-air refueling cannot be undertaken by the UH-2 Seasprite because of the location of the helicopter's fuel receptacle.

The Navy normally operates two destroyers or frigates in the Gulf of Tonkin to serve as radar picket ships and as advanced bases for SAR helicopters.

The Sikorsky SH-3A Sea King now being used in Vietnam is the Navy's standard antisubmarine helicopter. It is a twin-turbine aircraft with a gross weight of approximately 18,000 pounds
(Continued on following page)

This three-photo sequence above and at right records the rescue of an aircraft mechanic knocked from the flight deck of a carrier by the blast of a jet engine. At top, a crew member of the Kaman UH-2B Seasprite helicopter attaches a rescue collar around the mechanic. Above, the victim, uninjured by the mishap, is being lifted to the helicopter, and at right he is being drawn into the Seasprite's open hatch. Because its range is less than that of the Sea King, the UH-2B is normally employed in recovery operations adjacent to its carrier.





The Grumman HU-16 Albatross amphibian is flown by U.S. Air Force crews on rescue missions in the waters off Vietnam. Its crews have frequently been cited for bravery in recovering airmen under fire from shore batteries.

(8,165 kg). The Sea King is based aboard ASW carriers in squadron strength, and detachments are being assigned aboard attack carriers in the Western Pacific. In the SAR role much of the helicopter's specialized equipment, including "dunking" sonar, has been temporarily removed. Aircraft and personal body armor is used on SAR missions and two 7.62-mm machine guns are fitted to suppress enemy fire. The helicopter has a pilot, copilot, and two enlisted aircrewmen on SAR missions and can accommodate about a dozen passengers.

The U.S. Air Force uses a specialized rescue variant of this helicopter, the HH-3E, which is especially fitted with armor, jettisonable fuel tanks, and

rescue hoist, and is camouflaged to reduce vulnerability. This version—famously known as the "Jolly Green Giant"—can carry up to 25 passengers.

The Kaman UH-2 Seasprite, used only by the Navy, has a single gas-turbine engine and a gross weight of approximately 9,000 pounds (4,082 kg). The Seasprite is used for rescue and utility work aboard Navy carriers and cruisers. Like the Sea Kings, for SAR operations in Vietnam the Seasprite is fitted with armor and 7.62-mm flexible machine guns. Three or four men fly the Seasprite, and up to seven passengers can be squeezed into the aircraft.

The longer-range Sea King performs most of the Navy SAR missions along

the coast of North Vietnam, principally because of its greater endurance. However, because of the primary SH-3A mission of antisubmarine warfare, the immediate threat of enemy submarine action would cause all available Sea Kings to be fitted for combat and used in support of naval operations. In this situation, the UH-2 Seasprites would have to concentrate on strictly naval rescue and utility missions, leaving most of the SAR work over Vietnam to the Air Force, which has the only U.S. aircraft in Southeast Asia specifically designated for search and rescue (at this time HC-130H Hercules and HU-16 Albatross fixed-wing aircraft, and H-43 and HH-3E helicopters, a total of about 60). ☆☆☆

Closeup view of the Kaman UH-2B Seasprite, powered by a General Electric T58-8 engine with 1,250 shp. It has been fitted with 7.62-mm machine guns and armor plate for search and rescue operations off Vietnam.



Capable of in-flight refueling for long-range rescue operations is the Air Force's HH-3E "Jolly Green Giant." It is similar to the Sikorsky CH-3C transport helicopter but employs a more powerful engine and special communications and rescue equipment.

Both sides are girding for a step-up in the air war over Vietnam, as indicated by more frequent MIG encounters and a boost in U.S. orders for fighter planes. . . . NASA scientists, puzzled over difficulties of working in space, hope to learn more from Gemini-12's flight in November. . . . Guests at AFA's Fall Meeting in Washington included educators from 60 countries. . . . Smokeless missile propellant, a laser gyroscope, and in-flight reconnaissance photo processing are among recent technical developments. . . . And a parachutist has been recovered by an aircraft in a dramatic demonstration of a new rescue technique. It was a month marked by . . .

MIGS, Meetings, and Midair Recovery

BY ALLAN R. SCHOLIN, Associate Editor

Defense Secretary Robert S. McNamara announced a 30-percent increase in U.S. fighter aircraft production late in September. His action came at the same time that a Congressional subcommittee was investigating the U.S. tactical aircraft inventory and production rates.

Orders will be raised by a total of 280 aircraft, Mr. McNamara said, totaling about \$700,000,000. One type to be ordered, he said, is the Navy version of the Ling-Temco-Vought A-7A subsonic long-range attack fighter. He did not name the others, but they were understood to include the McDonnell F-4 for both Navy and Air Force, a small number of Northrop F-5A Freedom Fighters for the Air Force, and the Grumman A-6A all-weather Intruder and Douglas A-4F fighter for the Navy.

McNamara noted that he had previously stated the current Defense budget was based on the arbitrary assumption that the Vietnam War would be ended by June 30, 1967—the end of the current U.S. fiscal year.

"I told Congress repeatedly," he said, "that if the conflict were to continue beyond that date we would have to adjust certain programs accordingly."

"Because of the long lead times involved in aircraft production, I have come to the conclusion that it is wise now to place on order aircraft that may be required to support operations beyond June 30, 1967."

His announcement came on the same day that Arthur Goldberg, U.S. Ambassador to the United Nations, announced that the U.S. was prepared to halt fighter-bomber attacks on North

Vietnam "the moment we are assured, privately or otherwise," that Hanoi will make corresponding reductions in the North Vietnam war effort. McNamara insisted that there was no "carrot and stick" relationship between the two announcements.

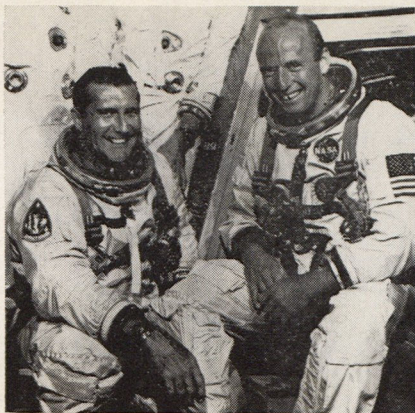
The Congressional investigation into aircraft shortages is being conducted by a subcommittee of the House Armed Services Committee. The group, headed by Rep. Otis G. Pike, a New York Democrat, is looking into the

current tactical aircraft inventory and future requirements, production capability, the length of time elapsing between a firm statement by the military of a requirement and delivery of operational aircraft, and the differences between costs of the delivered aircraft compared to that quoted when production is first approved.

The latter point is presumably prompted by the case of the General Dynamics F-111 variable-sweep-wing
(Continued on following page)



Shown at Williams Air Force Base, Arizona, are these Northrop F-5A Freedom Fighters and their pilots just before departure on transpacific flight to Vietnam. F-5s are among several aircraft types in new 280-plane order placed by U.S. Defense Department.



NASA Astronauts Richard Gordon, left, and Charles Conrad reached highest altitude of 850 miles (1,368 km) in manned spaceflight during three-day Gemini-11 mission in September. Both are U.S. Navy commanders. Double exposure photo at right showing launch complex at Cape Kennedy, Fla., captures liftoff of Atlas-Agena, right, 97 minutes before Titan II, left, boosted Conrad and Gordon to rendezvous with Agena on first orbit.

fighter, whose costs have reportedly more than doubled over the price estimated when the initial contract was announced in November 1962.

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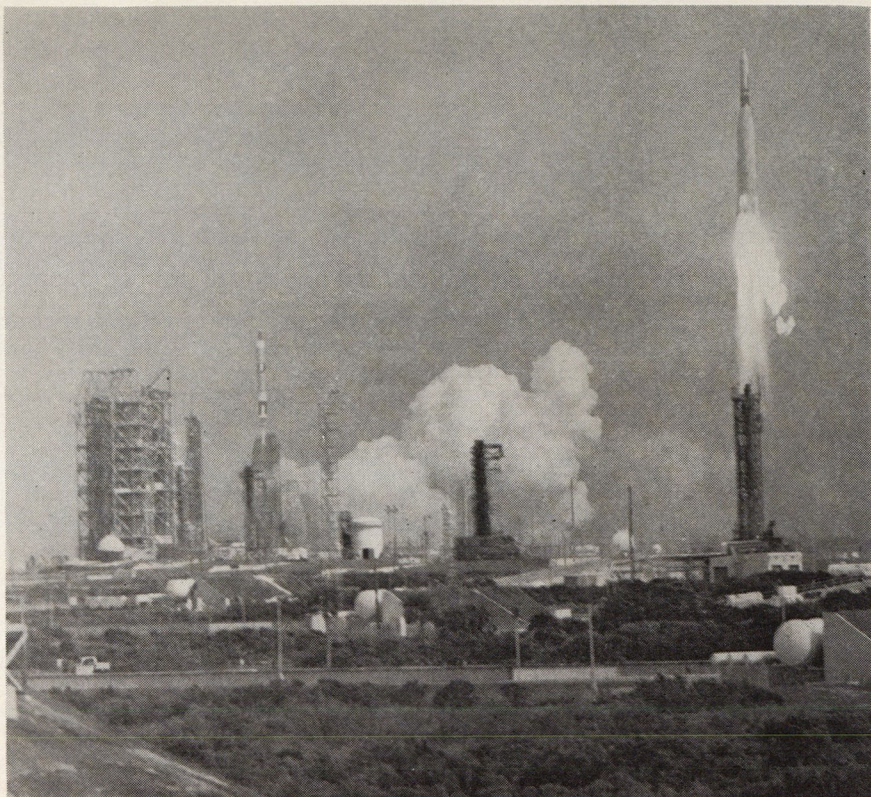
Gemini-12, a four-day mission and the last of the National Aeronautics and Space Administration's two-man Gemini spaceflight series, is expected to take place in November, clearing the way for the first manned Apollo flight in December or early January.

At the controls of Gemini-12 will be Navy Captain James A. Lovell as spacecraft commander, accompanied by Air Force Major Edwin E. Aldrin. Captain Lovell flew with Air Force Colonel Frank Borman in the 14-day mission of Gemini-7 last December. This will be Major Aldrin's first space mission.

Backup crew for Gemini-12 are USAF Colonel Gordon Cooper, veteran of the eight-day flight of Gemini-5 in August 1965, and Navy Commander Eugene A. Cernan, who flew in Gemini-9 last June.

Captain Lovell and Major Aldrin may find it difficult to improve on the flight of Gemini-11 in September. From a rendezvous and docking with an Agena target vehicle on their first orbit to splashdown only two miles from their recovery carrier three days later, the two-man crew of Gemini-11 set numerous new space records in carrying out an almost perfect mission.

Spacecraft commander was Navy Commander Charles Conrad, Jr., who flew in Gemini-5 with Colonel Cooper. His partner was a space neophyte, Navy Lieutenant Commander Richard Gordon, who was promoted to Com-



mander immediately following the flight.

Gordon spent a total of almost three hours outside the Gemini-11, more than any other astronaut. But his space walk proved as exerting as Commander Cernan had experienced in his attempt to don a maneuvering pack during the flight of Gemini-9 and Gordon was ordered to cut short his extravehicular experiments.

Difficulties of performing even relatively simple tasks in space surprised NASA scientists. "You'd think in the zero g [weightless] state that it would

be easier," said Dr. Charles A. Berry, Chief of Medical Operations in the manned spaceflight program. But he pointed out that in space every movement in one direction requires equal energy to be applied in the opposite direction. For example, to turn a door handle in space the astronaut must apply as much effort to keep from turning himself as he does to turning the handle.

On the second day, with Gemini docked to the Agena, Conrad fired the latter's rocket engine. Its thrust of 16,000 pounds (7,258 kg) boosted



First VTOL aircraft to reach speed above Mach 2 in level flight is Dassault Mirage IIIV. Flown by Dassault test pilot Jean-Marie Saget, the second of four prototypes in development program was clocked at Mach 2.04 on its eleventh flight September 12. Saget reported a very smooth transition from vertical to horizontal mode and back.

Gemini-11 into an orbit with an apogee of 850 miles (1,368 km), almost twice as high as the 475-mile (765 km) height reached by Gemini-10. At that altitude the astronauts could see almost a third of the earth's circumference.

"It's fantastic," Conrad exclaimed. "I've got India in the left window and Borneo under our nose."

The reentry on Thursday, September 15, was the first to be completely controlled by an on-board computer. It worked perfectly, bringing the capsule down in the Atlantic within two miles (3.2 km) of the USS GUAM.

NASA's joy over the success of Gemini-11 was tempered somewhat by failure of stabilization devices aboard its second unmanned Surveyor craft en route to a soft-landing photo mission on the moon. Launched from Cape Kennedy, Florida, on Tuesday, September 20, it was on a perfect trajectory when it began tumbling in space. Efforts to right the spacecraft failed and, with its retrorockets useless to slow its descent, it crashed into the moon two days later.

* * *

U.S. pilots attacking targets in North Vietnam can expect to meet growing air opposition in the coming months. Hanoi is getting more MIG-21 supersonic interceptors from the Soviet Union, and pilots to fly them are being trained in the USSR.

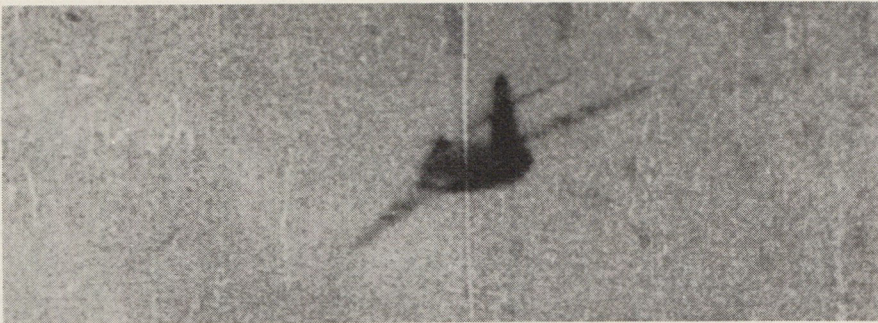
At least two 40-man classes have already been graduated from the Soviet Military Aviation School at Bataisk, near Rostov-on-Don in southern Russia. Training in single-seat MIG-21 Fishbeds includes air-to-air intercepts against Soviet instructors imitating U.S. fighter-bomber tactics.

The Soviet newspaper Pravda described one such flight by Vietnamese pilot Lieutenant Khan Van Tyuk.

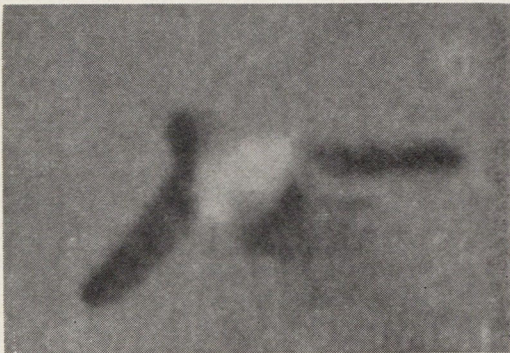
"His 'adversary' took complex evasive maneuvers, changing speed, altitude, and direction in an attempt to escape the 'hammer blow,'" said Pravda. But Van Tyuk, guided by ground control radar, soon spotted the "enemy" and pressed home his attack.

Moscow has promised Hanoi as many MIG-21s as its pilots and ground crews can handle. That it may be adding some all-weather MIG-23 Flippers was indicated by a passage in the Pravda article claiming that Hanoi pilots would be able to fly "at any altitude in any weather." The MIG-21 is basically a day fighter.

The MIG-23 employs the same type delta wing as the MIG-21 but has an elongated forward fuselage and is probably equipped with two engines, giving it a Mach 2.5 capability. A conical search radar extends from the huge



These gun-camera views show the first North Vietnamese MIG-17 to be destroyed by a Republic F-105 Thunderchief pilot. The action occurred on August 18. Above, the MIG-17 appears in the Thunderchief pilot's gun-sight. As he opens fire with his 20-mm Vulcan Gatling gun, hits appear on the wing and fuselage at the wing root. Third photo shows MIG-17 bursting into flames. It went into dive and crashed moments later. Two more MIG-17s were downed by F-105 pilots on September 21, bringing to 21 the total number of MIGs destroyed over North Vietnam by Air Force and Navy pilots.



F-105 pilots who bagged second and third MIG-17s on September 21 are First Lieutenant Fred Wilson, 26, left, and Karl W. Richter, 23. Richter is youngest pilot to claim air victory in Vietnam War.

nose air intake. It also carries a pair of air-to-air missiles under the wings, similar to the U.S. Sparrow III, but larger. Pravda said the training at Bataisk includes practice in missile firing.

The main MIG targets in North Vietnam are U.S. Air Force F-105 fighter-bombers, which are limited to about half the MIG's speed until they complete a bomb run. Combat air patrol (CAP) cover for the F-105s is flown by F-104s and F-4Cs which move in quickly to peel the MIGs off the Thunderchief pilots' backs. Once the F-105 gets rid of its bombs, it can take care of itself. Three MIG-17s were destroyed by F-105s in just over a month—two on September 21 and one on August 18.

CAP-cover pilots look forward to more MIG activity. When North Vietnamese planes are nearby, they point out, SAM anti-aircraft missile sites below hold their fire. And U.S. interceptor pilots are confident that with more MIGs around they can quickly improve on the present five-to-one ratio of air-to-air kills in the U.S. favor so far.

* * *

Advanced education techniques, including those the U.S. Defense Department will apply to salvage individuals rejected for military service because of educational deficiency, were featured at a two-day Seminar

(Continued on following page)

on Educational Technology in conjunction with the annual Fall Meeting of the Air Force Association in Washington, September 15-16.

More than 500 educators and school administrators from throughout the U.S. and 60 foreign countries joined with executives and education specialists from Government and industry in the seminars, conducted by the Aerospace Education Foundation, an AFA affiliate, in cooperation with the U.S. Office of Education and the U.S. Air Force. Foreign educators were visiting the U.S. under auspices of the Office of Education and State Department.

Defense Secretary Robert S. McNamara announced in August that thousands of men now being rejected for military service would be salvaged "first for productive military careers and later for productive roles in society," through the application of advanced educational techniques pioneered by the Air Force. These techniques were described by Air Force training specialists at the seminar.

Participants also attended a series of Aerospace Development Briefings, in which scientists and engineers from 45 U.S. and Canadian firms discussed aerospace applications of advanced equipment and techniques.

Among more than 3,000 who attended the briefings were military and civilian executives of the Defense Department, National Aeronautics and Space Administration, Federal Aviation Agency, Atomic Energy Commission, and Department of Commerce, as well as members of Congress and foreign military attachés in Washington.

* * *

A military pilot forced to parachute from a disabled plane over enemy territory can be rescued in midair with a



Feasibility of performing midair rescue of pilots forced to abandon disabled aircraft over enemy territory was demonstrated at Georgetown, Delaware, in September by All American Engineering Company, which designed recovery equipment in collaboration with Pioneer Parachute Company. Reportedly the first human to be recovered in midair by an aircraft, Charles Alexander, Pioneer engineer, is shown here being drawn into ramp of C-122 aircraft after his parachute was snagged by the unique retrieval system.



This was the scene in exhibit hall as U.S. Vice President Hubert H. Humphrey, at left, opened the Air Force Association's Fall Meeting in Washington, D. C., September 14. Flanking the Vice President on his left are Gen. J. P. McConnell, USAF Chief of Staff; Dr. Glenn Seaborg, Chairman of the Atomic Energy Commission; and Dr. Robert Seamans, Deputy Administrator of NASA. At right, with back to camera, are Air Force Secretary Harold Brown and William F. McKee, Federal Aviation Agency chief.

device developed by the All American Engineering Company at Georgetown, Delaware.

In the first known demonstration of a live midair retrieval, a parachutist falling through the air at a rate of more than 1,000 feet (305 m) a minute was snatched out of the sky by an airplane traveling at 120 miles per hour (190 km/hr).

The successful test was performed at All American's facility at Georgetown in September, cosponsored by the Pioneer Parachute Company which developed the parachute system.

Basic equipment required to recover a man in the air is already in existence. It has been used by U.S. military aircrews to recover capsules released from orbiting spacecraft and to pick up personnel and cargo from the surface of land or sea.

The parachute system requires only slight modification to the standard fighter pilot's chute. To it is added an engagement parachute 11 feet (3.3 m) in diameter, attached to the main 28-foot (8.5 m) canopy by a nylon line 70 feet (21 m) long. Thus, if for some reason the midair retrieval should fail, the pilot's main parachute would not be affected.

Heart of the retrieval system is an energy-absorbing winch in the retrieval aircraft. A line from the winch is connected to a nylon loop-and-hook assembly held in place below and behind the aircraft by two steel poles. The aircraft flies directly over the top of the engagement canopy and as the poles make contact with the small parachute the winch line slips into strong nylon loops across the canopy's top.

When the parachutist is snagged, the winch yields line, much as a fishing reel unwinds in response to a retreating fish, reducing "g" forces until the individual's speed matches that of the plane. Then the winch reverses and reels him into the aircraft.

Subject for the first test was Charles Alexander, a veteran parachutist and Pioneer's project engineer. He reported the "g" force he experienced when the device caught his chute was less than the opening shock of the parachute itself.

All American, the foremost U.S. company in designing and producing retrieval equipment, said the system could be installed on many types of cargo or helicopter aircraft.

* * *

What's the most widely flown military aircraft in the world? Not too surprisingly, it's the ancient Douglas C-47, represented in the air forces of 66 nations from Argentina to Zambia, no-

tably excluding the hard-core Communist bloc. The world's second most popular plane is the North American T-28 trainer/light fighter, serving in 50 nations. T-28s are still being withdrawn from storage and modified as the T-28D COIN fighter for some countries receiving U.S. military aid, so the total may grow slightly in the coming year, but won't approach the C-47's record.

In third place is the Lockheed T-33 trainer, flown in 31 nations. The fourth is the Beech C-45 Expediter, a twin-engine utility transport, operated by 27 countries, closely followed by the Sikorsky H-19 Chickasaw helicopter in 25, and Bell H-13 Sioux in 23. Next comes the North American F-86, flying in various configurations in 22 nations.

The most widely flown Soviet planes are the MIG-17 and MIG-15 UTI trainer, each operated by 21 countries. Britain's Vampire T.11 trainer shows up in 20 air forces. Eighteen nations fly the Ilyushin IL-14 transport, tied by the French Alouette II helicopter, de Havilland of Canada's Beaver light utility plane, and Grumman's HU-16 amphibian.

France's Alouette III helicopter appears in 16 countries, the Soviet Beagle light bomber and de Havilland Chipmunk trainer in 15, the Northrop F-5 in 14, and Lockheed's F-104 in 13 and its C-130 transport in 12.

* * *

Development of an airport control-tower communications system that automatically broadcasts prerecorded weather, runway availability, and other flight information to incoming and outgoing airplanes was announced recently by General Telephone & Electronics Corporation, New York City.

Called Automatic Terminal Information Service (ATIS), the system was designed by Automatic Electric Company of Northlake, Illinois, a subsidiary of GT&E, to reduce the workload of control-tower operators, ease radio-frequency congestion, and permit pilots to obtain routine flight information when cockpit duties are least demanding.

The U.S. Federal Aviation Agency already has installed an ATIS unit at Chicago's O'Hare International Airport, and will install the system over the next several months at airports in 34 states, Washington, D. C., and Puerto Rico.

O'Hare International is the world's busiest airport, having handled 21,000,000 passengers and 510,000 flight operations (takeoffs and landings) in 1965. Other airports scheduled to receive ATIS equipment include those in New York, Boston, Pittsburgh, Cleveland, Detroit, Dallas, San Francisco, Los Angeles, and Seattle.

Darwin H. Deaver, President of Auto-

matic Electric, said the system was developed "to provide the telephone reliability in ground-to-air communications that is required for the constantly increasing air traffic."

ATIS enables control-tower personnel to prerecord broadcasts on magnetic tape providing such data as ceiling, visibility, wind direction, barometric pressure, runway in use, and similar information. The recorded messages are revised whenever conditions change, usually several times daily.

Incoming pilots tune to the designated radio frequency and receive the broadcasts several minutes prior to their initial contact with the control

MAC crews fly men and equipment through unpredictable weather from the United States to New Zealand and then to McMurdo Station throughout the Antarctic summer—October to March—every three or four days.

The Navy transport task unit, commanded by Lieutenant Commander Frank A. Achille, will be based at Christchurch until December 10, 1966. Working with them are four seven-man flight crews and maintenance teams stationed in New Zealand and McMurdo.

To prepare for their new mission, task unit members were sent to the Arctic Survival School at Eielson Air



Support of U.S. Antarctic exploration teams is again being provided this year by U.S. Navy and C-130 Hercules transports under direction of Military Airlift Command. Resupply operations for Antarctic posts are conducted during south polar summer, from October to March, when the temperature occasionally reaches as high as 32° F. (0° C.).

tower, while departing pilots obtain the information before leaving their gate positions at the airport.

* * *

One of the most arduous airlift assignments in the world—support of Operation Deep Freeze—is being conducted this year by Lockheed C-130 Hercules aircraft crews of the Military Airlift Command's (MAC) Naval Air Transport Wing Pacific of Moffett Field, California.

Deep Freeze is the code name for the supply and support of the U.S. National Science Foundation exploration of the Antarctic.

The U.S. Navy has over-all responsibility for the 1967 Deep Freeze operations, with MAC providing the bulk of the airlift support. The Moffett unit takes on the Deep Freeze assignment from another MAC C-130 unit, the 86th Military Airlift Squadron at Travis Air Force Base, California, which has flown Deep Freeze missions for the past two years.

Force Base, Alaska. Each man spent three days in the Alaskan wilderness living off the land and using the survival kit carried on Antarctic missions. They flew training missions over the Arctic to accustom themselves to polar flying, encountering such hazards as polar magnetic forces and the converging longitude lines which compound navigators' problems.

Another flying hazard is the Antarctic "whiteout," in which light is so perfectly reflected between cloud and snow that there are no shadows, horizon, or other surface definitions by which to gauge depth or height. Aircrews must depend upon instruments and ground controllers to guide them.

Antarctic "summer" temperatures can rise as high as 32 degrees F. (0 degrees C.), but often go to 40 degrees F. below zero (-40 degrees C.).

* * *

The 19th Annual International Air Safety Seminar of the Flight Safety
(Continued on following page)

Foundation, an independent, nonprofit organization with worldwide membership, will be held November 15 through 18 at the Castellana Hilton Hotel in Madrid, Spain.

Among the subjects of exceptional current interest scheduled for discussion by air safety experts coming to the seminar from every continent except Antarctica are the crash survival aspects of supersonic transport planes of the future, and the requirements for safety in design and development of very-large-passenger-capacity aircraft. A new look at the problems of terminal area air traffic control, aimed at eliminating or minimizing "stacking" of aircraft as it now is practiced, is expected to create considerable discussion among the air safety experts examining areas of improvement.

New developments, including experiments and tests with emulsified fuel, sensory illusions and human factors related to midair collision and landing accidents, and psychological techniques used in aircrew selection also will be discussed and analyzed.

There will be a panel on safety problems peculiar to European operations, and a roundtable on how to implement navigational and other aids in newly emerging and developing nations.

Safety approaches and problems affecting General Aviation—a term used to describe all flying except that done by the airlines and the military—will be examined carefully during the three-day Madrid Seminar.

There will be an updating of reports relating to bird "strikes" or collisions with aircraft, and a scrutiny of all jet accidents which have occurred since the 1965 International Air Safety Semi-



Biggest, heaviest, and fastest U.S. helicopter now in production is the Sikorsky CH-53A Stallion assault transport, which the Marine Corps expects to introduce into Vietnam operations late this year to supplement and later replace its CH-34 Choctaws. Meanwhile, the U.S. Air Force has ordered an air rescue version of the Stallion, designated HH-53B, with longer range and higher speed than its HH-3E Jolly Green Giant.

nar in Williamsburg, Virginia, together with a look at operational changes in flying which have resulted from previous discussions.

The Flight Safety Foundation, with headquarters in New York City, is supported by more than 300 corporations and agencies interested in improving air safety in all forms of flight. These include pilots' unions and associations, banks, insurance companies, fuel and oil companies, schools, air transport companies, manufacturers, and a great many general corporations having no direct connection with aviation.

Major General Joseph D. (Smokey) Caldara, a retired officer who was the U.S. Air Force's first Deputy Inspector

General for flight safety, is President, and Secor D. Browne, a member of the faculty of Massachusetts Institute of Technology and President of Browne & Shaw Research Corporation of Waltham, Massachusetts, is Chairman of the Board.

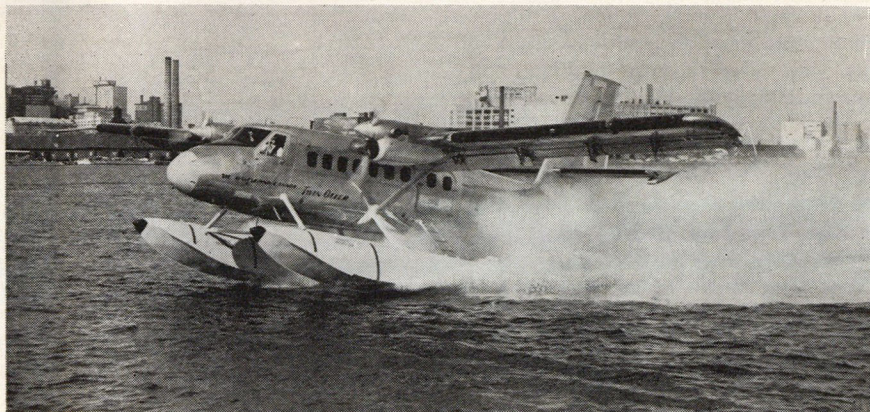
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The U.S. Air Force is joining the U.S. Marines in buying Sikorsky's CH-53 heavy-lift helicopter, the biggest and fastest helicopter in production in the Free World. The Marines expect to introduce the CH-53A into Vietnam combat before the end of the year, following crew training at their new helicopter training base at Santa Ana, California, and shipboard checkout. It will supplement and later replace the CH-34 Choctaw.

First deliveries of the Air Force HH-53B will begin early in 1967. Larger, faster, and with a heavier payload capacity than USAF's HH-3E Jolly Green Giant, it will be employed primarily in rescuing pilots downed in North Vietnam. Air-to-air refueling capability will give it an almost unlimited range for recovery missions.

Both Marine and USAF versions are powered by two General Electric T64 shaft turbines of 2,850 shp each, producing cruise speeds of 200 miles per hour (320 km/hr). Normal gross take-off weight is 35,000 pounds (15,880 kg), with payload of more than 15,000 pounds (6,800 kg). Range is about 300 miles (480 km).

The CH-53 employs many components of the U.S. Army's CH-54 Sky-crane, of which three prototypes are serving in Vietnam, but the Marine-Air Force helicopter has an enclosed fuse-



Seaplane version of DHC-6 Twin Otter taxis in Toronto Harbor testing its 32-foot (9.75 m) floats in preparation for certification trials, which its manufacturer, de Havilland of Canada, hopes to complete by November. Floats, built by Canadian Aircraft Products, Richmond, British Columbia, can be modified for water bombing, taking in up to 500 gallons (1,890 l) of water to be dropped on forest fires. The Twin Otter, powered by two United Aircraft of Canada PT6A-20 turboprop engines generating 578 eashp, cruises at 184 mph (296 km/hr) with a range beyond 800 miles (1,280 km).

large and watertight hull, permitting landings at sea. The Skycrane, with two 4,050-shp Pratt & Whitney shaft turbines, carries up to 20,000 pounds (9,070 kg) of payload. The Army has just placed an order for 18 more CH-54 Skycranes.

Larger than any U.S. chopper is the Soviet Mil MI-6. Powered by two 5,500-shp engines, it grosses at 88,000 pounds (39,900 kg), carrying 26,500 pounds (12,000 kg) of payload. Even bigger is the Mil MI-10 at 95,000 pounds (43,000 kg) gross weight. The cruising speed and range of the MI-6 is almost comparable to the CH-53, but the MI-10 barely exceeds 100 miles per hour (160 km/hr) over a 155-mile (250 km) range.

* * *

Development of a high-energy smokeless solid propellant for use in ground-launched tactical missiles has been announced by Lockheed Propulsion Company of Redlands, California.

U.S. Armed Forces have been seeking a smokeless propellant for use in tactical missiles launched by troops in the field because the smoke trail of existing propellants helps to identify the launch site.

Energy level of the smokeless propellant is notably higher than standard double-base fuels and equivalent in energy to regular rubber-base propellants in tactical use, said I. Lee Markovitch, manager of the Lockheed subsidiary which developed the product.

He described the propellant as non-toxic and noncorrosive, with very safe processing qualities. It can be tailored to a range of burning rates. Mechanical properties are very good over a temperature range of from -40 degrees to 60 degrees C., equivalent to rubber base systems.

* * *

A contract providing for a comprehensive study of an advanced materials-handling support system for movement of all Department of Defense air cargo has been awarded to Douglas Aircraft Company, Santa Monica, California.

The joint U.S. Air Force-Douglas \$488,500 study will form the basis for expansion and modernization of the Air Force's seven-year-old 463L materials-handling system employed with the Lockheed C-141 transport. Douglas also was prime contractor on conceptual studies that led to 463L, the first standardized, mechanized, and automated handling system for air cargo.

The new study will lead to maximum interchangeability between all modes of military and commercial transportation. It will provide for units packaged at the manufacturing site or other point of origin to be shipped as units

directly to the user, regardless of the user's location. It will also recommend the type, capability, and quantity of equipment needed at all stages of the transportation operation.

The new system is scheduled for implementation in Fiscal Year 1971 as part of the integrated U.S. Department of Defense worldwide distribution system.

* * *

Huge rubber tanks that look very much like giant bed pillows are helping assure the combat effectiveness of U.S. military forces in Vietnam.

Pillow tanks—several thousand of them—provide fuel for aircraft and ground vehicles that move troops and

(11,350, 37,850, 75,700, and 189,250 l, respectively). Empty weight varies from 150 pounds to 1,200 pounds (68 to 544 kg). Storage tanks are used individually or together in "tank farms," depending on fuel requirements.

* * *

A new film-processing system that can provide reconnaissance photos in seconds was demonstrated recently at the Air Force Avionics Laboratory at Wright-Patterson Air Force Base, Ohio.

The fast-reaction, high-quality aerial reconnaissance photography process was developed by Eastman Kodak Company, Rochester, New York. The system, called Bimat, uses a diffusion transfer technique that simultaneously



First photo of these Canadair-built jet planes in formation flight shows Northrop CF-5 tactical fighter, above, with CL-41 Tutor trainer. Montreal-based Canadair Ltd. has entered into production of 125 CF-5s for Royal Canadian Air Force. CL-41, featuring side-by-side seating, is the first trainer RCAF cadets fly. The Royal Malaysian Air Force has ordered 20 of a tactical fighter/trainer version, designated the CL-41G.

supplies and carry out attacks against the enemy.

Since military mobility depends so much on airpower, fuel is a critical item. Shipping fuel to Vietnam has posed only minor problems. Oil tankers arrive at coastal unloading areas on regular schedules. But distributing fuel to remote outposts had been a problem until rubber pillow tanks were put into service.

Because they are collapsible, the tanks can be moved quickly and easily. They are used primarily in areas where installation of permanent steel tanks is either impossible or impractical. They can be repaired quickly and easily in the field by inserting self-sealing elliptical compression clamps into holes and tears.

Pillow tanks, made by Goodyear of a synthetic rubber compound called Vithane, have been produced in 3,000-, 10,000-, 20,000-, and 50,000-gallon sizes

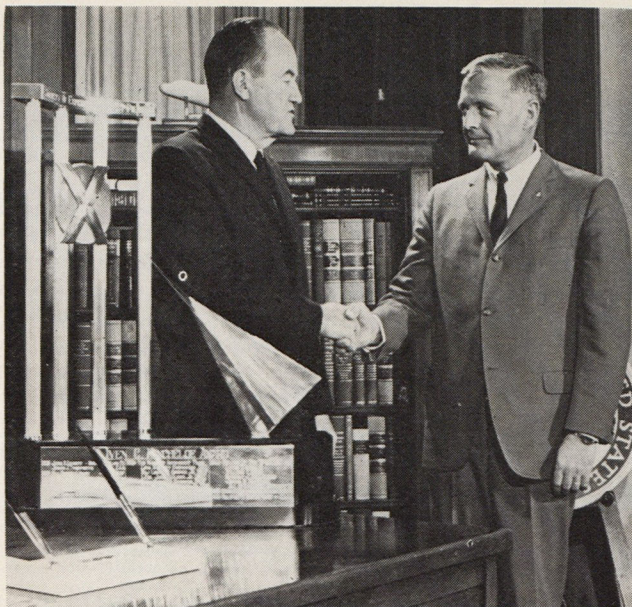
develops a negative and a high-resolution positive transparency in 30 seconds.

The four-year exploratory development program with Eastman Kodak was initiated to satisfy a continuing need for speedy acquisition of a positive imagery in the first-phase interpretation of aerial reconnaissance photography. The photos can be scanned in the air, jettisoned to the ground, or made available to photo interpreters as soon as the plane lands.

The portable experimental processor is six feet (1.8 m) long and one foot (30 cm) square, meeting tactical requirements for flexibility and mobility. In the Bimat process, a film-like material is brought into contact or laminated with an exposed negative material. When peeled apart after a brief interval, both the positive print and negative are available.

(Continued on following page)

Milton O. Thompson, right, National Aeronautics and Space Administration pilot, is congratulated by Vice President Hubert H. Humphrey on receiving the Iven C. Kincheloe Trophy. Thompson won the award for his pioneering flights in the M2 lifting body, forerunner of an aerospace plane.



A special processing film, consisting of a polyester film base carrying a gelatin layer containing physical development nuclei, is first soaked with one of the appropriate processing solutions, called imbibants. The imbibants contain chemicals which develop and fix the negative and transfer the positive image to the Bimat film.

No further processing steps are required. Three steps in three chemical solutions and large quantities of water are required in conventional film processing.

This processing technique is significant in tactical field use where it might be impossible to supply the chemicals and water necessary to maintain a conventional reconnaissance laboratory capability.

* * *

For his pioneering flights in a wingless and unpowered aerospace plane, Milton O. Thompson has been awarded the Iven C. Kincheloe trophy for 1966 by the U.S. Society of Experimental Test Pilots as the outstanding test pilot of the year. Presentation was made by Vice President Hubert H. Humphrey.

Mr. Thompson is a test pilot for the National Aeronautics and Space Administration. The M2 craft he flew, called a lifting body, represents the first step in establishing the technology needed for the design of a vehicle in which astronauts will be able to return to earth from orbiting spacecraft, with approach and landing under the pilot's control.

The Kincheloe Award memorializes Captain Iven C. Kincheloe, U.S. Air Force test pilot who in 1956 flew the experimental X-2 to a record height of 126,000 feet (38,400 m). A jet ace

in the Korean War, he was killed in July 1958 when his F-104 Starfighter crashed at Edwards Air Force Base, California.

Thompson made five flights in the original M2, a plywood design, beginning in 1963, and this year flew the metal M2-F2 for the first time. (See page 48, September 1966 issue.)

In the test program, the lifting body is airdropped from a B-52 bomber at 45,000 feet (13,600 m), then descends without power, gliding to a 200-mile-per-hour (320 km/hr) landing. The flight takes about four minutes.

In addition to his piloting duties, Thompson has been responsible for significant engineering and design contributions to the lifting body program. He has also flown the NASA-USAF experimental rocket plane, the X-15.

* * *

The world's first operational three-axis laser gyroscope is being tested by the U.S. Navy to assess the system's ability to precisely sense a ship's roll, pitch, and yaw, all of which affect the accuracy of naval radar and gunfire.

The advanced system, unlike any gyroscope previously built, was developed in only 12 months by military scientists and engineers of Honeywell, Inc., under contract from the Navy's ordnance and air systems commands.

For many years, engineers have sought methods to overcome friction-caused drift problems of conventional gyros by suspending its spinning rotor in a liquid, film of gas, or electrostatic or magnetic field.

The laser gyro utilizes a wholly new principle to sense rotational motion—two intense beams of coherent light

rotating in opposite directions. With no moving parts, the laser gyro potentially offers long operating life, high reliability, resistance to severe environmental conditions, wide dynamic range, and low cost.

Dr. Van W. Beringer, Vice President and General Manager of Honeywell's Systems and Research Division, said delivery of the working laser attitude sensor "marks a significant milestone in the development of the laser as a useful tool in military and space guidance and control."

Beringer said Honeywell scientists have been investigating basic properties of the laser (light amplification by stimulated emission of radiation) for more than four years, and seeking ways to apply its many inherent characteristics to ship, missile, aircraft, and artillery control problems.

The new system, Beringer said, incorporates significant advancements in laser design and fabrication that do away with fragile glass tubes and adjustable focusing mirrors of laboratory lasers, and permit immediate startup of the unit.

Each axis is built of a novel fused quartz block for ruggedness, long life, and ease of replacement. The triangular path through which the helium-neon gas beams pass is machined by a special precision technique.

Motion in one axis changes the apparent distance each beam must travel, causing a difference in the frequency at which each beam oscillates. The frequency difference is detected by two photocells and counted by associated electronic equipment. ☆☆☆



World's first operational three-axis laser gyroscope is checked out by a Honeywell scientist before delivery to the U.S. Navy. Without moving parts, the new system senses the roll, pitch, and yaw of a ship at sea, essential to the accuracy of its search radar and weapons control.

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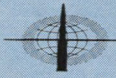
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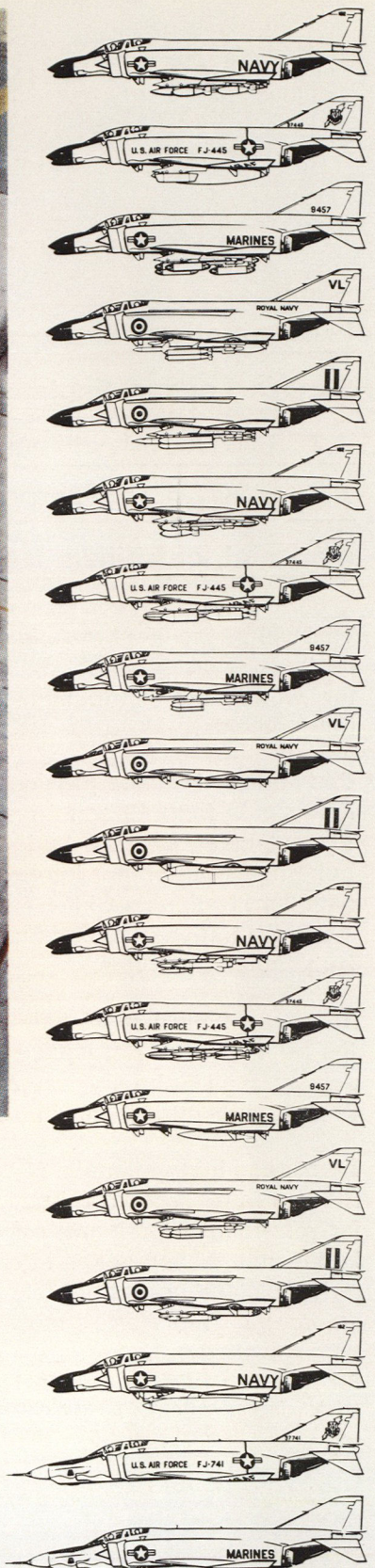
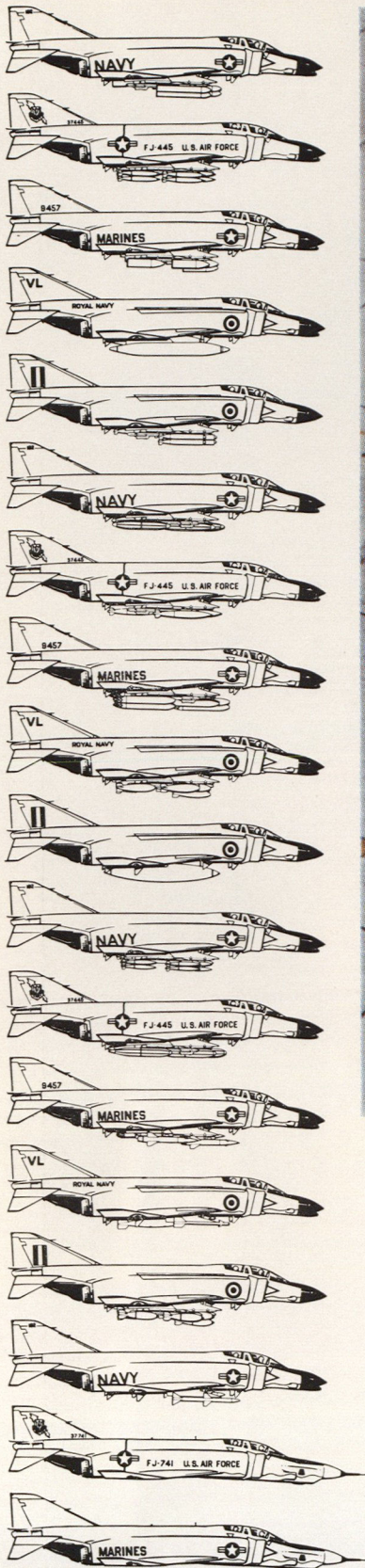
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