



The "oblique-wing" concept provides both drag and weight advantages over its swept wing. In low-speed flight, the wing is rotated to operate as a conventional unswept wing.

generation of supersonic flight aircraft. Operating at three times the speed of the Concorde — or about eight times the speed of today's jet transports — and capable of very long range flights, the hypersonic transport could be of interest in an era of increased East-West and African trade.

Hypersonic transports would operate at extremely high altitudes and use liquid hydrogen fuel. With respect to environmental considerations, the altitude increase significantly reduces sonic boom effects on the ground and the emissions of a hydrogen-fueled engine do no more than combine with oxygen to make water.

- In the much more distant future, there exists the possibility of semi-global, or sub-orbital, rocket-propelled transports which could evolve concurrently with further advances in space transportation — that is, with eventual development of a fully reusable successor to the Space Shuttle system.

The stage for NASA testimony before Congress was set by Administrator James C. Fletcher who stated:

"Any discussion of advanced aeronautical concepts requires that we project well out into the future. Our confidence in such projections depends largely on how solid a base we use as our starting point — and how well we have performed in the past. In this regard I believe NASA, and NACA before it, can point to a fairly impressive track record. The research conducted in our laboratories and flight facilities, in close cooperation with the military services and the aeronautical industry, has led to a succession of advances spanning all but the very earliest history of flight.

"These include early NACA accomplishments such as: airplane drag reduction; the development of a family of airfoil sections used in generations of successful military and civil airplane designs; a series of effective high-lift devices essential to high-performance transport and com-

bat airplane design; the establishment of a data base for high-speed airplane design resulting from the "X-airplane" series of research programs covering swept wings, low-aspect-ratio design, delta wings, and variable sweep; and, the so-called "area rule" which made sustained flight in the transonic speed range practical.

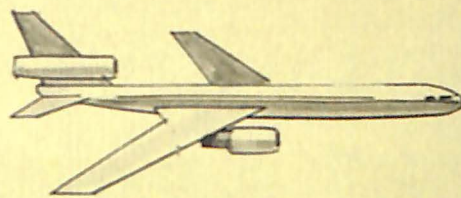
"More recently, the research has produced the supercritical airfoil technology which is now beginning to influence new military and civil designs, and the propulsive-lift concepts shortly to fly in the Air Force Advanced Medium STOL Transport prototype program."

Excerpts from the testimony of other witnesses follow. Dr. Jerry Grey, Administrator, Technical Activities and Communications, American Institute of Aeronautics and Astronautics:

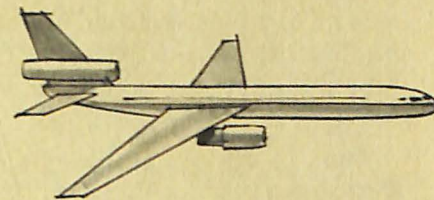
"The variable cycle engine concept is basically a variable bypass engine; that is; the fraction of the total air-flow through the engine which passes through the fan, thereby "bypassing" the fuel-burning core of the engine, can be varied over a wide range. The basic advantage of this variable bypass flow is that it can provide the optimum bypass ratio for each flight speed. Also, it has the potential for substantial reductions of "installation losses" in both the inlet and nozzle. Thus, a variable-cycle engine can operate at peak efficiency from takeoff to high supersonic flight speeds.

"Because this engine cycle requires a number of innovations in engine technology, it is still considered to be at least a decade from implementation in even a test aircraft. The principal developments needed are variable-pitch, variable camber fans (similar in basic principle to, but far more complex than, the familiar variable-pitch propeller), variable-area turbine inlet nozzles for *both* the low-pressure and high-pressure turbines, variable-area convergent-divergent exhaust nozzles, and a propulsion control system capable of integrating all these variable-area components with the fuel control over all flight-speed ranges.

SUPERCritical WING—FUEL SAVINGS



CONVENTIONAL WING



SUPERCritical WING

FUEL CONSUMPTION
200 AIRPLANE FLEET

1.6 Billion Gallons Per Year

1.36 Billion Gallons Per Year

ANNUAL FUEL SAVINGS: 240 MILLION GALLONS

Such further improvements as higher-pressure-ratio compressor blading, overall higher-pressure compressors, high-temperature (columbium-lined) combustion chambers, and in some cases regenerative heat recovery, are also important elements in variable-cycle engine development.

“Along with a totally new approach to blending the engine into the airframe, these features permit the use of a single engine over a wide performance range. Just as the automobile has several gear ratios to meet the requirements of its use, the aircraft in many instances has the same opportunity to save fuel through discrete cycle changes for takeoff, climb, subsonic cruise, supersonic cruise, dash, and other operating modes. The variable-cycle engine thus can provide high-performance STOL capability and/or low-noise operation at takeoff and landing while still being capable of high-speed economical cruise flight, and it also permits efficient subsonic and supersonic performance by a single airplane.

“The most imminent applications for this new engine cycle are military, which is why the Air Force is currently spearheading the effort. However, this nation will, someday, be forced to reconsider the needs and the implications of a commercial supersonic transport aircraft, and the variable-cycle engine will become a major element in that reconsideration.”

Dr. Walter B. LaBerge, Assistant Secretary of the Air Force for Research and Development:

“In the area of materials, I would highlight the composites which will enable us to either increase payload, range, and maneuverability of aerospace vehicles or to decrease the size and gross weight of a vehicle performing an equivalent mission.

“The Air Force is currently demonstrating composite empennages and secondary structure in the Lightweight Fighter program, and the F-15 has a composite stabilizer. In addition, other aircraft composite programs have been

initiated such as the development of a fighter wing and the Weapon Systems Advanced Composites Application Program which will develop bomber-scale wing and empennage structures.

“In regard to cost, composite structures offer the potential for significant reductions over conventional metal structures. We are attempting to exploit the directional properties of the composite material in wing designs in such a way that the wing will, under combined aerodynamic and weight loads, deform in a prescribed way.

“This load conforming deformation will be obtained while satisfying all other requirements such as strength and flutter. This will allow the wing to control its loading under maneuvering flight at high speeds where adverse load distributions can occur. Thus, future wing designs using composites show promise of achieving ‘Maneuver Load Control’ passively (i.e., without recourse to deflecting auxiliary surfaces).

“Also in the area of composites, the Air Force has produced a prototype graphite composite landing gear tailored to a 13,000 pound class aircraft. A 50 percent improvement in fatigue life is indicated with a 30 to 40 percent weight savings. Over the next ten years, we shall continue development of composite landing gears for application to large aircraft.”

William Koven, Director Advanced Aircraft Development, Naval Air Systems Command:

“Our programs are directed to the speed/altitude/size spectrum not presently being investigated elsewhere. In addition we are working on a concept which could have a significant impact on helicopter operations in the not too distant future, the Circulation Control Rotor (CCR).

“In the Circulation Control Rotor compressed air supplied by a compressor is ducted out a spanwise slot over the rounded trailing edge of a hollow rotor blade. By varying the amount of air flowing through the slot, the total lift as well as the lift distribution can be varied as necessary.

"The prime virtue of this rotor is that it is simple and we would expect it to be reliable. It eliminates the need for many hinges, bearings and mechanical parts so troublesome to conventional helicopters. Recent wind tunnel tests as well as structural and design feasibility studies continue to show this concept to have great promise. This year we intend to initiate development of a technology demonstrator to prove the CCR in full scale."

Paul F. Yaggy, Director, Research, Development and Engineering, U.S. Army Air Mobility Research and Development Laboratory:

"A government technical and cost risk analysis was completed in August 1971 to determine the probability of success in developing a Roto Systems Research Aircraft (RSRA).

"To determine the feasibility of the RSRA concept, a competitive solicitation was released to industry in August 1971 for two independent pre-design (feasibility) studies of the RSRA concept. In addition to the feasibility assessment required from the contractors, program costs and schedules for a RSRA, accompanied by an independent risk analysis, were also required. To assure program continuity and joint agency commitment, the Army and NASA entered into formal agreement in November 1971 to jointly develop and utilize the Rotor Systems Research Aircraft. The pre-design studies were completed in August 1972, concluding that the RSRA concept was feasible and within the state-of-the-art.

"Although different technical approaches were submitted by the contractors, the vehicle configurations were very similar. Also, technical and cost analyses confirmed the government's in-house estimate. Satisfied with the findings of government and industry efforts, the Army and NASA in November 1973 selected, by a competitive solicitation, Sikorsky Aircraft to design, fabricate, and demonstrate the RSRA. The objectives of the Rotor Systems Research Aircraft program are to provide those agencies of the government charged with the responsibility of developing rotor technology with a flying research tool having sufficient versatility to provide the necessary in-flight verification of supporting rotorcraft technology as well as to test a wide variety of new rotor concepts.

"One of the prime considerations of the program is that this research capability be cost effective and timely. These aircraft will provide research capability that cannot be duplicated in ground based facilities and which have

been previously restricted because of the expense of specialized vehicles."

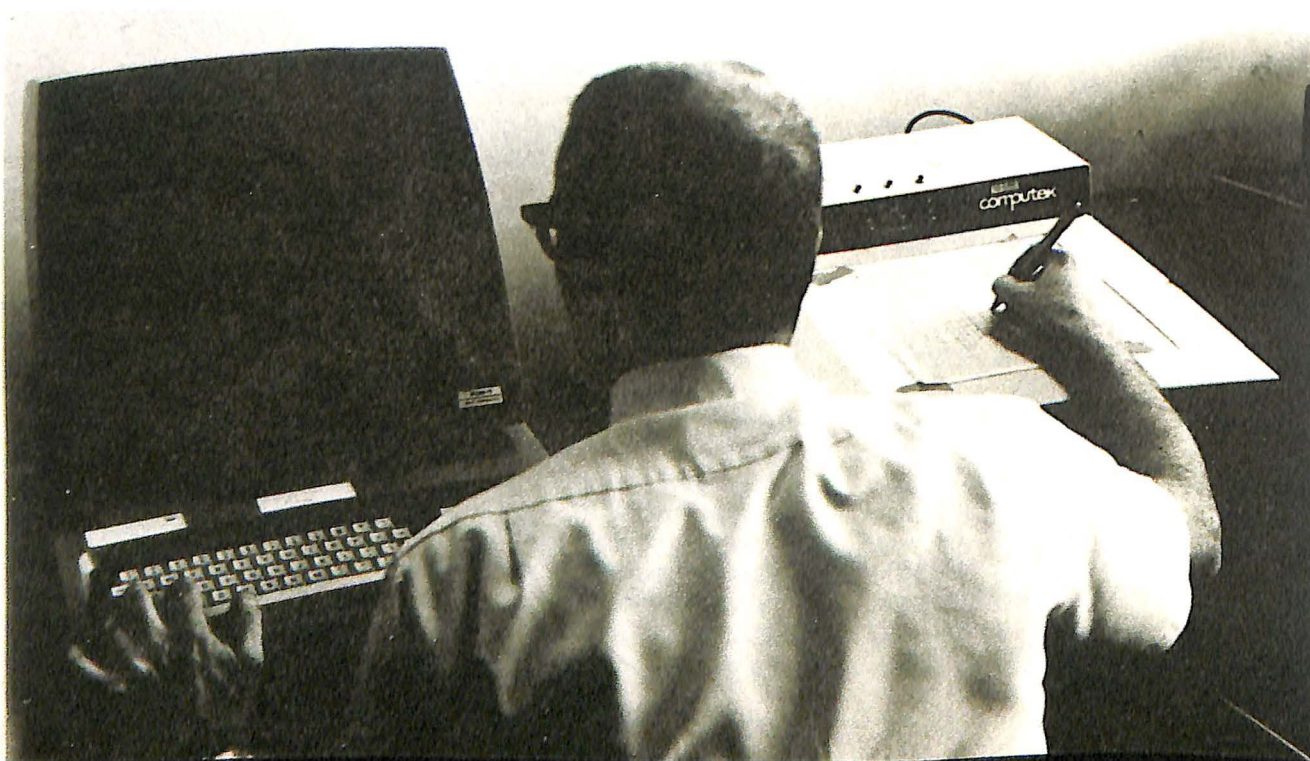
J. Gordon Veath, Director of System Engineering, National Environmental Satellite Service, National Oceanic and Atmospheric Administration. (Mr. Veath noted that his views were his own and did not represent those of his agency):

Why is the airship attracting such attention? The reasons have a lot to do with the energy, environmental, and transportation problems of today. The dirigible is an energy-saver for one thing. Being lighter than air, it need expend no propulsive energy to overcome gravity, using its engines only to move and maneuver. Compared with jet aircraft, its fuel requirements are low. Large, slow-turning, counter-rotating, stern-mounted propellers can make it exceptionally quiet, and it can be driven by environmentally desirable closed-cycle power plants.

"It can be sized to carry payloads of up to a million pounds with almost no limitation on payload dimension. It can transport extra-large, fully assembled structures and equipment and do so over intercontinental distances. Operating as a VTOL, it makes possible delivery of these loads to open areas or fields without heavy-duty runways or other costly and ecologically disturbing site preparations. By hovering over pick up and delivery points, it holds promise of being able to load and unload items without actually landing—winching cargo up and down while maintaining position with thrust vector control and buoyancy management. Alternatively it might use a type of shuttle craft between itself and the ground."

Thus it is clear that both industry and government are looking years into the future and are pushing forward the frontiers of aerospace technology. These efforts not only lessen the aeronautical impact on the ecology and help preserve the environment, but will maintain this nation's position of leadership in space exploration, and air transportation.

Economically, aerospace exports over the years has made strong contributions to maintaining its balance of trade position. Today, more than ever before, these aerospace exports have become absolutely essential to our economic health. For example, preliminary estimates indicate that U. S. aerospace exports may reach approximately \$7 billion in 1974. This compares with exports of \$5.1 billion in 1973. The expected increase is largely due to overseas sales of commercial transports.



A vital part of the evolution of future aircraft is computer-aided design methods. These advanced analytical techniques permit early exploration of design alternatives and reduce costs.

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Readers interested in learning about the effects of space exploration on society may wish to obtain a new book—*Space Among Us*. The book explores the impact which space research is having on philosophy, religion, medicine, management skills, literature (especially poetry), painting, science, ecology and pollution, our declining natural resources, global communications and its pricing, military security, economics (especially international trade), technology, international relations, education and the assault on illiteracy, archeology, the changes in politics and law, and on many other topics. It is a valuable reference book with an extensive Index.

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This important illustrated work is available for \$1.00 a copy from The Journal of AEROSPACE EDUCATION at the address above.



MANUFACTURING MEMBERS

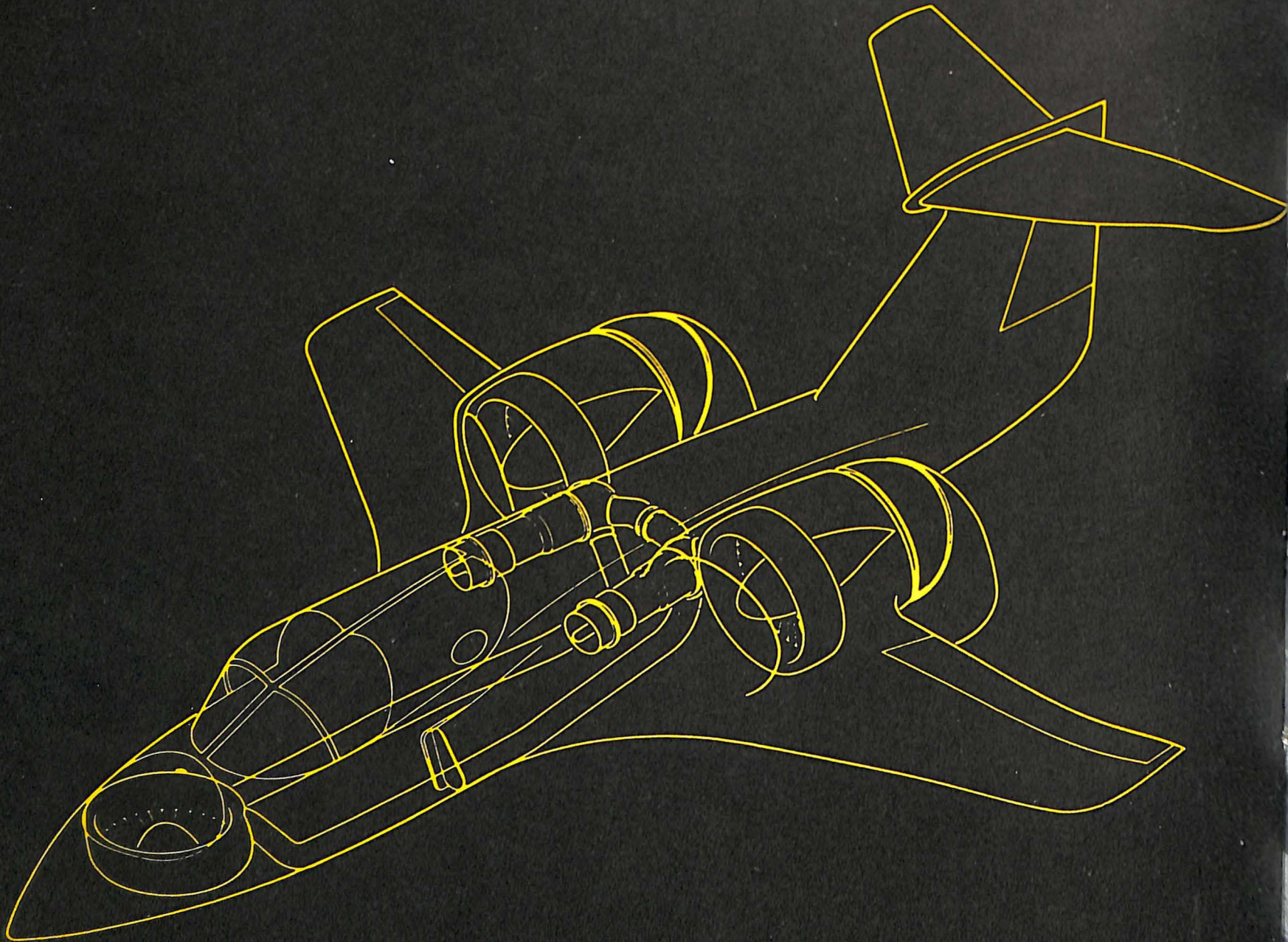
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Aerojet-General Corporation
Aeronca, Inc.
Avco Corporation
The Bendix Corporation
The Boeing Company
CCI Corporation
The Marquardt Company
Chandler Evans, Inc.
Control Systems Division of
Colt Industries
E-Systems, Inc.
The Garrett Corporation
Gates Learjet Corporation
General Dynamics Corporation
General Electric Company
Aerospace Group
Aircraft Engine Group
General Motors Corporation
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This lift-fan concept, which is being pursued by the U.S. Navy's Air Systems Command, offers good speed, high attitude performance and good endurance. (See *What's Ahead In Aviation*, p.10)



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The Shuttle: Space Saver

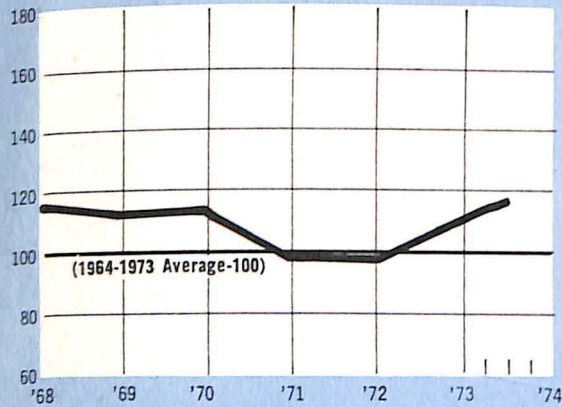
BY DR. MYRON S. MALKIN
Director, NASA Space Shuttle Program

AEROSPACE ECONOMIC INDICATORS

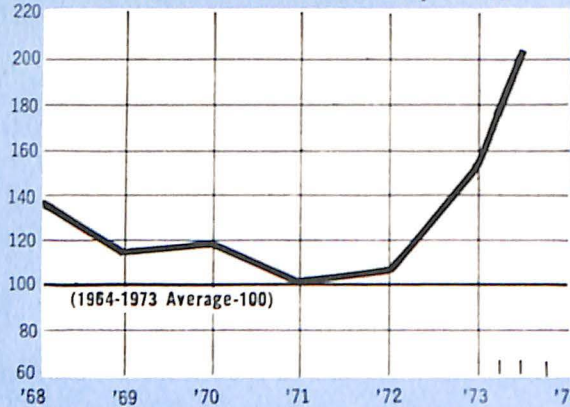
CURRENT

OUTLOOK

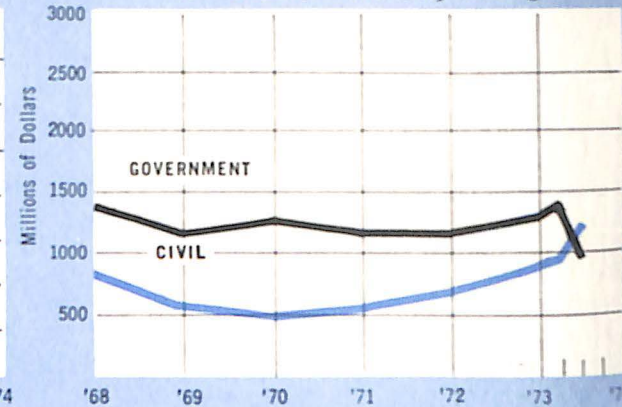
Total Aerospace Sales



Value of Civil Aircraft Shipments



New Orders — Monthly Average



— Aerospace obligations by Dept. of Defense and NASA.
— Non-government prime orders for aircraft and engines.

| ITEM | UNIT | PERIOD | AVERAGE 1964-1973 * | LATEST PERIOD SHOWN | SAME PERIOD YEAR AGO | PRECEDING PERIOD † | LATEST PERIOD |
|--|------------|-------------|---------------------------|---------------------------|----------------------------|-----------------------|------------------|
| AEROSPACE SALES: Total | Billion \$ | Annual Rate | 24.1 | 2nd Quarter | 23.5 | 24.9 | 25.5 |
| | Billion \$ | Quarterly | 6.1 | 1974 | 6.5 | 6.2 | 7.2 |
| AEROSPACE SALES: Total (1958 Dollars) | Billion \$ | Annual Rate | 15.8 | 2nd Quarter | 15.1 | 15.3 | 15.7 |
| | Billion \$ | Quarterly | 4.0 | 1974 | 4.2 | 3.8 | 4.4 |
| DEPARTMENT OF DEFENSE | | | | | | | |
| Aerospace obligations: Total | Million \$ | Monthly | 1,194 | June 1974 | 1,705 | 667 | 999 |
| Aircraft | Million \$ | Monthly | 716 | June 1974 | 1,294 | 355 | 572 |
| Missiles & Space | Million \$ | Monthly | 478 | June 1974 | 411 | 312 | 427 |
| Aerospace outlays: Total | Million \$ | Monthly | 1,129 | June 1974 | 1,547 | 1,196 | 1,159 |
| Aircraft | Million \$ | Monthly | 669 | June 1974 | 999 | 672 | 639 |
| Missiles & Space | Million \$ | Monthly | 460 | June 1974 | 548 | 524 | 520 |
| Aerospace Military Prime Contract Awards: TOTAL | Million \$ | Monthly | 1,061 | June 1974 | 1,592 | 605 | 825 |
| Aircraft | Million \$ | Monthly | 667 | June 1974 | 1,243 | 308 | 502 |
| Missiles & Space | Million \$ | Monthly | 384 | June 1974 | 349 | 297 | 323 |
| NASA RESEARCH AND DEVELOPMENT | | | | | | | |
| Obligations | Million \$ | Monthly | 283 | June 1974 | 252 | 140 | 360 |
| Expenditures | Million \$ | Monthly | 287 | June 1974 | 221 | 201 | 328 |
| BACKLOG (55 Aerospace Mfrs.): Total | | | | | | | |
| U.S. Government | Billion \$ | Quarterly | 25.5 | 2nd Quarter | 28.0 | 30.6 | 30.1 |
| | Billion \$ | Quarterly | 14.5 | 1974 | 15.5 | 17.3 | 16.3 |
| Nongovernment | Billion \$ | Quarterly | 11.0 | | 12.5 | 13.3 | 13.8 |
| EXPORTS | | | | | | | |
| Total (Including military) | Million \$ | Monthly | 249 | June 1974 | 383 | 592 | 704 |
| New Commercial Transports | Million \$ | Monthly | 77 | June 1974 | 96 | 214 | 305 |
| PROFITS | | | | | | | |
| Aerospace — Based on Sales | Percent | Quarterly | 2.7 | 2nd Quarter | 3.2 | 3.4 | 3.4 |
| All Manufacturing — Based on Sales | Percent | Quarterly | 4.9 | 1974 | 5.1 | 5.6 | 6.0 |
| EMPLOYMENT: Total | | | | | | | |
| Aircraft | Thousands | Monthly | 1,213 | June 1974 | 946 | 956 | 962 |
| Missiles & Space | Thousands | Monthly | 669 | June 1974 | 514 | 512 | 514 |
| | Thousands | Monthly | 128 | June 1974 | 94 | 101 | 103 |
| AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS | | | | | | | |
| | Dollars | Monthly | 3.86 | June 1974 | 4.91 | 5.30 | 5.36 |

* 1964-1973 average is computed by dividing total year data by 12 or 4 to yield monthly or quarterly averages.

† Preceding period refers to month or quarter preceding latest period shown.

SPEAKING OF MANDATES

BY KARL G. HARR, JR.
President, Aerospace Industries Association



Karl G. Harr, Jr.

With the calculated intent of being repetitive, spokesmen for this industry have sought attention time and again about the hazards of permitting erosion of the nation's high technology base. On many counts we think it unwise to ignore the potential impact of the decline since the mid-Sixties in our national investment in research and development as a percent of GNP. This year's 2.4 percent is the smallest percentage since 1958.

The energy crisis of a year ago — and the energy/economic dilemma of today — has somehow not brought into sufficient focus the fact that to ease up on technology-intensive endeavor is to open ourselves to ravages upon our economic stability and standard of living.

Immediately after the recent election we heard much about "challenges" and "mandates." With high technology in mind we speculated as to whether many in either established or new positions of responsibility and power sensed much urgency in the need to nurture U.S. technology. And we recalled, with little comfort, a view expressed last January by Philip H. Abelson, president of the Carnegie Institution of Washington. He said that "America's greatest weakness at present lies in her inability to mesh her political institutions with technological facts of life." He cited our reluctance to plan for and to deal with long term, undramatic problems — our tendency to focus on the here and now. Overlooked, Mr. Abelson states, is the long time span between discovery and application, if indeed we mean to employ technology in our socio/economic game plan.

As for aerospace, we see clearly that technology is a primary tool whereby supply can better meet demand, whereby substitute materials or techniques can be found to solve shortages and whereby productivity can be increased.

We also see clearly that without the \$7 billion in technology-intensive aerospace exports this year — largely based upon *yesterday's* technology — the U.S. trade deficit could be a catastrophic \$11 billion instead of the estimated \$4 billion, which in itself is alarming.



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Office of Manned Space Flight
National Aeronautics and Space Administration

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By Thomas V. Falkie
Director, Bureau of Mines
U. S. Department of the Interior

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The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

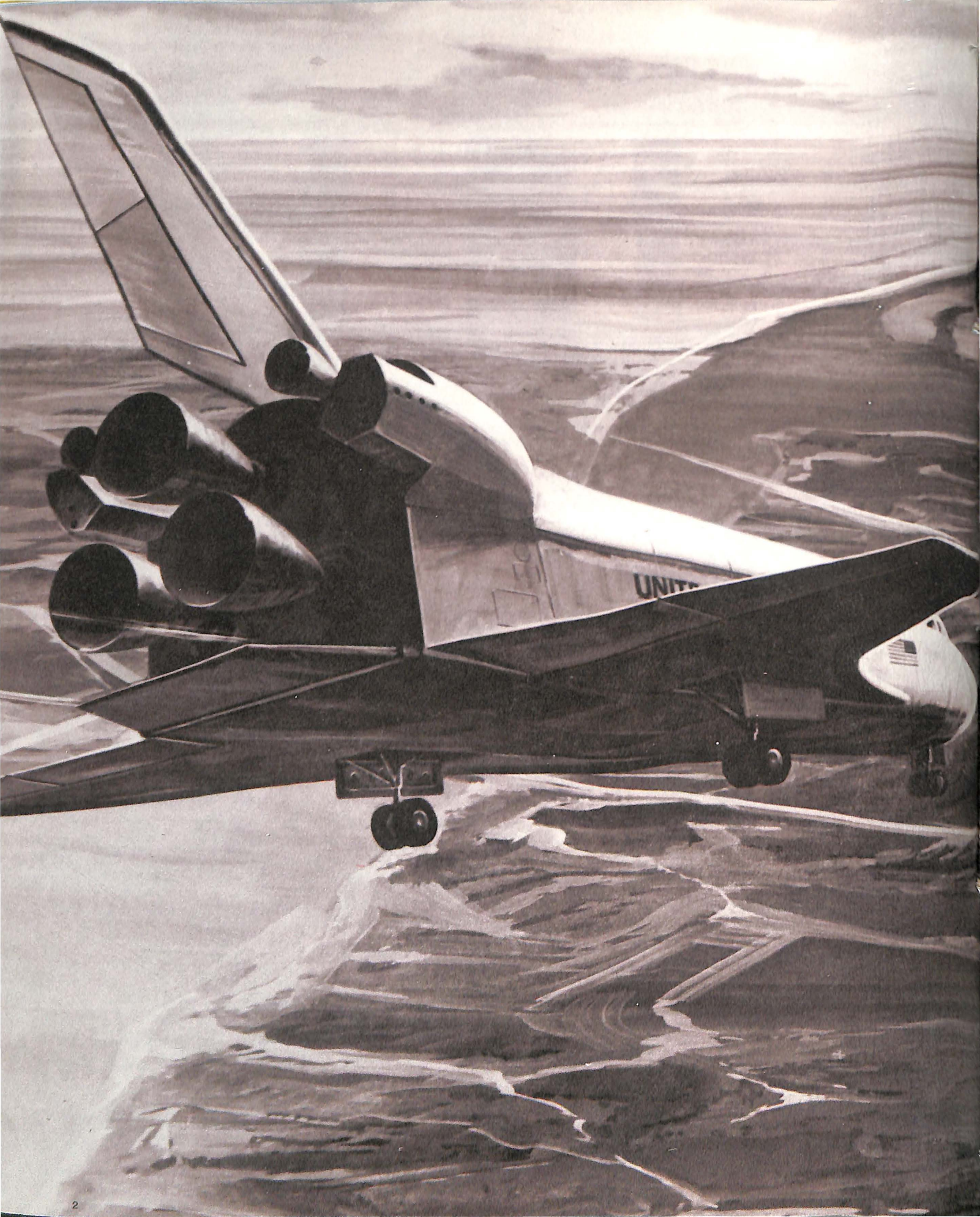
Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

AEROSPACE is published by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

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BY DR. MYRON S. MALKIN

Director, Space Shuttle Program
Office of Manned Space Flight
National Aeronautics and Space Administration

There may be someone, living in a cave somewhere, who doesn't realize the benefits mankind has derived from exploration—from Columbus and Magellan to Jacques Cousteau to communications satellites and, soon, the Space Shuttle.

The Space Shuttle will drastically reduce the cost of space transportation for the great variety of scientific and earth applications spacecraft planned for launch in the 1980s.

This will be possible because the Space Shuttle will be the first reusable space vehicle.

It will allow us to go into space routinely, without the enormous effort it now takes; quickly, on very short notice if necessary; economically, at greatly reduced costs; and it will fly back to Earth to be used many times.

The shuttle will help us study the Earth, the Sun, the planets, and the universe. Through space science, we will increase our fundamental knowledge of the basic processes in biology, in chemistry and in physics. By looking outward from above the Earth's atmosphere, we can see things we can't possibly see from the surface of our planet.

With the shuttle, we will continue to gain direct benefits from space for man on Earth. The shuttle will be able to put into place our communications and weather satellites and will be an advanced extension of our Earth Resources Satellites and the Skylab missions to monitor our environment.

Often the shuttle will just place an unmanned satellite into orbit and recover it later for repair, adjustment, updating and reuse. On occasion space experimenters, men and women, will accompany their experiments in the shuttle by using the Spacelab.

Baseline development costs are estimated at \$5.2 billion (in 1971 dollars) to bring the shuttle into operation. Initial development, test and operational facilities will cost \$300 million. The average cost per shuttle flight in the *baseline* program is estimated at \$10.5 million (in 1971 dollars).

The Shuttle: Space Saver

Space Shuttle Progress Report

| | |
|------------------|---|
| January 1972 | Space Shuttle authorized by the President |
| July 1972 | Contract for orbiter and integration of other elements awarded to Rockwell International's Space Division |
| August 1973 | Contract for external tank awarded to Martin Marietta Aerospace |
| November 1973 | Contract for solid rocket motors awarded to Thiokol Corporation |
| 4th Quarter 1977 | First approach and landing tests |
| 2nd Quarter 1979 | First manned orbital flight |
| 1980 | Operational |

A Space Shuttle traffic model developed from an analysis of a reference set of potential payloads by NASA, DOD, other government agencies, commercial and foreign users indicated a requirement for 725 Shuttle flights over the 12-year period from 1980 through 1991.

Models like these are not determined from the baseline Shuttle Program assumptions for the development and operations of the shuttle, nor are they approved NASA plans. Rather these models are instrumental in testing the basic economics of the Space Shuttle as a transportation system and they provide the medium for identifying the cost sensitivities and total system requirements for various design and operations options.

In an economic analysis using this model, transportation costs, assuming conventional expendable launch vehicles, would be about \$12.6 billion over the 12-year period. The transportation costs for shuttle utilization would be about \$8.45 billion, a saving of \$4.2 billion.

Likewise, the payload development and procurement costs for this model would, in the case of the conventional expendable launch vehicle, cost about \$44 billion over 12 years divided among NASA, DOD and the other users. Because the shuttle provides the capability for payload reuse, design simplification, and lowers the payload risk factor, payloads accommodated by the 725 shuttle flights would cost about \$30 billion. This is an additional saving of about \$14 billion.

Therefore, the 12-year flight program representing the mission model can be conducted by the Space Shuttle with gross benefits of about \$18.1 billion over conventional expendable launch vehicles—a saving of nearly \$1.5 billion per year.

The average annual cost for transportation and payloads for the mission model is about \$3.3 billion if the shuttle were assumed and about \$4.7 billion if conventional expendable launch vehicles were assumed.

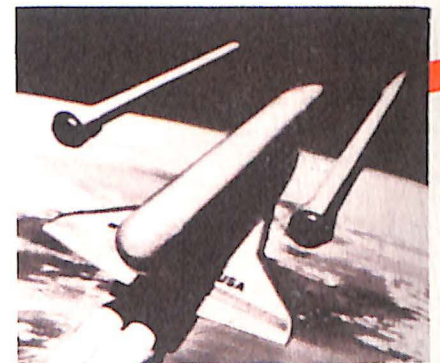
The shuttle system consists of four major elements—the orbiter, the main engines, the external tank and the solid boosters. The external tank is the only element that is expendable.

The three main engines, each providing .47 million pounds of thrust, are an integral part of the orbiter. These engines are reusable and represent an advance from the previous state of the propulsion art. They will be described later. The expendable external tank which carries the cryogenic liquid propellants for the main engines is 27.6 ft. in diameter and 153.7 ft. long. There are two recoverable solid fuel rocket boosters, one on either side of the external tank. Each booster provides about 2.66 million pounds of thrust, is 12.2 ft. in diameter and 149.1 ft. long.

FLIGHT OPERATIONS

Because the shuttle is to be the primary launch vehicle for future space payloads let us examine the manner in which it will be used. The shuttle mission consists of four basic phases:

- Lift-off to orbit insertion.
- On-orbit operations.
- De-orbit to landing.



2



1



7

- Ground turnaround operations which prepare it for the next flight.

At liftoff, the three main engines in the orbiter and the two solid rocket boosters are burned simultaneously generating a total thrust of about 6.3 million pounds. After the shuttle has cleared the launcher tower, it performs a roll maneuver to the desired launch direction. The solid rocket boosters burn out and are separated about two minutes into the flight. They are parachuted to a soft splashdown, tail first, into the ocean about 130 miles downrange. Here they are recovered, towed back to shore, refurbished, and reused on a subsequent flight.

The orbiter and external tank continue powered ascent until about eight minutes from liftoff when the orbiter main engines are shut down. The empty external tank, which provided liquid hydrogen and liquid oxygen to the engines, is jettisoned before orbit is attained and it impacts in a remote ocean area.

To enter earth orbit, the orbiter performs an insertion burn for approximately one and one-half minutes with its two orbital maneuvering engines. This places the orbiter into a 50 x 100 nautical mile orbit. At 100 nautical miles the orbital maneuvering system engines are

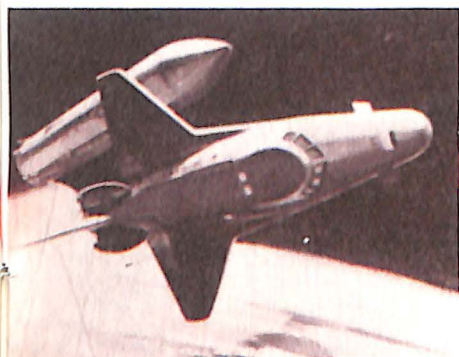
again burned for 50 seconds to circularize the orbit.

The shuttle has the capability to abort the ascent and return the orbiter, its crew, and its payload intact to the original launch site where the runway and landing aids are located. Unlike past manned and expendable launch vehicle programs, the shuttle does not splash down in the ocean or lose the payload in the event of an abort.

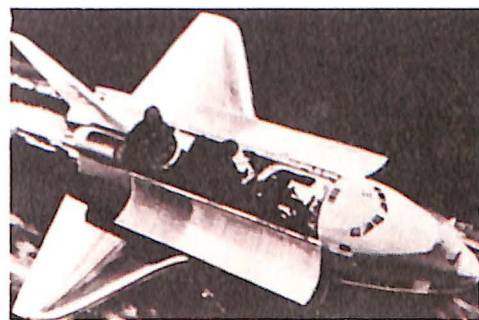
Until approximately four minutes into the flight, there is sufficient propellant remaining in the external tank to reverse the direction of motion by pitching the orbiter and tank over to a retrograde burn attitude. In this manner, the ascent velocity is neutralized and a return trajectory is established back to the launch site to provide for a direct return and landing. For this abort sequence, after main engine cutoff, the external tank is jettisoned offshore and the orbiter glides back to a landing at the launch and landing site.

When the orbiter exceeds the downrange limit of the return-to-launching-and-landing site (RTL) abort capability just described, the orbiter still possesses an abort-once-around (AOA) capability.

This allows the orbiter to land at the same site after one earth revolution. In this case, the external tank is



3

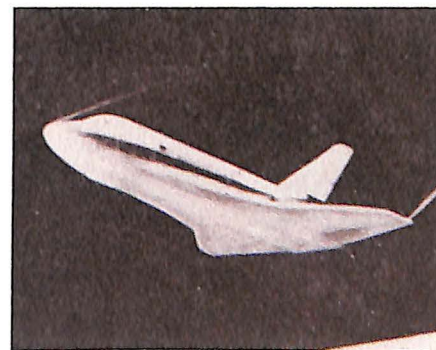


4



SPACE SHUTTLE MISSION PROFILE

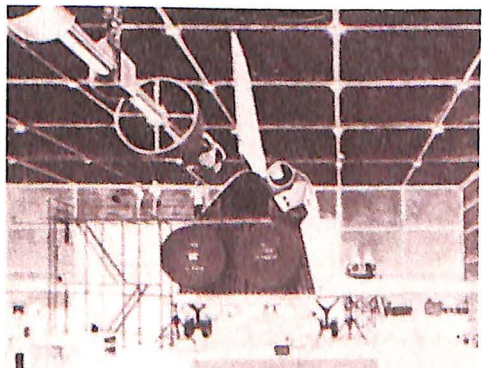
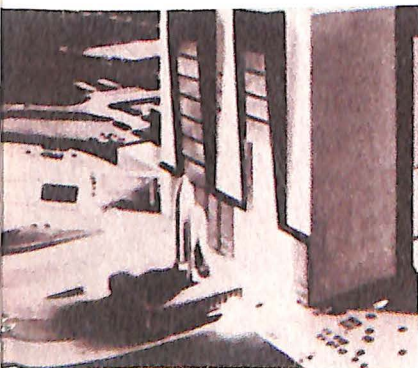
Major steps in a Space Shuttle mission are shown here. 1. Lift-off with three main engines in the orbiter and two solid rockets burning simultaneously; 2. The solid rockets are burned out and separated. Solid rockets are parachuted to a splashdown and are later recovered; 3. The empty external tank is jettisoned; 4. Orbiter inserts payloads into space and performs other operations; 5. Orbiter in Earth orbit; 6. Orbiter, after leaving space, makes re-entry and prepares to land like a conventional aircraft; 7. Ground turnaround operations start, moving from the runway to the Orbiter Processing Facility to the Vehicle Assembly Building and then to the launch pad for another mission. Turnaround time is 160 hours.



5



6



jettisoned to impact in the same pre-targeted remote ocean area as in a normal mission.

The two shuttle launch and landing sites are located at Kennedy Space Center, Florida, and Vandenberg Air Force Base, California. From these locations over-water launches can be achieved for the full range of orbit inclinations required to support payload needs. Payload weight-carrying capability of the shuttle varies with inclination; decreasing with higher inclinations due to the loss of earth's rotation effects.

Duration of a mission on orbit can be up to 30 days with a crew of up to seven persons by adding consumables and hardware for electrical power, life support, crew provisions and propellants above those normally carried for a seven day mission duration with a crew of four. The system provides for placing a 65,000-pound payload into a 100 nautical mile circular orbit due east or 32,000 pounds to 100 nautical miles at 104° inclination (retrograde) orbit. The shuttle can return up to 32,000 pounds to the landing site.

By trading off payload weight for extra orbital maneuvering propellant orbit altitudes up to about 650 nautical miles are possible. Therefore actual payload weight capability depends on the orbital inclination and the circular orbit altitude desired. Kits containing the extra orbital maneuvering propellants are stowed in the aft end of the payload bay when required. Each tank set kit contains 500 feet per second of velocity change capability.

When the on-orbit operations required by the payload are completed, the orbiter is prepared for entry and landing and the de-orbit burn is made. The orbital maneuvering engines provide the retrograde thrust for de-orbit which nominally requires a burn duration of about two minutes and takes place about one-half an earth revolution from the landing site.

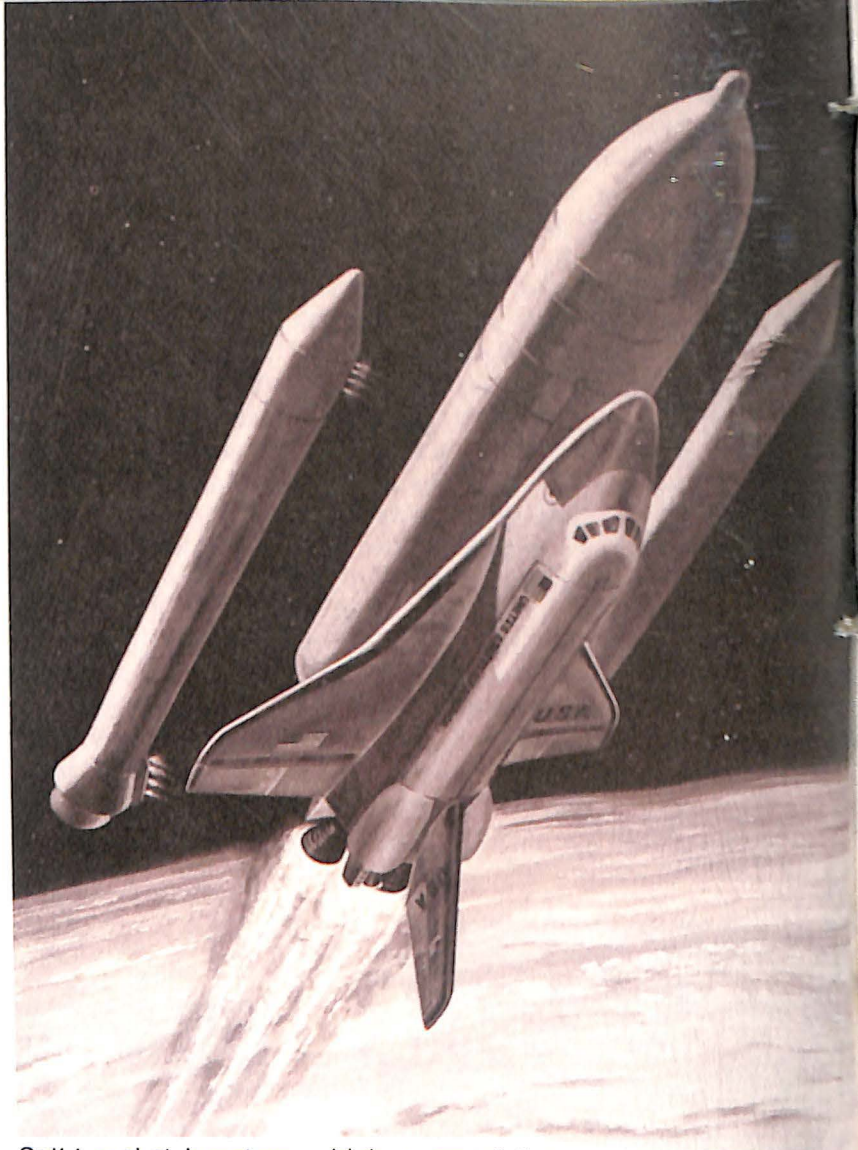
After a communications blackout period, the orbiter interrogates a ground navigation station for a final navigation update and, at an altitude of 142,000 feet, begins a transition to an angle-of-attack of 12 degrees.

The final maneuver consists of a descent to a position about 5.8 nautical miles short of the runway at an altitude of 12,000 feet. The orbiter is aligned to the runway and begins the final approach. Final flare and landing is 2000 feet down the runway at a speed of about 190 knots.

The end of one mission begins the next mission because the ground turnaround operations are a key element of each flight. There is no dead time between missions. The turnaround operation takes 160 hours or two weeks with a two-shift operation on a five-day work week. The operations move from the runway to the Orbiter Processing Facility to the Vehicle Assembly Building, and then to launch pad. The 160-hour operation includes payload removal and installation of a new payload. Stacking the segmented solid rocket boosters and mating the external tank are both done before the orbiter arrives at the Vehicle Assembly Building.

SPACE SHUTTLE MAIN ENGINE (SSME)

To be consistent with the size and weight restrictions of the orbiter, a liquid propulsion system had to be designed which represented a technological advance from the previous state of the art. The 470,000-pound



Solid rocket boosters, which augment the shuttle's main engines during initial launch phase, are released at approximately 27 miles altitude.

vacuum thrust Space Shuttle Main Engine (SSME) is being developed for the Space Shuttle orbiter and provides the primary thrust for the vehicle. Three of these engines are clustered in the aft end of the orbiter. The design of the SSME, the rocket engine of the future, is based on maximum utilization of existing technology. At the same time, it will have a new dimension: long life. It is the first large liquid fuel rocket engine designed from the beginning to be reusable and to require minimum maintenance between flights, these factors minimize cost per flight. The engine is computer controlled to ensure operation within the limits of the high temperatures and pressures used in the combustion cycle. Performance is increased using a more efficient two-stage power cycle which allows a nozzle with a high expansion area ratio.

The SSME operates both in the low altitude regime normally reserved for booster engines and also in a vacuum where upper stages normally are employed. Historically, booster engines were designed for low altitude operation only, and burned oxygen-kerosene-type fuels.

The J-2 engine, the large upper stage engine that burned oxygen and hydrogen propellants (used on the upper stages of the Saturn/Apollo vehicle), was the most efficient engine during the Apollo era.

A comparison of design life requirements for the

Saturn/Apollo engines and the SSME shows a seven-fold increase in duration.

The J-2 engine was capable of multiple starts, and about one hour and two and one-half minutes of operation, but it was used for only one flight. We are designing the SSME to last for 55 flights and seven and one-half hours of operation before a major overhaul is required.

Although the shuttle engine weighs 2940 pounds more than the J-2, it can develop more than twice the vacuum thrust. Even with the increased engine weight, the efficiency of the SSME is such that its thrust-to-weight ratio has increased over the J-2.

The Space Shuttle introduced many new challenges for the rocket engine: high performance, light weight, long life, and low cost-per-flight maintenance.

The SSME has been designed to meet these requirements using the latest technology. Materials and hardware are flowing into the plant to support first article schedules. Component testing has been initiated. The program is moving ahead toward the first sea level test firing of a complete engine in early 1976 and delivery of the first set of flight hardware in 1978.

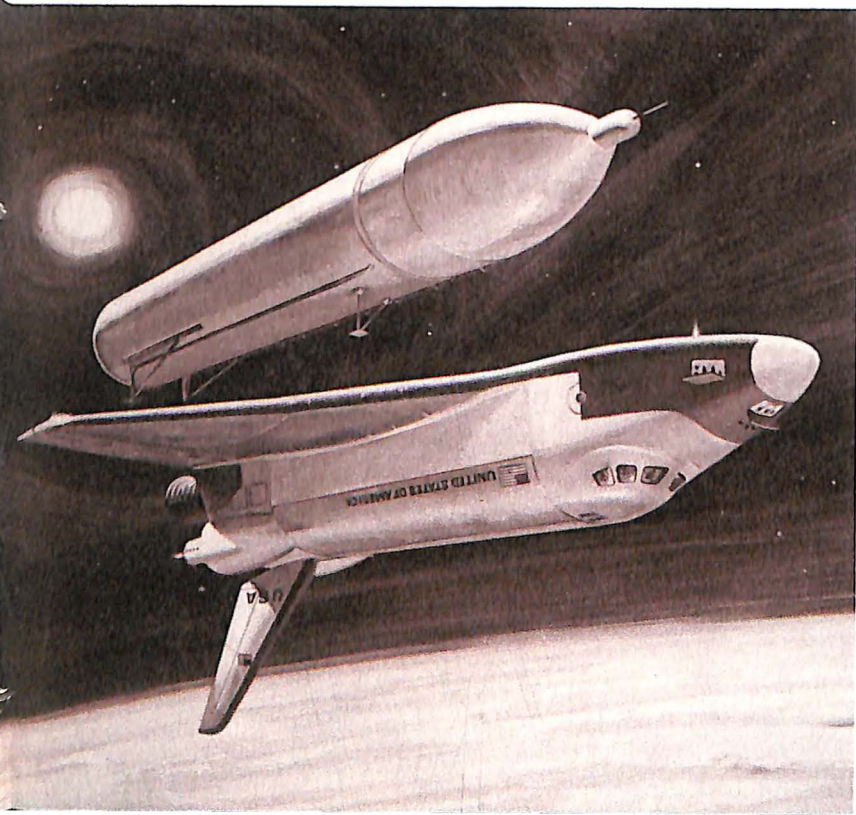
In fact, the first full-power firing of a Space Shuttle Main Engine preburner was conducted successfully at Rockwell International's Rocketdyne Division recently.

Firing of the preburner is the first step in the ignition sequence of the engine, which uses a liquid oxygen-liquid hydrogen propellant.

Three main engines, developing a total of more than 1.4 million pounds of thrust, will be used to help boost NASA's Space Shuttle orbiter that will be launched like a rocket and return to Earth like an airplane.

The test was conducted for a main stage duration of 8.2 seconds, reaching a combustion pressure of 6200 pounds per square inch. This is six times greater than the Saturn J-2 engines that sent Apollo astronauts to the moon, and is the highest combustion pressure ever

Shuttle orbiter jettisons external fuel tank shortly after reaching Earth orbital altitude.



achieved for this large an engine. Test results met all performance predictions.

THERMAL PROTECTION SYSTEM

The thermal protection system (TPS) attenuates aerothermal heating on the external surface of the orbiter during ascent and reentry. It limits the temperatures of the metallic structure to a maximum of 350 degrees Fahrenheit during all flight phases to allow the use of conventional structural design and materials. While meeting the stringent thermal requirements, the TPS also must sustain non-thermal external environments—both flight induced, such as acoustic and structural deflection, and natural environments, such as rain and dust. In addition, the TPS must provide an acceptable aerodynamic surface, be reusable with minimal refurbishment, be light in weight and not impose unrealistic manufacturing, installation or flight restraints.

The thermal protection system for the shuttle is a departure from previous concepts which were designed for single flights. Ablators and heat sinks were ruled out because of the refurbishment necessary for reuse and the excessive weight.

Metallic re-radiative concepts possess a much too slow thermal response capability. Metallics also were rejected because the necessary associated internal insulation could not be adequately protected against moisture without prohibitive weight.

The system to be employed on the shuttle uses two materials. For the stagnation areas and areas which exceed 2300 degrees Fahrenheit, pyrolyzed carbon was selected. This material covers the nose cap and wing leading edges. These are designed for repeated reuse at temperatures up to 3000 degrees Fahrenheit. The other TPS material is made of reusable silica tiles which take care of the lower temperature range and are replaceable if necessary during refurbishment.

A detailed test program is underway to completely define the mechanical and thermal characteristics of the TPS materials under the extremes of low space temperatures for the initial flight and after repeated exposures.

Although extensive and thorough test programs will continue for some time, it already has been proved that the materials selected will provide the protection required under operational conditions.

SUMMARY

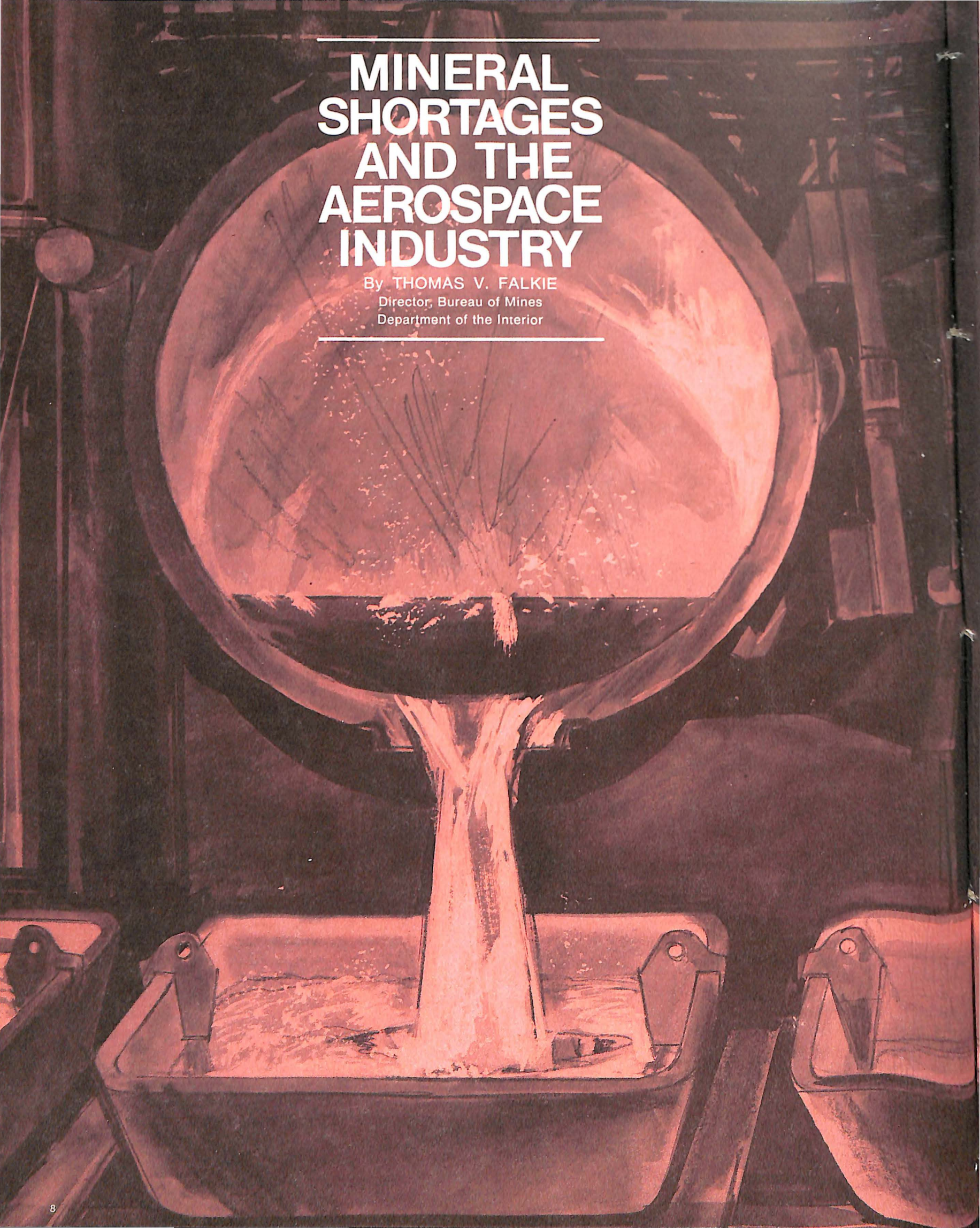
The Shuttle Program to date is on schedule and within cost projection. Progress continues to be encouraging. We have selected the configuration, the materials for fabrication and the mode of operation. Our contractors are all on board. The development is entering the metal cutting phase and early testing of components has begun.

Since 1969 we have traveled the long road through three phases of this program. The next few years will see extensive component and system testing leading to the integration of all orbiter elements for the approach and landing test at Edwards Air Force Base in 1977.

Orbital tests will start with the first manned orbital flight in 1979 and are expected to extend into 1980. After that the system will become operational and ready to benefit users throughout the world.

MINERAL SHORTAGES AND THE AEROSPACE INDUSTRY

By THOMAS V. FALKIE
Director, Bureau of Mines
Department of the Interior



The presence of some element or compound in the ground, in the air or in the sea doesn't mean that a usable product is readily available.

There is enough hydrogen in the oceans to provide all of the non-polluting power that the world could use in a zillion years. But the high technology plants to extract that hydrogen, liquefy it, transport it, store it and then feed it to homes, automobiles, lawnmowers and aircraft does not exist—yet.

It takes tremendous amounts of electrical power applied to bauxite to produce aluminum ingots, and still more skill and power to create heavy forgings and skin-quality aluminum for the aircraft that will transport millions of passengers and millions of pounds of freight this year, and more next year and during each succeeding year.

Already the situation is such that if any airline ordered a modern U.S.-made wide-body commercial transport aircraft today (and 80% of all transports flown by free-world airlines are U.S.-made) it probably would be June 1977 before that aircraft could be delivered. You can't deliver an aircraft without landing gear, and the lead-time on that assembly alone is 81 weeks, providing that production, refining, machining, assembly, testing and delivery all meet schedules.

But we have to start somewhere, and the foundation is the availability of raw materials. That is why we asked the Director of The Bureau of Mines, Department of The Interior, to explore this subject in the accompanying article.

As reported by Dr. Falkie, minerals from which the basic primary metals can be produced, not only for aerospace but also for all other sectors of the American economy are in great abundance.

It is now up to industry and the government to develop a program for the allocation of limited capital resources for the mining and production of the primary metals to meet the needs of our nation.

The plan must be balanced among the various metals produced to meet the diverse needs of industry and the ultimate consumer.

But to produce the primary metals is not enough—we must then allocate additional limited capital to expanding and/or building new facilities for converting the primary metals to the alloys required in the form for the next step in the manufacturing operations, e.g. forgings, castings, extrusions, bar, rod, sheet, and tubing. This must be accomplished with the proper regard for the environment and limited energy sources.—*Editor.*

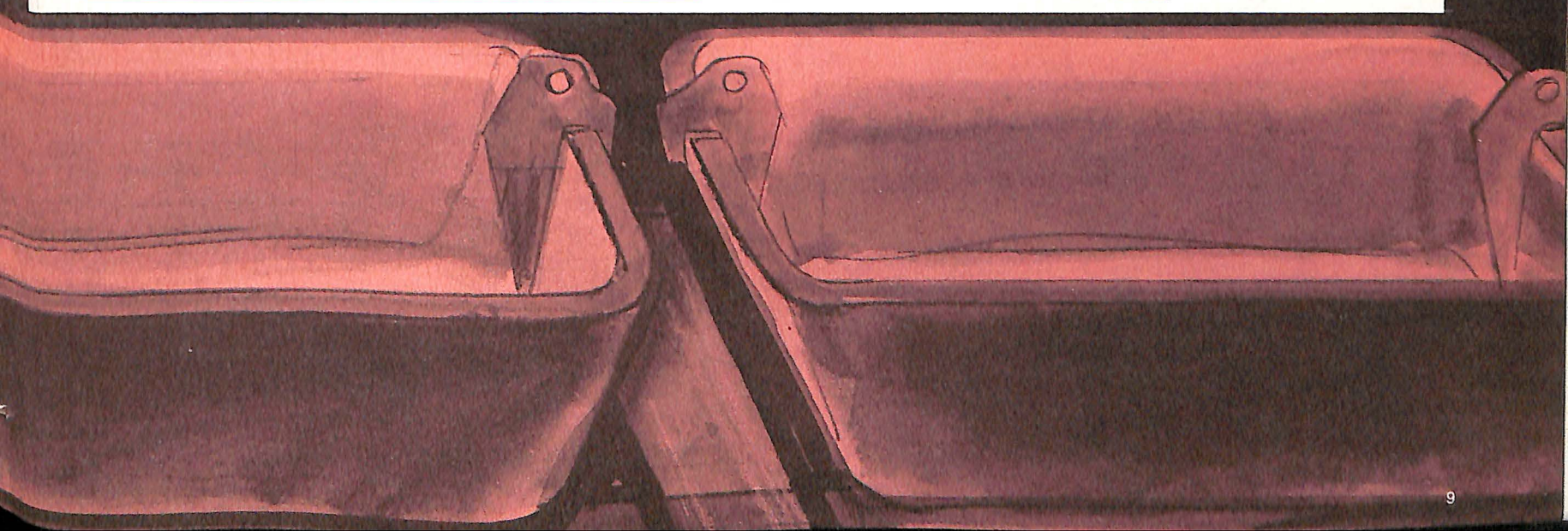
By and large the United States is blessed with abundant mineral resources. But it is important to realize that when geologists, mining engineers and metallurgists use the broad term "resources" they are talking about natural concentrations of raw minerals in the crust of the earth. These may be solid, liquid or gas in form, or may be in the waters of the Earth, or in Earth's atmosphere.

There are a few materials, notably antimony, asbestos, chromium, stragetic mica and tin which, based on present knowledge, are small or insignificant resources in the U.S.

Consequently, broadly viewed, our primary concern is not with inadequacy of resources but rather with improving our technology to convert the raw rocks, soils and fluids of the earth, from whatever sources, into energy and processed mineral materials useful to man, while at the same time safeguarding the environment and meeting health, safety, sociologic and other safeguarding standards, and doing so economically to the extent that investment in domestic mineral industries appears attractive to venture capital.

The job of The Bureau of Mines is to assure that, in line with the Mining and Minerals Policy Act of 1970, the Government is equipped to provide an overview of national materials needs, and direction as to how those needs must be met. It must complement industry's basic responsibility and efforts to develop our natural resources to meet those needs, while at the same time assuring that other public goals, such as environmental protection and national security, are served. In this activity Government, industry and educational institutions must play increasingly interactive roles, because no one of these has sufficient knowledge and authority to arrive at significant improvement alone. If these efforts are successful, improvements can be expected in such areas as mining, metallurgy and ceramic technology, and recycling waste materials.

Minerals are especially important to the aerospace industry because it uses materials derived from minerals for everything from small mica insulators in electrical components to the cobalt, nickel and chromium in the superalloys used to make jet engine components. When the average person thinks of aerospace materials, he usually thinks of aluminum, magnesium, and perhaps titanium, but the aerospace industry also uses large quantities of steel, plastics, ceramics, as well as other metals and nonmetals.



While it is vitally important to supply the aerospace industry with the materials it needs, the industry must realize that the supply is limited and that other industries are competing for the available supply.

More than 40,000 pounds of new mineral materials equally divided between energy minerals and other are required annually for each U.S. citizen, about minerals. The total annual use of new minerals in the United States exceeds 4 billion tons.

Unfortunately, much of the material used by the aerospace industry must be imported.

The 1974 estimated \$35 billion increase in imports of raw and processed minerals is attributable in large measure to increased costs of imported fuel minerals, and these import values are probably conservative in that they are based on published "freight on board" data and do not include the insurance and freight costs involved in delivery to U.S. ports. Of course, exports of aerospace, agricultural and mineral commodities and manufactured goods and services, as well as floating exchange rates and capital flows help the United States to pay for needed imports of minerals. Exports of raw and processed minerals in 1974 are now estimated at \$17 billion.

Materials Valued at \$35 Billion

Domestic mineral raw materials produced in 1973 were valued at approximately \$35 billion. These domestic mineral raw materials were supplemented by imports valued at \$7 billion. The total supply of mineral raw materials was then utilized by the mineral processing and energy generation industries to produce energy and mineral-based materials valued at \$175 billion. At this stage of processing, imports in 1973 supplied processed mineral materials valued at \$12 billion. Exports of both raw and processed minerals in 1973 were valued at \$11 billion.

In much of the two decades following the Korean War period, many materials were available from foreign sources at prices which discouraged development of domestic mineral industries and encouraged many U.S. firms in the mining and mineral business to expand their foreign operations. Now, however, consumers of mineral materials are finding that foreign nations wish to reap the benefits of the value added by manufactur-

ing. Thus, for example, foreign nations would prefer to produce alumina, rather than bauxite. If possible, and if they have access to energy sources, they will seek to produce aluminum metal rather than alumina. The same trends are obvious in almost all materials.

Further, it is important to remember that the U.S. population of 212 million people is only about 6 percent of the total world population. Consequently, as the other 94 percent of the people in the world strive for higher material standards of living, mineral raw materials and manufactures thereof increasingly will find attractive markets in many parts of the world, leaving less for vital U.S. needs.

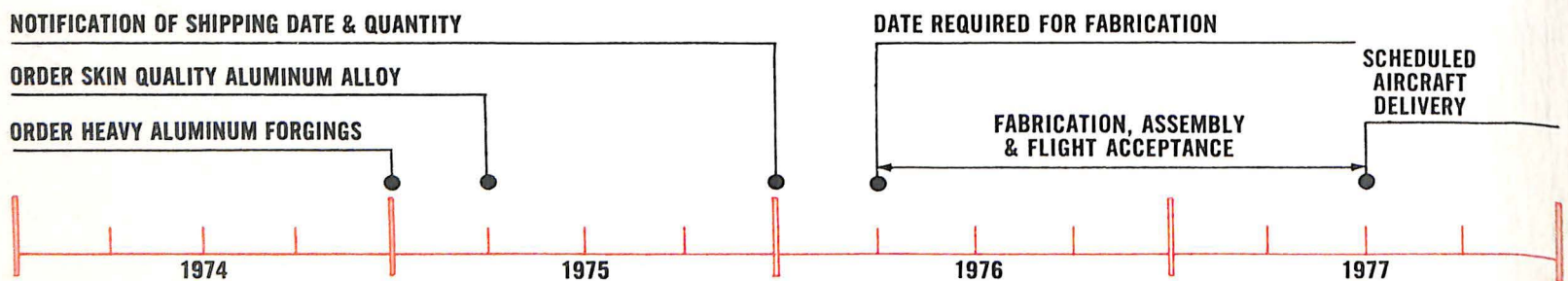
Bureau Program

The Bureau of Mines' activities center on the efficient extraction, processing, and use of the nation's mineral resources. In attacking problems in these areas, the Bureau conducts programs in mineral information, mineral position analysis, and mining and metallurgical research. Mineral information and position analysis are concerned with careful and thorough investigation of all metals and minerals to determine the near- and distant-future supplies that must be made available to meet the nation's needs. The mining research and development activity of the Bureau is concerned with conservation of mineral resources through improved extraction technology. Metallurgical research is conducted to develop the base technical information that will encourage industry to produce from domestic resources the supply of minerals and metals needed.

One example of how this is done relates to the non-magnetic taconites resources of the upper midwest.

The Bureau launched a research program to develop technology whereby vast quantities of nonmagnetic taconites which were being wasted or not being exploited could be made acceptable for iron production. Estimated reserves are over 6 billion tons in the north central states. As a result of our research, a process was developed for recovering usable grade iron ore from a northern Michigan nonmagnetic taconite. The technique has been adopted by industry and the Cleveland Cliffs Iron Company has completed a new \$200 million iron ore and pellet production plant at Tilden, Michigan. This is the nation's first large-scale com-

ALUMINUM FOR COMMERCIAL TRANSPORT AIRCRAFT



- NOTES: 1. Assuming order is accepted and delivery date is as requested.
2. Price is fixed at time of delivery.

The impact of material shortages on the ultimate delivery of a finished product is such that if an airline orders a present generation U.S. transport aircraft on the first day of 1975 it *might* get delivery at the end of June 1977, two and one-half years later. A number of factors are involved: A firm order must be placed for large aluminum forgings, skin quality aluminum, landing gear and many other major assemblies and sub-assemblies. (Lead-time on landing gear is 81 weeks, forgings 65 weeks, aluminum sheeting 52 weeks).

(Source: Aerospace Industries Association of America, September 1974)

mercial venture in processing nonmagnetic taconite. The facility will treat 10 million tons of ore containing about 35 percent iron, and will produce 4 million tons of high-grade iron ore pellets having a value of \$72 million annually. Plans are to increase pellet production to 12 million tons annually. At least 1 billion tons of ore which heretofore could not be economically processed now can be considered as treatable reserves.

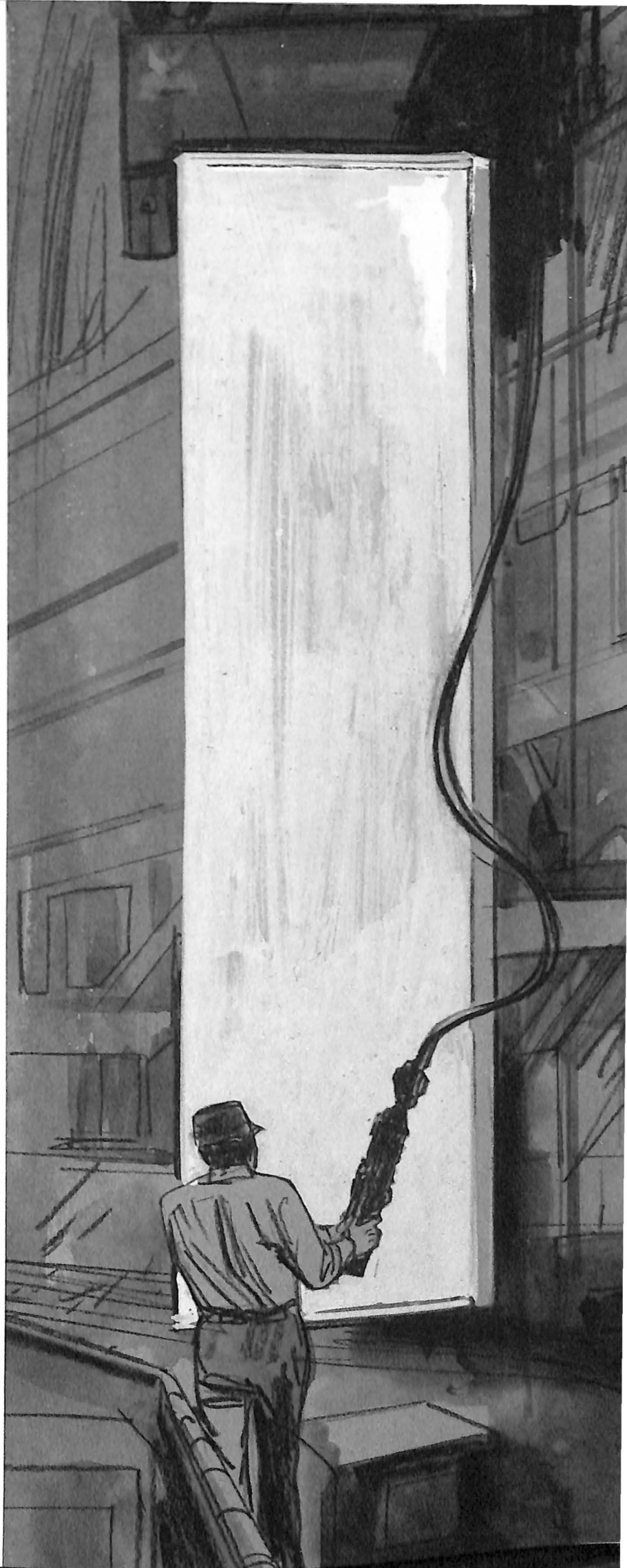
Assurance of a continuing supply of aluminum is especially important to the aerospace industry. Unfortunately, the United States is almost completely dependent upon imported bauxite as a source of aluminum. Less than 10 percent of our needs for the metal is supplied by domestic sources. The bulk of the U.S. imported ore comes from nations in the Caribbean Basin. Within the past few months, Jamaica has increased the tax on exported bauxite by 500 percent, resulting in an increase of 2 to 3 cents per pound in the cost of making metal in the United States. In a similar action Guyana is increasing its tax on exported bauxite to over \$11 per ton, which effectively doubles the price. We have abundant resources of aluminum-bearing minerals, but none of the proposed processes for recovering the alumina content from such minerals as clay, anorthosite, or alunite proved economically competitive with the Bayer process for treating imported bauxite ore at former prices. Now the Bureau of Mines is testing, on a small pilot-plant scale, alternative processes to recover alumina from domestic clay and other raw materials.

Pilot Plant Plan

In order to accelerate the program, interested firms were invited to participate in a cost-sharing, cooperative effort, and eight domestic aluminum-producing companies joined the Bureau of Mines in a cooperative effort. Because of the added impetus the cooperative effort gave to the program, and the promising early results, the information will be available in 1976 on which to base the design of several trial or large pilot plants that will be able to produce 50 tons of alumina per day. By designing more than one such plant and by careful evaluation of the designs, selection may be made of the best process/plant system for construction of a single pilot plant. The eventual information from this plant will allow easy scale-up to commercial sized plants to produce 1000 to 2000 tons of alumina a day. Further, this pilot plant will demonstrate openly that the U.S. has established the ability to meet its aluminum needs from a domestic resource.

However, low-grade resources such as clay will require more energy to produce an equivalent amount of alumina. For example, the hydrochloric acid-ion exchange process for leaching clay will require more than twice as much energy as the Bayer process using imported bauxite. Consequently, additional research is needed to develop more efficient processes.

Titanium also is an important aerospace metal. More than 95 percent of the rutile, the mineral from which titanium is made, is imported. Although rutile is scarce, ilmenite, an iron-titanium oxide, is abundant in the United States, and Bureau research has focused on recovering titanium from this mineral. The most promising process developed by the Bureau appears to be the chlorination of ilmenite to obtain titanium tetra-



chloride, from which high-purity titanium can be obtained. The chlorine is recycled and a useful, non-polluting, iron oxide byproduct is recovered.

Nickel is another important aerospace metal that is largely imported. It is the basis metal for many of the superalloys used by engine manufacturers. However, the United States does not have significant nickel resources in the laterite deposits near the California-Oregon border and in the nickel-copper deposits in Minnesota. Both are submarginal resources, but research is being performed to develop the technology that will allow their utilization.

Research on methods to recover zircon sand and milled zircon used in close tolerance molds for casting superalloy turbine blades was initiated because of recent price increases. In June of 1974, the price of milled zircon was \$575 per ton and was expected to increase to the \$700 to \$900 per ton range by 1975. Zircon sand increased in price from \$99.40 per ton to \$292 per ton between January and July of 1973. Bureau research has shown that the zircon in discarded molding material, now being used as landfill, can be separated for reuse by sink-float techniques. Studies also have shown that most of the zircon in this waste material is the high-grade milled zircon, rather than zircon sand.

Recovering Chromium

Chromium, an important alloying element for superalloys, is especially critical. There are no significant deposits of chromium-bearing ores in the United States. Despite our total dependence upon imports, industry throws away substantial quantities of the metal in electroplating solutions and electrochemical machining sludges. To recover this wasted chromium, the Bureau developed a process in which two different waste liquids are mixed together to form a precipitate that can be filtered and treated to recover the chromium and other valuable metals. If not recovered, superalloy scrap would also represent wasted chromium as well as nickel, cobalt, and molybdenum. The Bureau has successfully developed a process to recover nearly 90 percent of these critical metals for reuse.

The Bureau also is seeking ways to use less chromium by such techniques as restricting it to the surface of metals where it is used for oxidation and corrosion resistance. We are also considering substitutes for high-chromium alloys. Greater use of titanium obtained from domestic sources would relieve some of the demand for high-chromium stainless steels.

Future turbine engines will have to operate at higher temperatures to be more efficient. This means using alloys and ceramics having better high-temperature properties than our present nickel or cobalt based alloys. The melting points of high-temperature metals are shown in figure 6, along with the melting points of the major metals melting at lower temperatures. Of the high-temperature metals, the Bureau is developing oxidation-resistant coatings and composites for molybdenum, and we also are investigating improved melting and casting techniques. Molybdenum alloys are being studied for turbine components and for other applications because molybdenum is domestically abundant and could, therefore, relieve the demand for materials that are in short supply.

Tungsten is another important superalloying element and it also is used to make rocket nozzles. The Searles Lake brines in California contain an estimated 170 million pounds of tungstic oxide. This amounts to about a 10-year supply at the present rate of U.S. consumption of tungsten. In addition they contain a variety of sodium, potassium, and boron chemicals. These chemicals are being commercially extracted, but the tungsten is being returned to the lake with depleted brine. The Bureau is developing a process to recover this unused tungsten.

We have discussed some of the Bureau's programs designed to relieve future mineral shortages. These shortages are of great concern to the Bureau of Mines and to the Department of the Interior. Recently, Secretary of the Interior Rogers C. B. Morton, said:

"If we are to meet the challenge of providing minerals . . . , we must begin a massive revitalization and rededication of mineral science and technology.

"If new resources are to be discovered—as they must—we shall need something better than yesterday's techniques. And yesterday's methods of mining and processing will have to be examined critically in order to develop new technologies that will permit more effective exploitation of the mineral resources now being mined.

"Moreover, all these things must be done with due regard to health, safety, environmental protection and land use.

"Downstream, our technology with respect to reuse of mineral commodities—their recycling into productive channels—must be improved and the application of new methods accelerated.

"The job to be done is immense. Can we solve these problems? The answer will depend upon the sense of commitment, of involvement, of cooperation that we can muster."

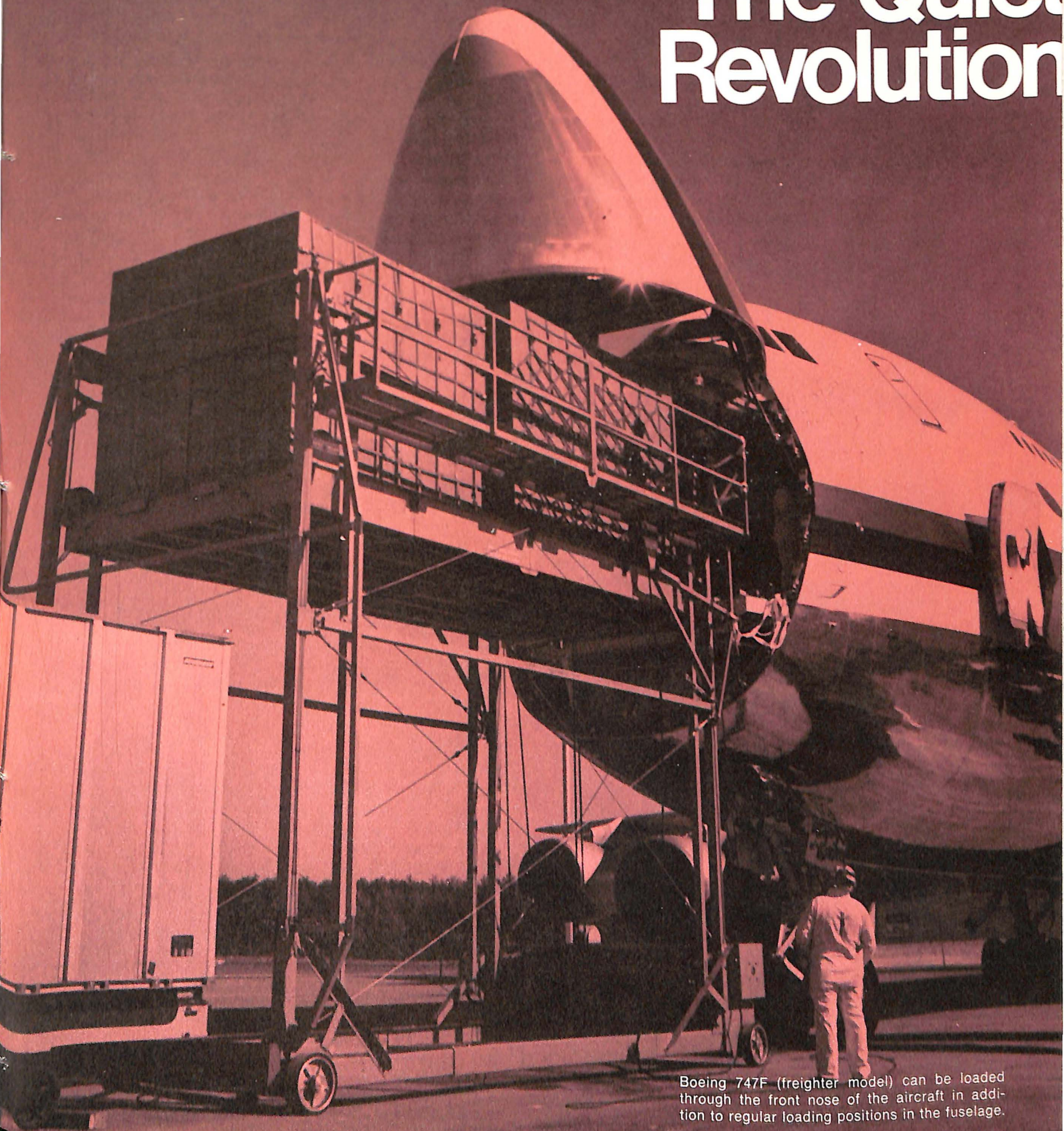
Viewing these problems, Secretary Morton concluded that he "chose to be optimistic."

The Bureau of Mines is devoting its best efforts to solving these problems by making maximum effective use of the mining and metallurgical expertise of its research and development organization. In our metallurgy program, advancing minerals technology involves research that will result in major improvements in minerals and metals processing technology. Effecting pollution abatement is aimed at developing methods for reducing or eliminating pollution caused by the minerals processing industry. Improving mineral and metal recycling is directed toward improved methods for recovering materials from urban refuse and a variety of mineral and industrial wastes. Research on minimizing mineral and metal needs involves developing high-quality and improved-performance materials which, because of longer life, will result in more efficient utilization of our resources.

The Bureau of Mines intends to discharge effectively and efficiently its responsibilities under all mineral legislation, particularly the Mining and Mineral Policy Act of 1970.

AIR FREIGHTER

The Quiet Revolution



Boeing 747F (freighter model) can be loaded through the front nose of the aircraft in addition to regular loading positions in the fuselage.



Lockheed's L-1011 belly compartment can accommodate a wide variety of load sizes. Addition of wide-body jets to the U.S. air fleet doubled the air carriers' freight capability during the past four years.

For several years it was predicted that an air freight "breakthrough" would come about. Now the revolution has happened — without fanfare, and even without wide public awareness.

Robert D. Timm, Chairman of the Civil Aeronautics Board, eloquently placed the air freight "revolution" in perspective:

"An historical event has occurred, and none of us recognized it when the sun came up. As long as I have been in the transportation regulatory business — almost ten years — everyone has said, 'One of these days — one of these days the shipping of goods by air will explode and a new day will dawn . . . When the breakthrough in air cargo comes, it will be a new era of commerce.'"

"We all must have been looking on the dark side of the moon for this momentous event because the air cargo dawn slipped up on us and we are at that new time," Chairman Timm concluded.

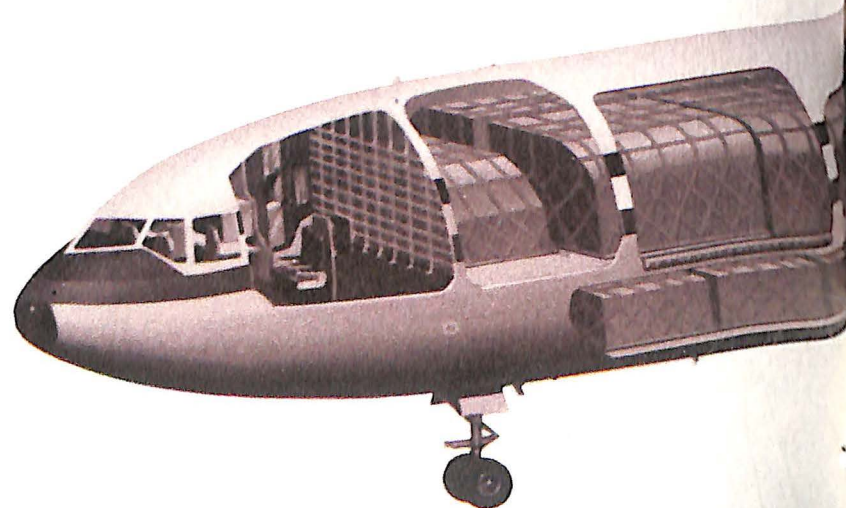
The basic factor in launching the startling escalation of tonnages carried by aircraft, was the design, development and production of increasingly larger and more efficient aircraft by transport manufacturers.

The evolution producing more and more space for cargo has been going on for about 30 years. One air cargo executive sums it up this way:

"When we put our first freighter aircraft into service about 30 years ago it could handle 6,000 pounds of cargo — less than half the 14,000 pounds that can be carried in a single 8'x8'x10' container designed for the wide-body air freighters. Each of these freighters can handle 30 of these big containers." The capability and

impact of the wide body jets will be discussed later.

The international growth alone is quickly apparent as an area of great economic importance to the nation. Air freight tonnage carried between the United States and Europe has increased five-fold during the last 10 years — from 97,000 tons to 583,000 tons or more. This amounts to approximately a 20 percent annual compounded growth rate. It is much greater than the growth rate of passenger traffic, which draws more attention. Air Transport Association data for the first seven months of 1974 shows that international air freight traf-



fic is up nearly 14 percent over the same period in 1973, measured in ton-miles of freight service.

The *Journal of Commerce*, in an interview with the chief cargo executive of a leading U.S. carrier of international air freight, provided this assessment of the reasons for the growth.

- The movement into an era of shortages in many products and materials, resulting in increased reliance on airlift to keep things going.

- High interest rates, resulting in the need to keep inventories low, thereby reducing interest on capital spending.

- Increases in the value of many products and commodities, making it more logical, from a business standpoint, to ship by air.

- A continuation of capital expenditures aboard, despite high interest rates. Air freight is involved here because of its role in carrying abroad goods such as construction materials.

- Multinational corporations continue their search for new bases of operation throughout the world and they are finding them in some out-of-the-way places. The result is the need for speedy transportation of materials to distant places.

It is interesting to note that this assessment emphasizes the current economic conditions — inflation, tight money, high interest rates and, in addition, material scarcities in changing traditional distribution patterns. Thus air freight has become an important business tool in helping to minimize the impact of these factors.

The move to passenger jets was a major step in the air freight story. The under-bellies of jet airliners held more than twice as much freight as the piston-powered aircraft they replaced; jet speed delivered their cargoes twice as fast as before.

The first jet freighter was introduced in 1963, another evolution in cargo-lift capability. They are heavily used and will continue to be.

Then the wide-body jet aircraft — the Boeing 747, the Lockheed L-1011 and the McDonnell Douglas DC-10 — provided a freighter-like capability to complement the service of the jet freighters. These aircraft, even when carrying a full load of passengers and their luggage,

IMPORTANCE OF AIR TRANSPORT TO EMERGING NATIONS

Space considerations limit this article to a discussion of the explosion in air freight carried by scheduled airlines and major freight carriers.

But there is another facet of this subject that demands mention.

Emerging nations, often with few roads, few rail lines, largely undeveloped waterways and few if any airports that can let them accept and utilize efficiently the wide-body jets when and where they need them, still are finding air transport essential to development.

They are turning to multipurpose transports of all sizes, from helicopters and general aviation aircraft to, mostly, the large turboprops that can carry everything from people to produce to bulldozers, and can land on unimproved strips or even a short piece of open ground.

It makes no difference whether the aircraft are purchased by the civil government or the armed forces, they are used to develop the country and to improve communications and commerce.

In fact, in 1954 Lockheed first produced the C-130 troop and cargo transport for military use. Today more than 1400 aircraft of the civilian "Hercules" model have been sold to 37 nations outside the U.S., and the production line is still humming.



McDonnell Douglas DC-10 All Freighter is shown in an artist's conception. This version features two cargo decks with powered loading systems and large cargo doors.

can also carry up to 45,000 pounds of freight. U.S. scheduled airlines bought 320 of these wide-body aircraft, and that investment doubled air freight capability during the last four years.

Now major airlines are turning to the wide-body freighter, an aircraft that put big wings on big things. These freighter versions of the wide-body jets are another step in the evolution of the burgeoning air freight system.

The first wide-body jet freighter was put into service by a foreign carrier. It proved highly successful. As of October 1, 1974, 11 airlines had purchased 21 wide-body jets with main-deck cargo-carrying capability. Of these, 14 will have been delivered by the end of 1974. Boeing predicts that more than 100 747Fs (freighters) will be ordered by the end of the decade.

One air industry official points out that a wide-body freighter can carry up to three times as much cargo as its big four-engine predecessor could after conversion to an all-freight vehicle. As he puts it: "When you slam the door on a wide-body freighter it sounds like the world's biggest cash register."

What makes air freight ring up such sales?

Here are some examples of the capability of the wide-body freighter to carry out-sized cargo:

- A complete mobile television studio, housed in a 40-foot trailer, was shipped back to New York from Europe after video taping an international track and field competition in which the U.S. fielded a team. It was handled as a single 27,000-pound unit.

- A chemical production line weighing a total of 30 metric tons.

- An aircraft ground support tractor weighing 40,000 pounds.

- Large logging tractors.

- A \$1 million dollar painting requiring protective packaging that resulted in 14 feet by 10 feet 10 inch

dimensions, beyond the limits of loading doors of other aircraft.

Stuart G. Tipton, former chairman of the Air Transport Association, tells this anecdote about air freight and an entrepreneur.

"I came across the story," he states, "when I found a strange looking specific commodity air freight tariff. It provided for the shipment of live eels at 57 cents per pound from Washington, D. C. to Tokyo.

"Behind the tariff is a man who lives in Montross, Virginia, in the Tidewater area where the Potomac River empties into the Chesapeake Bay, and where the water teems with succulent eels. He learned that pollution had reduced the eel supply in Japan at the same time that demand for this Japanese delicacy was growing in that country.

"The man in Montross was but a stone's throw from some of the finest eels in the world. He designed his own water-tight container, approached a U.S. flag carrier serving both Washington and Tokyo. A deal was struck, a tariff was filed and that first year a few hundred pounds of eels made the long journey."

"Last year, the airlines flew some 70,000 pounds of eels from the East Coast of the United States to Tokyo."

From this anecdote Mr. Tipton deduces: "The moral is clear to all of us. Air freight users and carriers alike must join in imaginative marketing."

One of the more prosaic facts of air freight gains is simply the method in which it is shipped. It is termed "containerization" in the industry. A method of efficient and safe handling of shipment.

Containerization is important for a number of reasons:

- Containers protect freight from theft and other losses.

- Containers reduce packaging costs.

- Incentive rates are given shippers who build up their own container loads.

- Containers of different sizes have been developed. A few years ago they could only be used on freighter-type aircraft. Then another type was developed that fit the lower decks of the wide-body jets. Today wide-body freighters can handle truck-size loads.

Each of the above factors reduces costs.

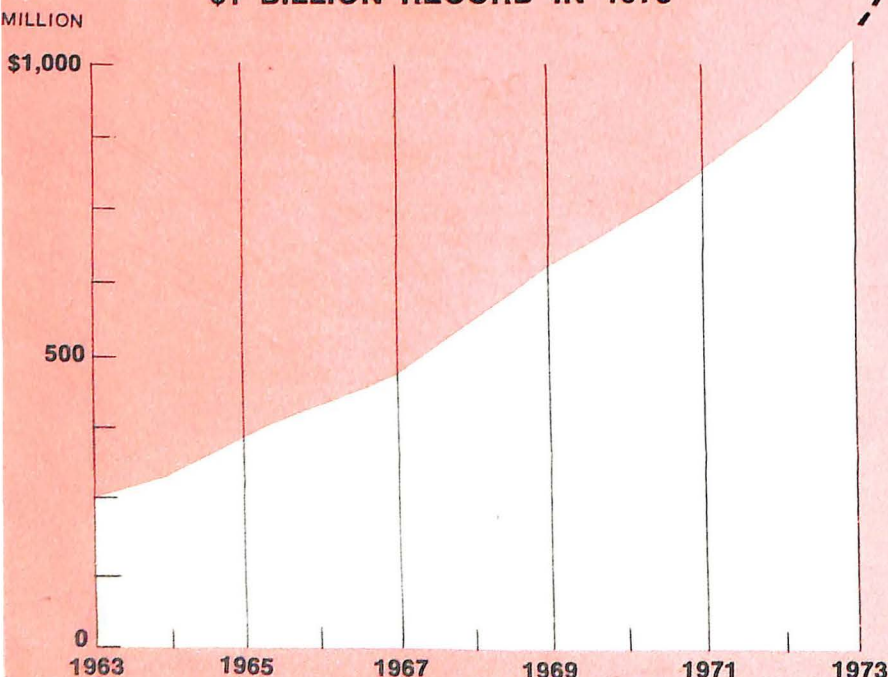
In addition, service innovations have helped the shipper of small packages, and there are some large volume shippers of small packages, and their business is growing. One innovation is a service that involves a shipper bringing a package generally limited to 50 pounds and total outside dimension of 90 inches to a ticket counter 30 minutes before flight time; the package is picked up 30 minutes after arrival at the destination airport. This service is one of the fastest growing phases of the air freight business.

Fortune Magazine in May 1946 published an article entitled "Freight By Air." The concluding paragraph was prescient:

"Among all the uncertainties in the air freight picture, one thing is sure: as rates go down and the operational efficiency goes up, the American businessman and the public will get the benefits of a vast network of fast airplanes."

That has come about. Last year the air freight business hit a landmark, achieving \$1 billion in revenue. And this year will exceed the 1973 record.

**AIRLINE FREIGHT REVENUES SET
\$1 BILLION RECORD IN 1973**



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RETURN REQUESTED

The belly compartment of a McDonnell Douglas DC-10 is loaded with a container of freight. The aircraft also carries a passenger load and their luggage in addition to accommodating large freight shipments. The Boeing 747 and Lockheed L-1011 also have huge compartments beneath their passenger cabins. (See *Air Freight: The Quiet Revolution*, p. 13)



aerospace

OFFICIAL PUBLICATION OF THE AEROSPACE INDUSTRIES ASSOCIATION

FEBRUARY 1975



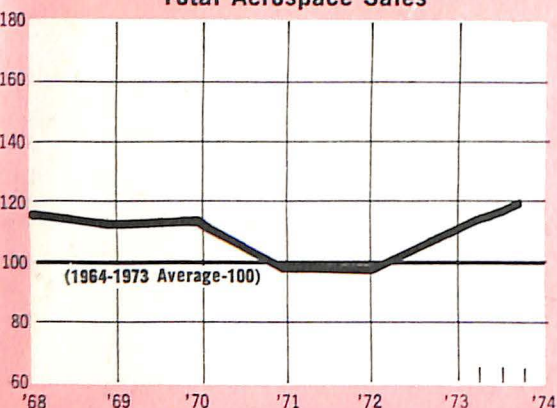
A Salute to
WOMEN IN
AEROSPACE

AEROSPACE ECONOMIC INDICATORS

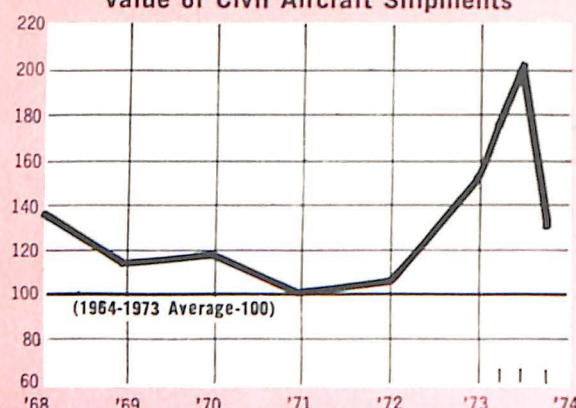
CURRENT

OUTLOOK

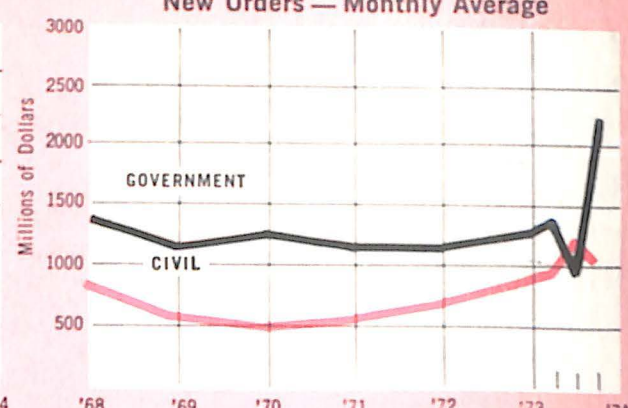
Total Aerospace Sales



Value of Civil Aircraft Shipments



New Orders — Monthly Average



— Aerospace obligations by Dept. of Defense and NASA.
— Non-government prime orders for aircraft and engines.

| ITEM | UNIT | PERIOD | AVERAGE 1964-1973 * | LATEST PERIOD SHOWN | SAME PERIOD YEAR AGO | PRECEDING PERIOD † | LATEST PERIOD |
|---|------------|-------------|---------------------------|---------------------------|----------------------------|-----------------------|------------------|
| AEROSPACE SALES: Total | Billion \$ | Annual Rate | 24.1 | 3rd Quarter 1974 | 23.5 | 25.5 | 26.2 |
| | Billion \$ | Quarterly | 6.1 | | 5.7 | 7.2 | 6.3 |
| AEROSPACE SALES: Total (In Constant Dollars, 1958=100) | Billion \$ | Annual Rate | 15.8 | 3rd Quarter 1974 | 15.2 | 15.2 | 15.2 |
| | Billion \$ | Quarterly | 4.0 | | 3.6 | 4.3 | 3.7 |
| DEPARTMENT OF DEFENSE | | | | | | | |
| Aerospace obligations: Total | Million \$ | Monthly | 1,194 | Sept 1974 | 860 | 1,704 | 1,638 |
| Aircraft | Million \$ | Monthly | 716 | Sept 1974 | 506 | 834 | 962 |
| Missiles & Space | Million \$ | Monthly | 478 | Sept 1974 | 354 | 870 | 676 |
| Aerospace outlays: Total | Million \$ | Monthly | 1,129 | Sept 1974 | 953 | 1,143 | 968 |
| Aircraft | Million \$ | Monthly | 669 | Sept 1974 | 516 | 620 | 502 |
| Missiles & Space | Million \$ | Monthly | 460 | Sept 1974 | 437 | 523 | 466 |
| Aerospace Military Prime Contract Awards: TOTAL | Million \$ | Monthly | 1,061 | Sept 1974 | 1,302 | 1,021 | 1,714 |
| Aircraft | Million \$ | Monthly | 667 | Sept 1974 | 867 | 591 | 866 |
| Missiles & Space | Million \$ | Monthly | 394 | Sept 1974 | 435 | 430 | 848 |
| NASA RESEARCH AND DEVELOPMENT | | | | | | | |
| Obligations | Million \$ | Monthly | 283 | Sept 1974 | 161 | 218 | 192 |
| Expenditures | Million \$ | Monthly | 287 | Sept 1974 | 184 | 182 | 206 |
| BACKLOG (55 Aerospace Mfrs.): Total | Billion \$ | Quarterly | 25.5 | 3rd Quarter 1974 | 29.2 | 30.0 | 33.6 |
| U.S. Government | Billion \$ | Quarterly | 14.5 | | 16.3 | 16.2 | 19.1 |
| Nongovernment | Billion \$ | Quarterly | 11.0 | | 12.9 | 13.8 | 14.5 |
| EXPORTS | | | | | | | |
| Total (Including military) | Million \$ | Monthly | 249 | Sept 1974 | 448 | 468 | 505 |
| New Commercial Transports | Million \$ | Monthly | 77 | Sept 1974 | 163 | 103 | 163 |
| PROFITS | | | | | | | |
| Aerospace — Based on Sales | Percent | Quarterly | 2.7 | 3rd Quarter 1974 | 2.9 | 3.4 | 2.9 |
| All Manufacturing — Based on Sales | Percent | Quarterly | 4.9 | | 4.6 | 6.0 | 5.7 |
| EMPLOYMENT: Total | | | | | | | |
| Aircraft | Thousands | Monthly | 1,213 | Sept 1974 | 953 | 972 | 976 |
| Missiles & Space | Thousands | Monthly | 669 | Sept 1974 | 516 | 519 | 539 |
| Missiles & Space | Thousands | Monthly | 128 | Sept 1974 | 95 | 105 | 93 |
| AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS | | | | | | | |
| | Dollars | Monthly | 3.86 | Sept 1974 | 5.01 | 5.43 | 5.48 |

* 1964-1973 average is computed by dividing total year data by 12 or 4 to yield monthly or quarterly averages.

† Preceding period refers to month or quarter preceding latest period shown.

THEY ALSO SERVE



Karl G. Harr, Jr.

BY KARL G. HARR, JR.
President, Aerospace Industries Association

January 1975 began "International Women's Year," so designated by the United Nations General Assembly. The United States chose to start the year by saluting Women in Aerospace — from those who fly to those who contribute so much to the development of aircraft, spacecraft, missiles and all the complicated systems that go into them. In paying tribute to them all, we identify some of them in this issue.

In a brief salute to such women it is easy to concentrate on the "doers" and slight those whose unsung efforts do much to make the U.S. preeminent in the aerospace field. These are the dedicated aerospace homemakers and child raisers who maintain a stable family base while their spouses meet the demanding schedules and performance that are characteristic of aviation, space and missile careers.

"Rosie The Riveter," who helped turn out 50,000 airplanes a year for the U.S. during World War II, was celebrated in song. But there are no songs about the wife of an astronaut, a military, airline or test pilot, or an aerospace technical representative supporting his company's product in some distant country or aboard an aircraft carrier at sea.

Unsung they may be, but these able and silent partners are a part of our industry's salute to Women in Aerospace.

Official Publication of the
Aerospace Industries Association of America, Inc.

PRESIDENT • Karl G. Harr, Jr.
VICE PRESIDENT
FOR PUBLIC AFFAIRS • Carlyle H. Jones
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FORECAST

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REMOTELY PILOTED VEHICLES

COVER: Amelia Earhart — aviation pioneer — in 1932 was the first woman to make a trans-Atlantic solo flight; in 1935, the first to make a solo record-breaking flight from Honolulu, Hawaii, to Oakland, Calif., and a charter member and first president of The Ninety-Nines, Inc. (international organization of licensed women pilots).

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

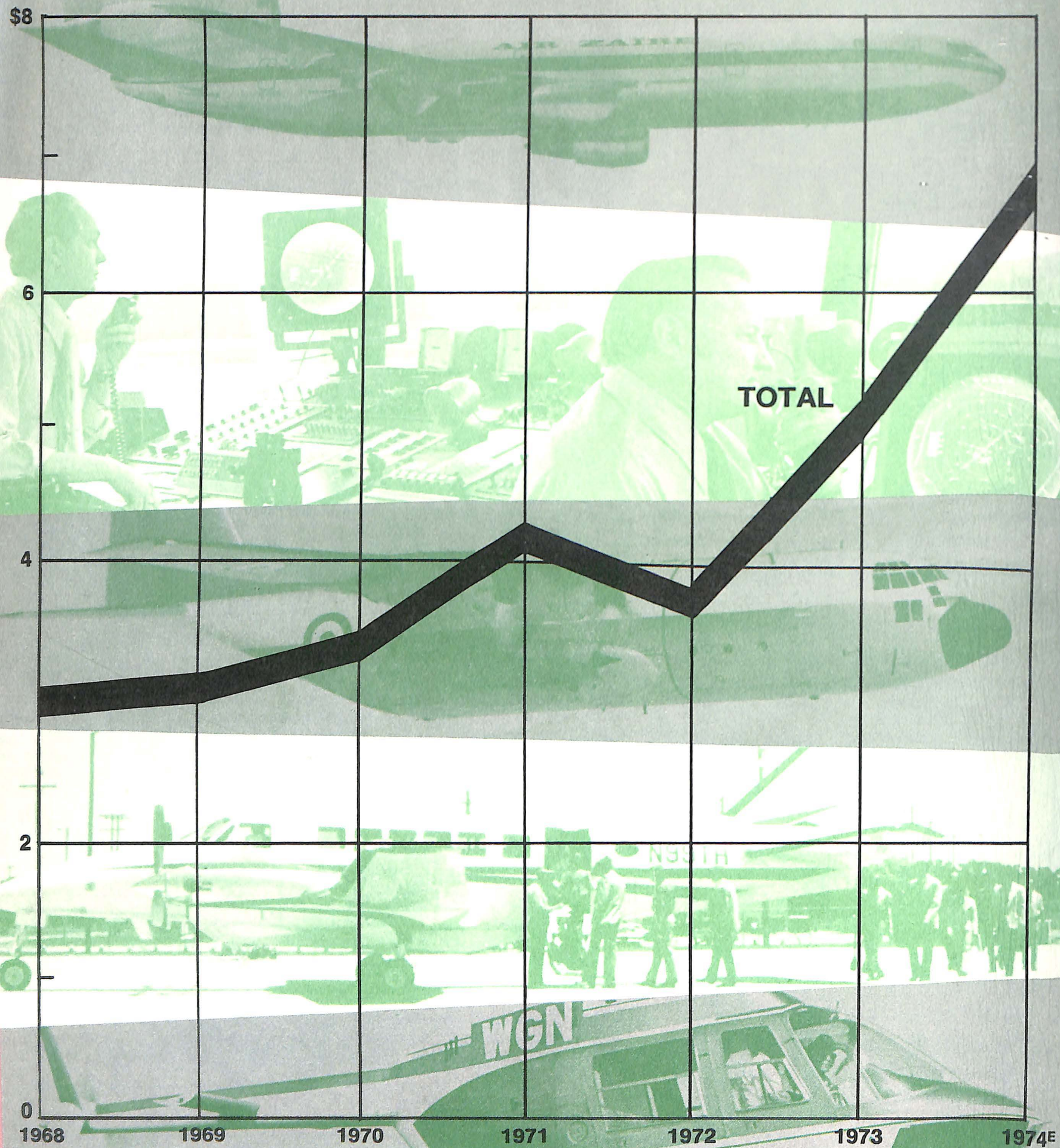
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EXPORTS OF AEROSPACE PRODUCTS

(Billions of Dollars)



E Estimated
Source: Bureau of the Census

Karl G. Harr, Jr., President of the Aerospace Industries Association of America, recently appraised the aerospace industry's performance in 1974 and looked at what probably lies ahead for 1975. His annual "review and forecast" was presented at a Washington, D.C. meeting of the Aviation/Space Writers Association.

Sales for the aerospace industry during 1974 are estimated at more than \$27 billion, an increase of more than \$2 billion over the previous year in current dollars. Mr. Harr forecast that 1975 sales would approach \$29 billion.

He explained that while total 1974 sales did exceed all earlier predictions, the *constant* (1968) dollar value of aerospace sales (see chart, p. 5) was down slightly from last year, emphasizing that "this erosion of our industry will continue unless the nation is successful in its efforts to stem inflation and arrest the current recessionary movement

of our national economy."

Noting that last year a slight downturn was forecast in aerospace sales due to the uncertainties of energy supplies and to the expected increases in both materials and labor costs, he said: "We all were somewhat cautious in our predictions, but the superiority of U.S. aerospace products assisted greatly in overcoming negative factors."

Once again the contribution of export sales to the total U.S. balance of trade was cited as a significant feature of the industry's 1974 performance. "Exports," Mr. Harr said, "will not only reach their highest level this year at \$6.8 billion, but also will more than double the 1970 total. In light of the expected overall U.S. trade deficit for the year, such an accomplishment is of critical importance."

In specific areas, both sales to the Department of Defense (DOD) and to the National Aeronautics and Space Administration (NASA) rose by less than

5 percent. DOD, however, remained the single biggest customer of the aerospace industry, paying more than \$13 billion for goods and services. At the same time, commercial sales in the non-aerospace category continues to expand rapidly. The latter category includes aerospace products, such as electronic equipment and engines, that are used in non-aerospace applications.

"Commercial aerospace sales during 1974 increased by nearly 22 percent to an all time high of \$7.5 billion. And the sale of non-aerospace products approached the \$4 billion level for the first time," he said. He added further that this increase in commercial sales contributed to a change in the profit picture for the industry, as net profit after taxes as a percent of sales will rise above the 3.0 percent level for the first time since 1968. This rate is still far short of the 6.0 percent achieved by all manufacturing industries.

1974

AEROSPACE REVIEW AND FORECAST

HIGHLIGHTS OF 1975 FORECAST

"Although the industry expects that total sales will rise even more in the coming year, the conflicting forces of inflation and recession will substantially negate gains normally associated with increased sales," Mr. Harr reported. Thus, while total 1975 sales in current dollars will approach \$29 billion, constant dollar figures will continue a three year downturn.

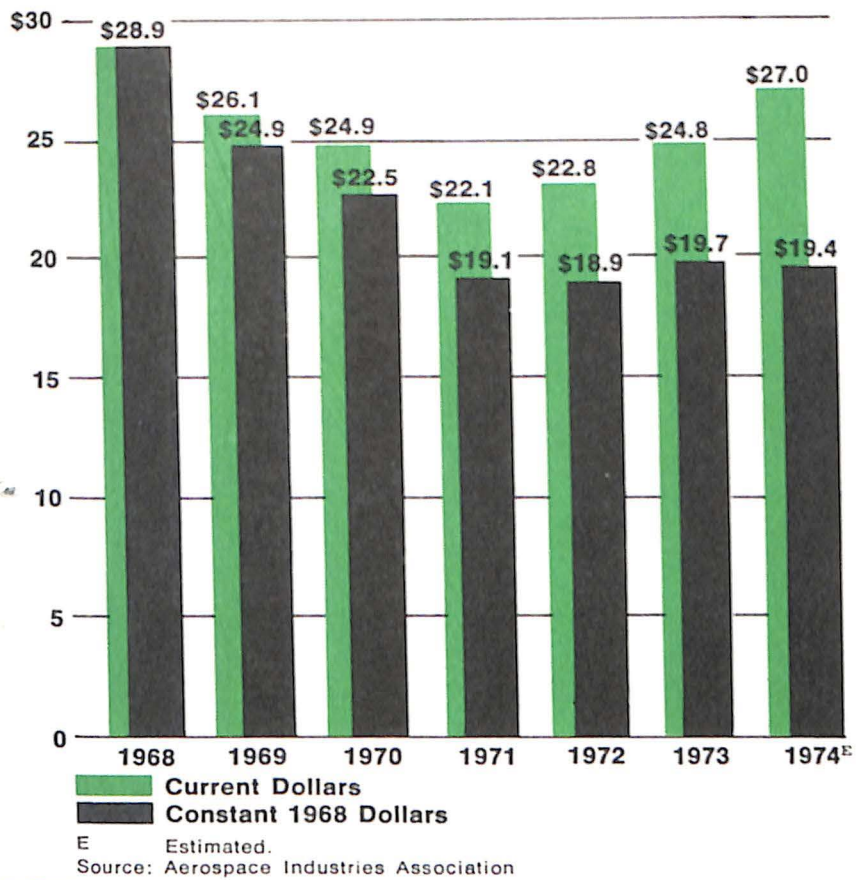
"One of the effects, particularly of the inflationary spiral," he pointed out, "is an extraordinarily high backlog of orders which in the long run may prove to be somewhat artificial." At the end of 1974, the backlog will be a record high of \$32 billion. On this basis, consistent sales gains are predicted through 1975. "This type of growth is misleading and in fact may mean no growth at all if the gap between current and constant prices widens any farther," he said.

Mr. Harr reported that estimates for 1975 aerospace sales by customer show a decline in all major areas when measured in terms of constant dollars. "In spite of the slight increase predicted in sales to the Department of Defense, the constant dollar figure indicates a better than 7.0 percent decline. Regarding NASA and other government agencies, the real dollar decline will be in excess of 12 percent. Furthermore, commercial aerospace sales which are expected to reach \$8.2 billion during the coming year in current dollar figures, actually will realize a very slight decline in constant dollar value."

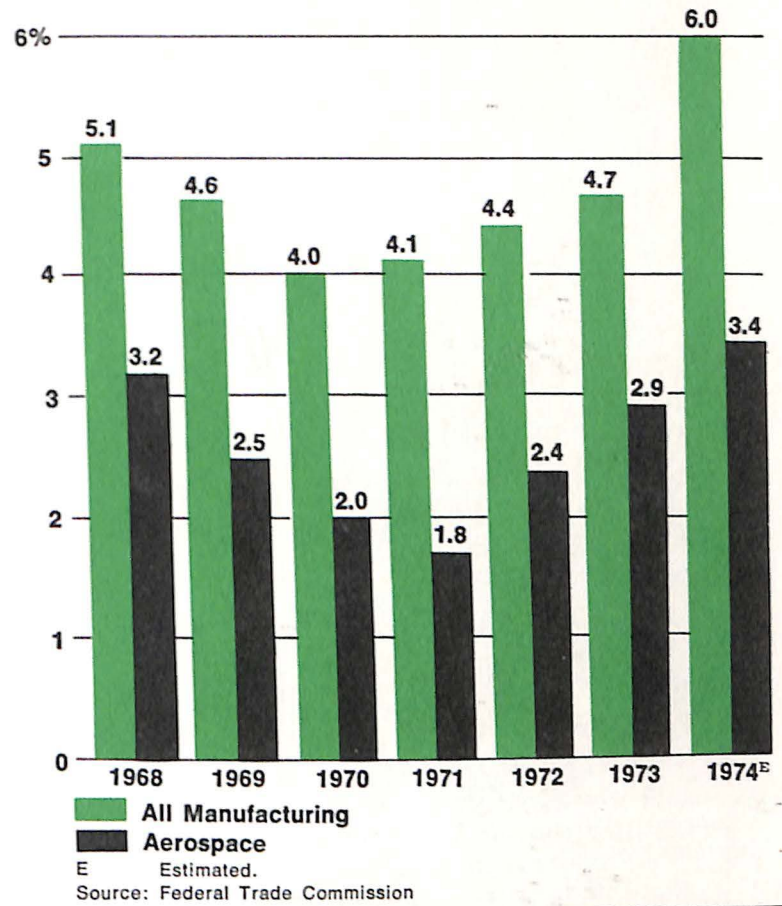
Employment levels are expected to respond to the constant dollar figure and will decline to 959,000 during 1975, down from 968,000 at the end of 1974.



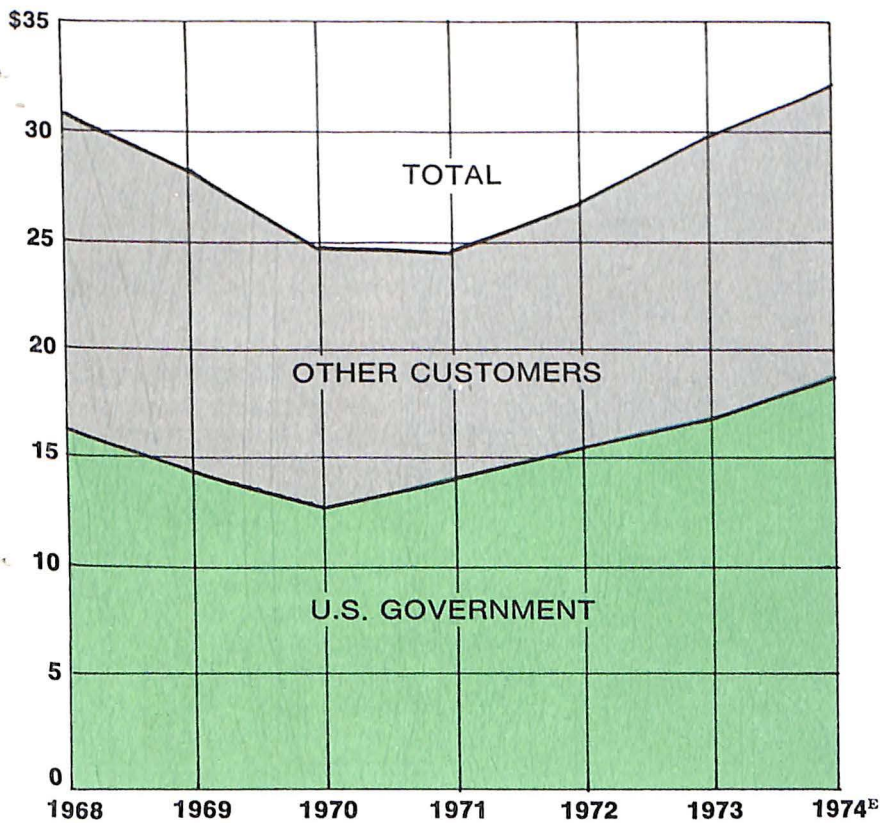
AEROSPACE INDUSTRY SALES
(Billions of Dollars)



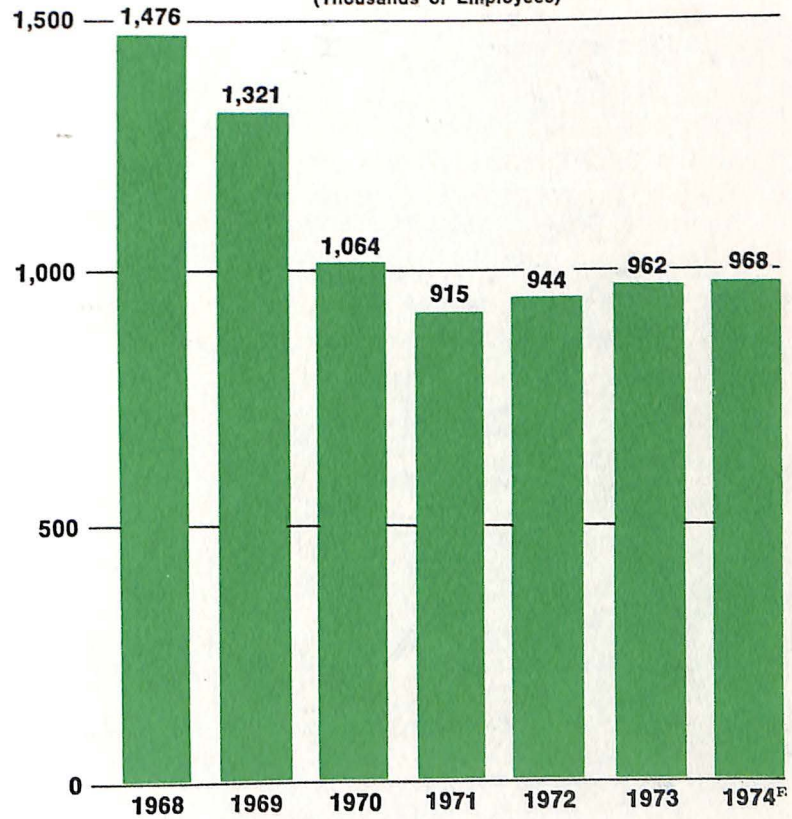
AEROSPACE AND ALL MANUFACTURING CORPORATIONS
NET PROFIT AFTER TAXES AS A PERCENT OF SALES



BACKLOG OF MAJOR AEROSPACE COMPANIES
(Billions of Dollars)



AEROSPACE EMPLOYMENT
(END-OF-YEAR)
(Thousands of Employees)



A Salute to WOMEN IN AEROSPACE

The year 1975 has been proclaimed by the United Nation's General Assembly as International Women's Year. America's year-long "Salute to Women" is outlined in an alphabetical calendar. It began in January with A — for women of achievement in aviation and the aeronautical and aerospace sciences. Thus, this is an appropriate time to recognize women for their significant contributions to the broad field of aerospace.

January 11, 1975, the 40th anniversary of Amelia Earhart's record-breaking flight from Honolulu to Oakland, was selected as the take-off date for the year because Amelia Earhart's deeds and qualities were an inspiration to women everywhere.

"AE", the first woman to fly both the Atlantic and Pacific solo, was the first president of The Ninety-Nines, international organization of licensed women pilots. She was always interested in encouraging other women to fly and to help them in their careers.

In 1929, 99 of the then 117 U.S. women pilots met and organized; hence the name. Today there are more than 4000 members in 22 countries. The 99's award seven Amelia Earhart scholarships each year.

TODAY, WOMEN IN AEROSPACE:

- push the throttle
- monitor oil spills in the Gulf of Mexico
- help launch satellites
- dust crops
- hunt hurricanes
- make trans-Atlantic delivery flights
- design cockpits
- serve as manufacturers and airlines executives
- wear Army and Navy aviator wings
- establish world aviation records
 - pilot corporate aircraft
 - serve as airport/heliport consultants, as FAA flight examiners

- control air traffic
- direct aviation education programs
- work as propulsion, human factors, electrical and design engineers
- operate airports/heliports
- instruct ground, flight and instrument students
- program computers in missile guidance and control systems, flight simulators
- give aerial traffic and weather reports
- patrol pipelines
- publish and write for aviation newspapers, magazines, books
- transport personnel and parts to off-shore oil rigs
- co-pilot commercial airlines
- fly rescue missions
- teach our youth aerospace subjects

But all this is not really new. In the early days of aviation, women soon proved skilled and qualified as balloon, airplane and helicopter pilots and were accepted and welcomed into the aviation fraternity. Through the years, women have held responsible positions in all segments of aviation. Many have won international recognition for their achievements.

It would be impossible here to report completely and accurately all the many and diversified jobs done by women in aerospace today. Here are just a few that are representative of what women have done, can do, are doing, and, given the opportunity, will do, to further advance technological developments for continued U.S. leadership in aerospace.

In 1910, Blanche Scott Stuart, in an unscheduled take-off (strong wind) was the first woman to solo. She went on to become an exhibition pilot. Harriet Quimby, drama critic of *Vogue* magazine, was the first American woman licensed pilot, and the first to fly the English Channel in 1912.

In the 1930's, Helen Richey was the first woman to wear an airline uniform and fly



Anna Chennault, widow of General Claire Chennault, Commander of the World War II Flying Tigers, is now Vice President — International Affairs of the Flying Tiger Line, Inc.

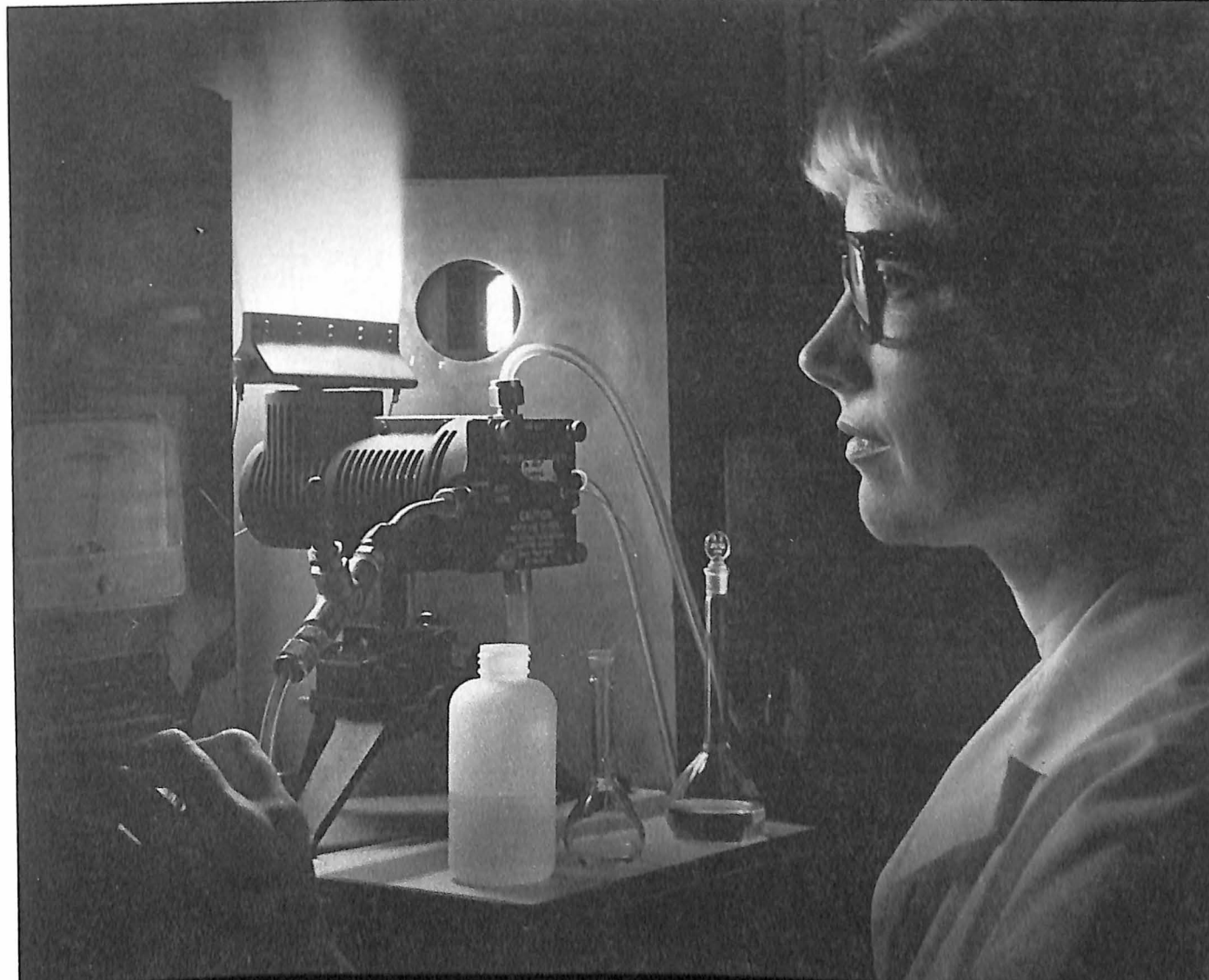


First Officer Emily Howell of Frontier Airlines, Inc., winner of the 1973 Amelia Earhart award as the year's outstanding woman in U.S. aviation, has logged more than 8,000 hours in Twin Otters, Boeing's 737's and Convair 580's. She is the first woman to qualify for membership in the Air Line Pilots Association.

Kay Rodgers, Lockheed Electronics Co., studies procedures for analyzing rocks and minerals using an atomic absorption spectrophotometer. Her unit received a group achievement award from the National Aeronautics and Space Administration.



Kiki Fleck, a thermodynamics expert at Lockheed Aircraft Corp., worked on the cooling of advanced avionics systems in the P-3 Orion and the S-3A Viking antisubmarine patrol planes.





Phyllis Veit is an engineer with Aerojet Solid Propulsion Company's Propellant Development organization.



Barbara Greenough, staff scientist at Lockheed Missiles & Space Company, received an award for a patent application.



Dr. Anne Belfort holds a key staff position with General Electric's Reentry and Environmental Systems Division.



Dr. Nancy Roman is the Chief of Astronomy/Relativity for the National Aeronautics and Space Administration.



Dr. Dora Dougherty Strother is Chief of the Human Factors Group at Bell Helicopter Co. She also is a commercial glider pilot, a qualified ground instructor, holds an airplane transport pilot certificate and a commercial helicopter rating.



Dr. Nancy Mann, Rockwell International, uses her expertise in biostatistics to measure air pollution.



The Honorable Isabel A. Burbess of Arizona is the first woman member of the National Transportation Safety Board.



Mary T. Gaffaney, a member of the 1970 World Aerobic Team, is the first person to win a Gold Medal in World Aerobic Competition for the U. S. She is also the first woman helicopter instructor in Florida.

Yvonne Brill, of RCA, designed this system which enables a satellite to change orbit in space.



Gini Richardson, Whirly-Girl No. 64, operates helicopter flight schools in Washington and California, and won the 1971 Powder Puff Derby.



Marjorie Townsend is the Small Astronomy Satellite Project Manager for NASA.



Claire Phillips, a corporate pilot, is the first woman to win the National Business Aircraft Association's Million Miler Safety Award.



Olive Ann Beech co-founded with her husband, the late Walter H. Beech, the Beech Aircraft Company in 1932, and is now Chairman of the Board and Chief Executive Officer.



Shirley Mahn, a corporate pilot, has logged 12,000 hours.

from the right seat. Also in the 30's, the famous Jacqueline Cochran started her record-breaking career (her speed records in the P-51 still holds), and she was the first woman to break the sound barrier.

During World War II she organized the WASPs (Women's Airforce Service Pilots). In the program 1074 women won their wings and flew 60 million miles for the U.S. Army Air Corps.

The first woman to reach toward space was the record-setting balloonist, Jeannette Picard of Minneapolis, Minn., who in 1934 rose to the height of 57,559 feet. And today Constance Wolf of Blue Bell, Pa., holder of 15 international records, is the leading U.S. woman balloonist.

IN AEROSPACE

It is not possible to recite here the large number of positions held by women throughout all facets of the aerospace industry.

The variety of their important roles includes research and development, engineering, airframe welding, assembly and installation of complicated electronic systems and subsystems, computer programming, designing aircraft components and interiors, selling and flying the finished products, and performing in top management positions.

For example, Mrs. Yvonne Brill invented and patented a design for a "Dual Thrust Level Monopropellant Spacecraft Propulsion System." With RCA since 1966, Mrs. Brill analyzes and designs spacecraft propulsion systems for use in communications, navigation, scientific and meteorological applications.

IN AEROSPACE EDUCATION

One of the greatest contributions of women has been in the field of education where they are teaching aerospace subjects in our educational systems all the way from pre-primary to post-graduate levels. And the 99's are actively involved in supporting aerospace education at all levels of learning.

Elsie W. Adams, Marilyn Link and Jane N. Marshall have received our nation's highest award in aerospace education — the Frank G. Brewer Trophy — awarded annually for the most outstanding contribution in the field of aerospace education.

Dr. Carol St. Cyr served as President of the National Aerospace Education Association from 1972 to 1974.

Both NASA and the FAA, as well as numerous associations have women in their education program offices.

IN GOVERNMENT

As in industry, more women are being named to top positions in government. Aerospace-connected jobs are no exception.

The Federal Aviation Administration of the Department of Transportation has women in many key jobs all over the country.

For example, since World War II, women have been manning the control towers at many of our airports. In Hillsboro, Oregon, Delphine Aldecoa is the tower chief. Many women are FAA flight examiners. At FAA headquarters, Mary Jo Oliver is an aviation education specialist. And aeronautical engineer Joan Barriage holds a top post as the Deputy Director of the Office of Environmental Quality.

And at NASA women have important roles in space research. Marjorie Townsend of NASA's Goddard Space Flight Center was the first woman to manage a space launch and was the winner of the Federal Women's Award in 1972. Dr. Nancie Lee Bell is a lead-

ing microbiologist at NASA's Ames Research Center in California. Dr. Nancy Roman, one of the world's leading astronomers, is program scientist for the astronomical Netherlands satellite and the small astronomy satellite to be launched this year to investigate X-ray sources.

In 1961, Jerrie Cobb was the first U.S. woman to undergo the astronaut tests. She passed, but did not have the test pilot experience required then. For the last eight years Jerrie has been a jungle pilot in South America, flying doctors, missionaries, and medicines to the Indian tribes in Amazonia.

IN THE MILITARY

When the WASPs (Women's Airforce Service Pilots) flew for the Army Air Corps during World War II, they were civilians. In 1973, the Navy for the first time opened aviator training to women and enrolled eight prospective pilots in the first course. They have completed their training and are now assigned to naval air stations around the country. The Army followed in a few months, and now has two qualified women Army Aviator helicopter pilots. The first, Lt. Sally Murphy, now is taking fixed wing training at Ft. Rucker, while the second, Lt. Linda Horan, is at Army Test Pilot School at Ft. Eustis, Va.

IN AIR TRANSPORTATION

Amelia Earhart pioneered many of the air routes flown today and predicted the world-wide use of air transportation. She proved to be right and would have been proud of the women who followed her flight paths and of their role today in this segment of aerospace.

In May 1963, Betty Miller made a record solo flight from California to Australia (the reverse of Miss Earhart's flight), the first such flight by a woman. For this she was awarded the first FAA Exceptional Service Award and personally was congratulated by President Kennedy in the Oval Office. In May 1964, a Columbus, Ohio, housewife and mother of three, Jerrie Mock, flew her Cessna 180 around the world in 29½ days in history's first globe-circling flight by a woman. She too received the FAA Gold Medal and was congratulated by President Johnson in the Rose Garden.

Both Betty Miller and Jerrie Mock served on the FAA Women's Advisory Committee for Aviation, and both are members of the 99's and The Whirly-Girls, the latter a world-wide organization of women helicopter pilots.

IN COMMUNICATIONS

Tony Page began her aviation news writing career in 1940 by contributing articles to *Southern* (now *Flight*) magazine. She became aviation editor for *The Valley Times* of North Hollywood, Calif., in 1945 while free-lance writing for other aviation publications including *Cross Country News*. In 1952 she purchased *Cross Country News* and is now its editor and publisher.

The versatile Valerie Petrie keeps herself busy at *Plane & Pilot* magazine, where she is both managing editor and company pilot.

Page Shamburger's first flying reporter job was for *American Aviation*. Flying in her own plane, she visited 3000 airports. In 1965 she was the first woman to fly on an official Air Force hurricane hunter mission. She is the author of six aviation books.

Jean Blashfield served as Editor-in-Chief of the "Encyclopedia of Aviation and Space Sciences."

There is no doubt that women in aerospace have done and are doing much. It is a field that is expanding for them every day, and in all directions.



Ensign Joellen Drag, the Navy's first woman officer helicopter pilot, received her wings in 1974. She is now stationed in San Diego, Calif.



Kelly Rueck is president of the Association of Flight Attendants. There are about 35,000 women flight attendants employed by airlines.

Lt. Sally Murphy, a helicopter-rated Army aviator, checks the cockpit.





Laretta Foy, is a helicopter/heliport consultant and demonstration pilot for the Bell Helicopter Company's Van Nuys, Calif. Center. She is the 1975 president of The Whirly-Girls.



Margurite Myrick is WIVK's pilot for the traffic reporter in Knoxville, Tenn.



Louise Sacchi heads Sacchi Air Ferry Enterprises (S.A.F.E.). She has made more than 260 solo ocean crossings.

The Honorable Betty Crites Dillon, who holds the rank of a U.S. Minister, is the first woman appointed as Permanent Representative to the International Civil Aviation Organization.



Helen Jost, Whirly-Girl No. 139, president of Kennebec Helicopters, Inc., is the only woman to operate a commercial power-line helicopter patrol.



Fran Bera won the Powder Puff Derby not once but several times—in 1951, 1953, 1955, 1956, 1958, 1961 and 1962.



Lt. Linda Horan, the second woman Army aviator, is shown with General W. J. Maddox, Commander of the Army Aviation Center (left), and her husband, Lt. Col. Michael Horan, also a helicopter pilot.



Ensign Rosemary Conatser, Ensign Jane Skiles, Lt. Barbara Ann Allen and Lt. Judith Ann Neuffer, are all Navy aviators.



Ruby Sheldon (left), a remote sensing specialist for the U.S. Geological Survey, collects airborne data for studies of the nation's water and other natural resources. A flight and instrument instructor, she recently taught Mary Lou Brown (right) to fly helicopters. Mrs. Brown, one of the few women licensed jet airplane pilots, is research program administrator for the U.S. Geological Survey.



There is nothing new about remotely piloted vehicles. Ask any boy (or father) of this century who ever has made an electric train go forward, stop, back up, switch tracks or blow a whistle just by pushing buttons.

But the breed of aerial vehicles emerging from the technology of today is something else.

The drone male honeybee may have no sting and gather no honey. Today's aerospace drone — whether it is called a "Remotely Piloted Vehicle" (RPV) or a Remotely Manned Vehicle (RMV) — has plenty of sting and can gather tremendous amounts of information. Its most obvious roles are weapon delivery and surveillance missions.

This is not to suggest that manned combat and reconnaissance aircraft are on the way out. Far from it. There are certain tasks that always will require the brain, the senses, the training, the judgment and the touch of human beings on board at the scene. Witness how much more men could do on the moon than could machines. Witness the intricate reactions of fighter aircraft zeroing in on a hard target. Witness the helicopter picking an injured climber off the precipitous face of a mountain, or rescuing potential victims from the roof of a high-rise building where they are above the reach of ground fire-fighting equipment.

An RPV performing surveillance or bomb damage assessment, as during the war in Southeast Asia, is a lot more expendable than an F-4 Phantom with its pilot and radar observer. And should an RPV be shot down over hostile territory, it is a small pile of scrap — no casualties, no prisoners.

Studies by the Rand Corporation have noted how the improved accuracy of air defense systems, sophisticated technology and inflation have impacted on military aircraft budgets in such a way as to make RPVs more and more attractive. A World War I fighter probably cost about \$5000. By the early 1950s the first military supersonic aircraft—the North American F-100 Super Sabre — passed the \$1 million-per-copy mark. Today's new air superiority fighters cost more than \$15 million each. Given the equivalent of its present dollar budget for aircraft in the dollars of the year 2000, how many such aircraft will the Air Force be able to buy then? With luck, a dozen or so, if the past trend continues.

Costing from \$15,000 to \$500,000 when put into production, depending on the type and mission, RPVs promise to be economical co-workers with more costly modern sophisticated fighters.

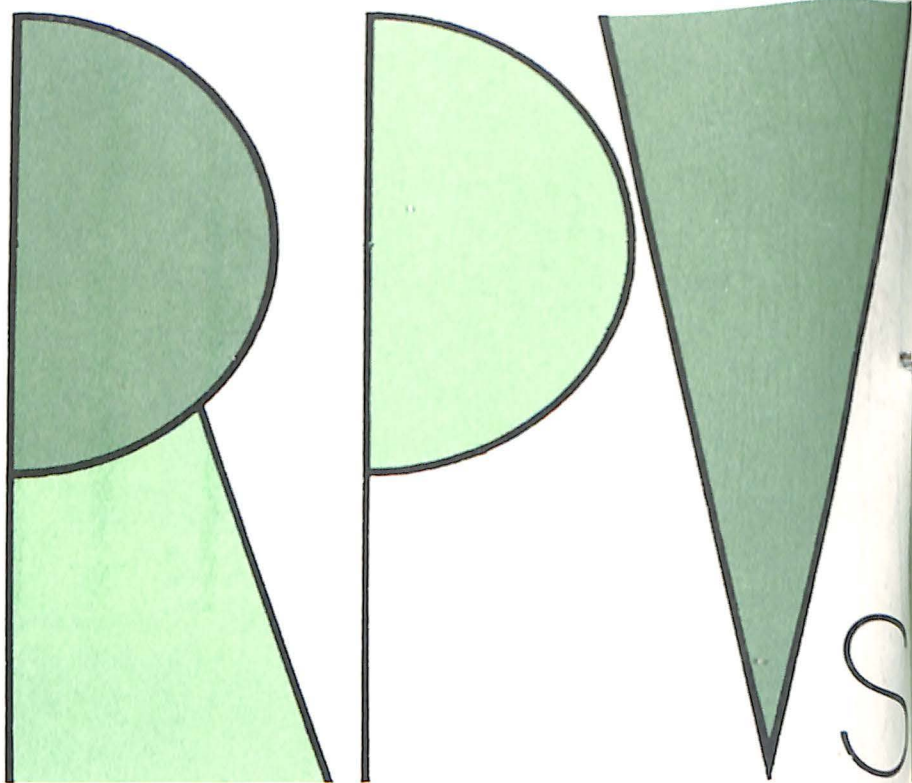
The Air Force notes: "In an era of declining defense budgets and increasing weapon system (procurement) costs, the remotely piloted vehicle (RPV) offers a cost-effective way of accomplishing the desired mission with minimum risk to man and his resources."

This is what makes relatively low-cost RPVs more attractive and has drawn more and more aerospace companies into a growing variety of RPV aircraft and systems development programs with the U.S. military services.

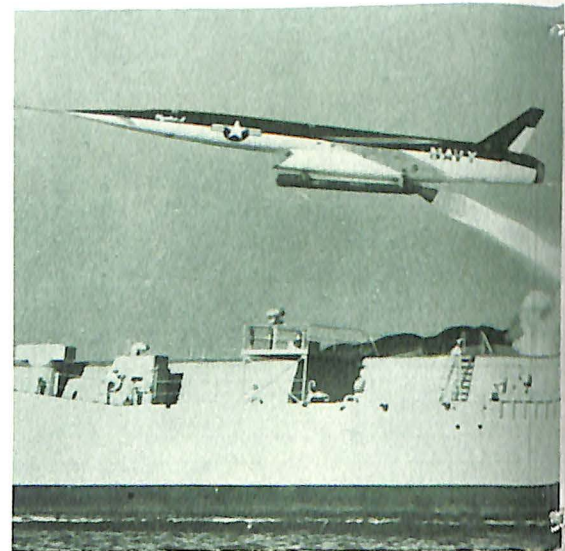
Technically there is a difference between a drone, which has been serving as an aerial bomb or aerial target for decades, and the RPVs of today and tomorrow.

The drone is an unmanned vehicle which traverses a pre-programmed mission profile as directed by an

A New Breed of Super Servants — REMOTELY PILOTED VEHICLES

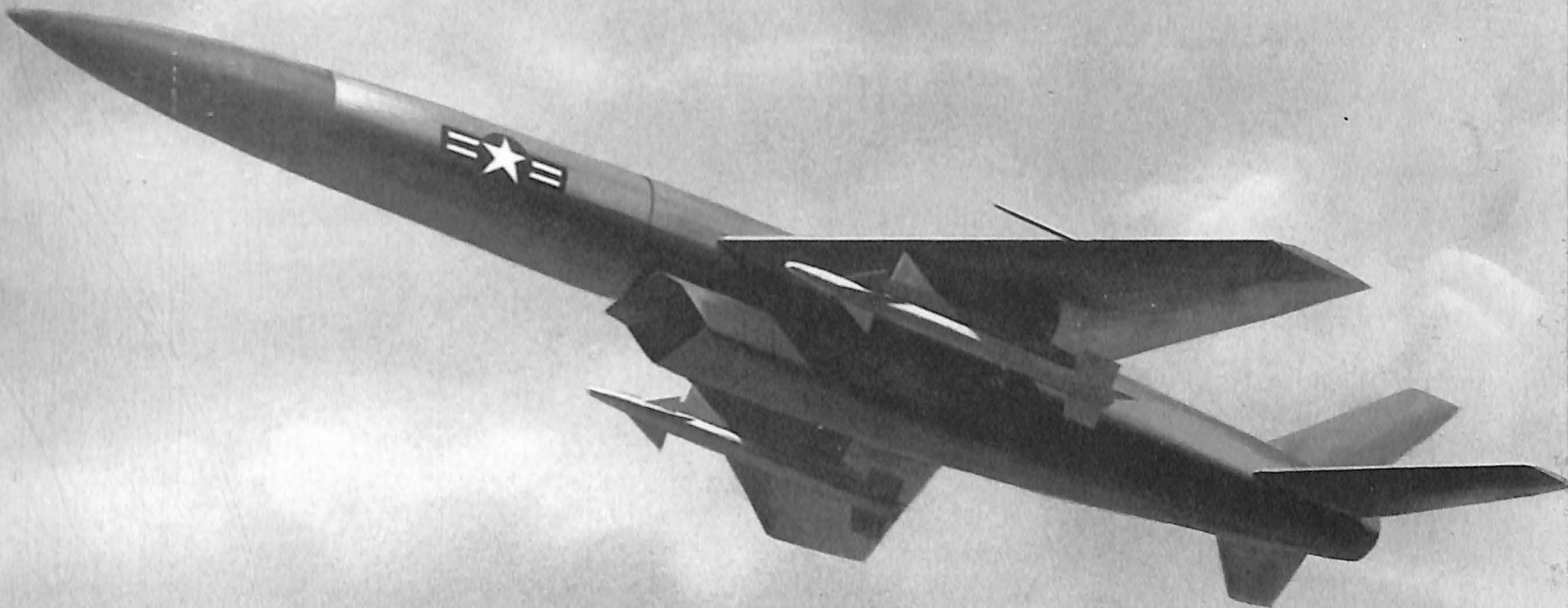


LTV got into the guided missile business in 1947 and by 1955 the Navy's first surface-to-surface missile, REGULUS I, was fully operational. This marriage of a guided missile and Navy ships, particularly wide-ranging submarines, provided a vital combat capability during the cold war period. REGULUS II (right) and REGULUS I could be configured as a missile with a nuclear warhead, as a wheeled flight test training version and as a wheeled drone to test guided missiles.



Now in U. S. Army testing is a Westinghouse Electric Corporation system, BLUE SPOT, that consists of a television camera, laser designator, composite optics, stabilized pointing and tracking system, and provision for a rangefinder. A unique feature allows any of four different sub-miniature cameras to be installed.

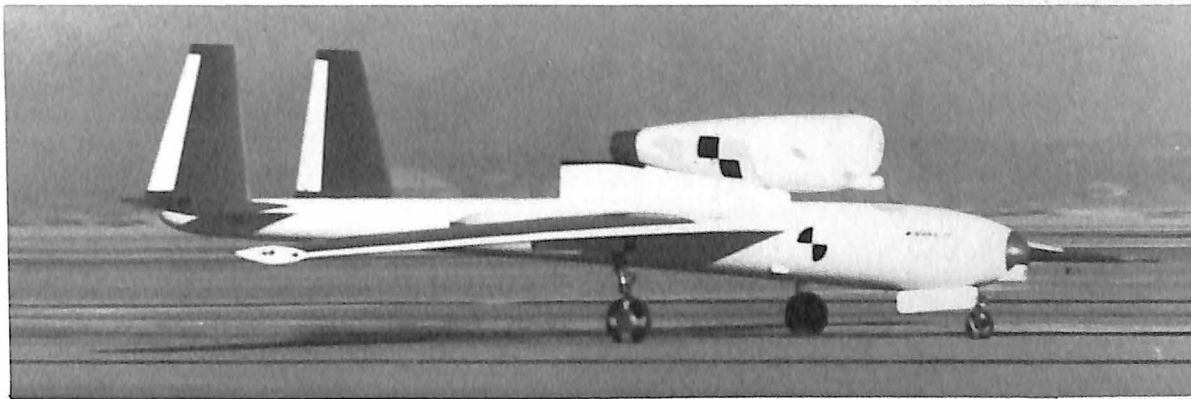




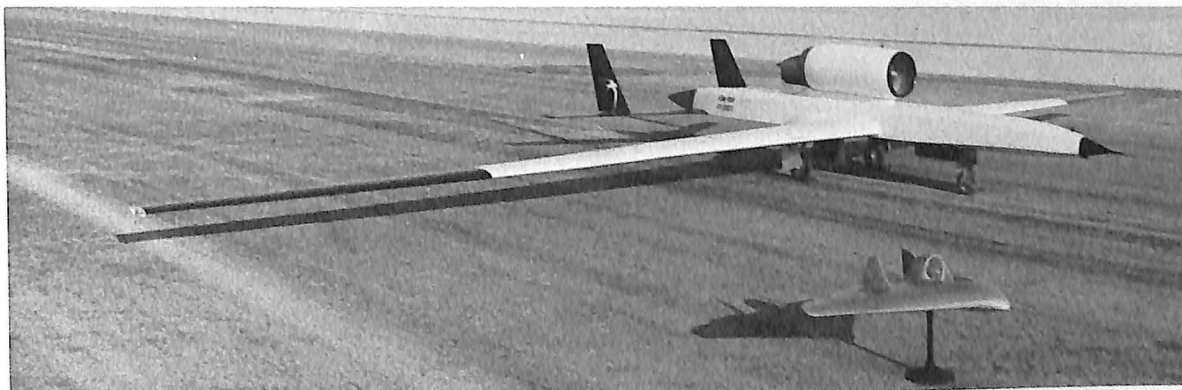
In addition to producing many operating RPVs and their components this one of several Northrop Corporation concepts shows a vehicle for reconnaissance, air-to-ground and air-to-air missions. It also could be designed as a single multi-purpose vehicle.



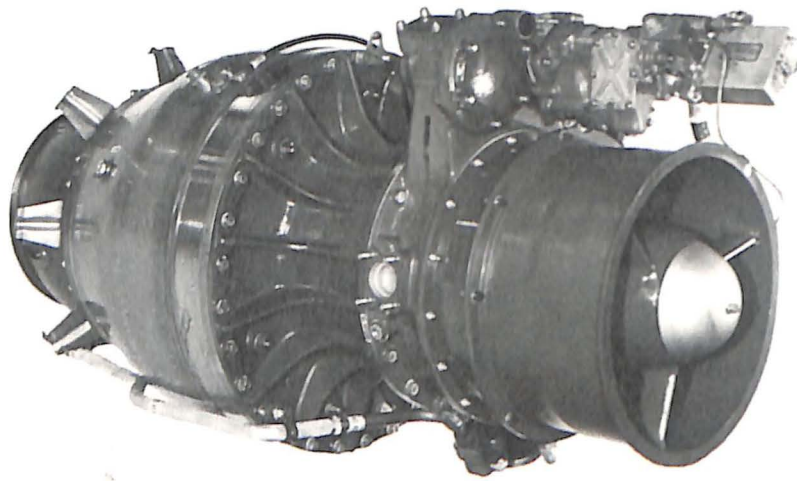
Another interesting RPV development is the completely de-manned aerial target for training pilots in air-to-air combat. The Sperry Rand Corporation has developed an electronic control package that can be mounted in a Convair Delta Dart F-102 which can be put through all paces of aerial combat and flown back to a smooth landing by the ground controller. Betty Schubert finishes wiring the pilot's "stand-in."



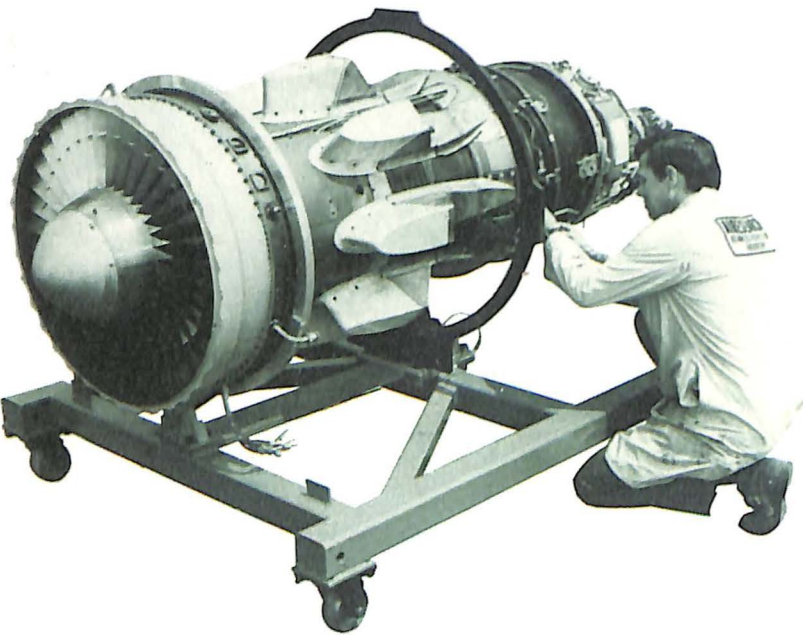
The Boeing Company recently met all test objectives with its "B" version prototype of the Air Force's COMPASS COPE RPV program with a flight of 17 hours that attained altitudes of more than 55,000 feet where temperatures reached -95° . The all-fiberglass, single-engine jet, which can carry surveillance or other equipment, has a wingspan of 90 feet and an overall length of 40 feet. The final test flight achieved a "first" by being brought in to a perfect landing in pre-dawn darkness.



A great majority of the inventory of operational Air Force drones and RPVs are a series of modifications (some 20) of the Teledyne Ryan FIREBEE, developed to satisfy urgent requirements during the Southeast Asia War. Now the company is competing in many development programs, two being its long range COMPASS COPE-R entry (wingspan more than 80 feet) and has progressed to a full scale mockup of a mini-RPV with a wingspan of 7.5 feet. COMPASS COPE-R recently flew for more than 24 hours, reaching altitudes above 55,000 feet.

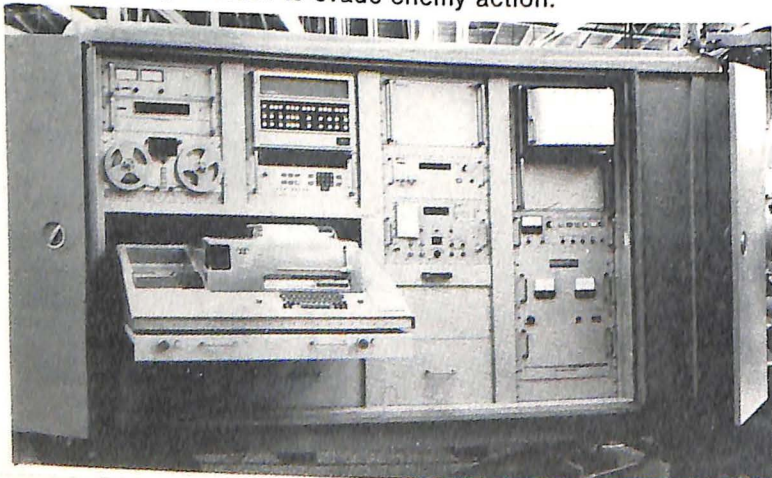


Teledyne CAE probably is the largest supplier of engines for RPVs. Within the family of engines is one tri-service model (the J69-T-29, above) of which some 4250 have been delivered. Another model is intended for use in vehicles flying up to 90,000 feet.

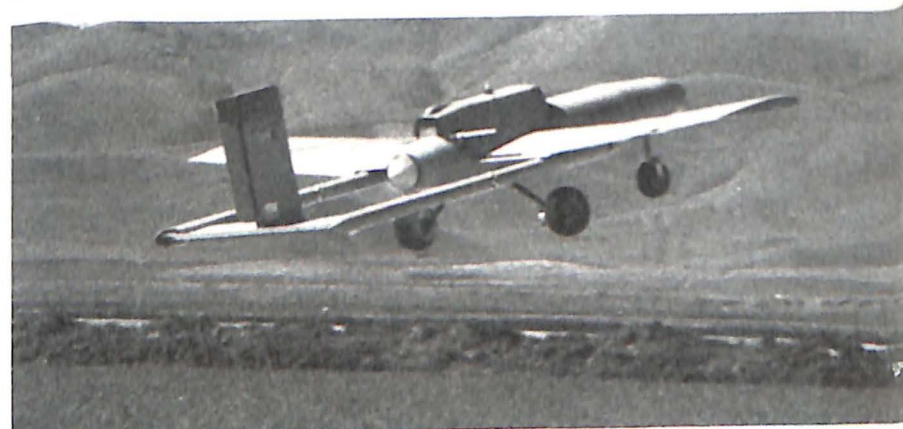


A significant advance in propulsion of RPVs is the Garrett ATF3 turbofan engine. This 4000-plus horsepower engine which weighs only 950 pounds, powered the Teledyne Ryan Aeronautical COMPASS COPE-R RPV to an unofficial record for such vehicles — flying more than 24 hours on one test mission and attaining altitudes above 55,000 feet. The engine could power 10 to 12-passenger business jets at high subsonic speeds on non-stop transcontinental or intercontinental flights with adequate fuel reserves.

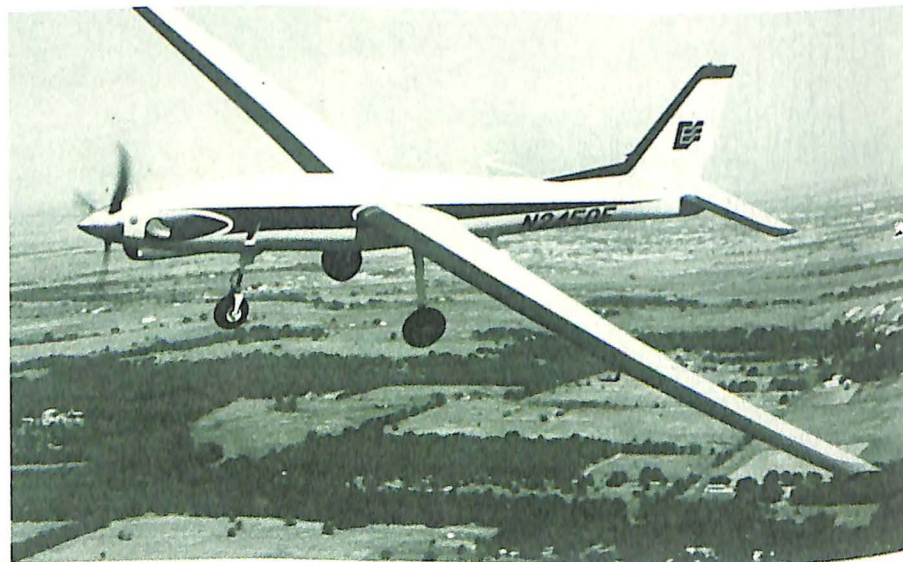
The Air Force UPDATE program under development by Lear Siegler, Inc., is designed to produce an Interface and Control Unit (ICU) that will improve substantially the performance and versatility of future operational RPVs. Improvements sought are in accurate, low altitude delivery of unmanned sensors; accuracy and effectiveness of reconnaissance capabilities, and low altitude flight capability in order to evade enemy action.



The RCA Corporation has been in the operations, control and communications of droned aircraft for all services since the early 1960s — from DASH to FIREBEE, as well as mini-drones. The company is deeply involved in the Air Force Control and Data Retrieval System (CDRS) a program developed to direct remote bombing, control the flight of multiple aircraft automatically and, for NASA, provide television links that make possible the transmission of live lunar pictures from the moon to the networks.



Lockheed Aircraft Company's little F-1 RPV test-bed weighs only 350 pounds and can carry 45-lb. payloads for a variety of missions. At the other end of the scale, the big HC-130H transport will be able to carry four 5-ton MAVERICK winged RPVs that can conduct reconnaissance or launch missiles at enemy targets and return. Also in the works is an F-2, AEQUARE mini-RPV weighing 150 pounds, yet able to carry a laser designator and TV sensor.



A record-setting turboprop aircraft is E-Systems' L450, a high-altitude, long-endurance aircraft capable of being operated as either an RPV or a manned aircraft. Flying slowly at altitudes between 45,000 and 55,000 feet for 24 hours, the aircraft can receive and relay line-of-sight communications from extreme distances. It can be packed full of sensors and used for military reconnaissance, earth resources survey, mapping, or border surveillance.

The U.S. Navy's most advanced RPV missile system is the extremely accurate Rockwell International Corporation CONDOR. This television guided, air-to-surface system (here on the wing pylon of an A-6 aircraft) can be fired at a target well out of sight while the attacking aircraft is far from enemy defenses.



autopilot, with the ground or airborne control station able to make only minor changes in the mission once it is under way.

In fact, the first two offensive military drones were developed in World War I. These were the Sperry "Aerial Torpedo" and the "Kettering Bug," biplane weapons mounted on a jury-rigged cart on rails. Whatever their success, they did spark subsequent interest that led eventually to the 1928 droning of a Curtis Robin which, with its radio controls, flew training missions off and on until funding problems cut the program in 1932.

In about 1938, the U.S. armed forces began to show increased interest in developing remotely controlled offensive weapons. In one attempt a pair of plywood wings and plywood rudders were affixed to a 2000-lb. bomb that could be dropped by a B-17 bomber and visually guided to a target. More than 200 of these were launched in a World War II raid against Cologne, Germany. The Germans reported that the manned bombers were turned back by anti-aircraft fire, but that "the following fighters" all were shot down, exploding violently and causing much damage.

In the late 1940s, interest in RPVs spurted throughout all of the military services and the aerospace industry. In mid-1948 the first major contract was let to the Ryan Aeronautical Company (now Teledyne Ryan Aeronautical). This program really demonstrated the high interest of the military services and the aerospace industry, serving as the first benchmark in the RPV boom.

Teledyne Ryan continued to improve the performance and to reconfigure the capabilities of the "Firebee" until today there is a family of some 20 models. And other aerospace firms are not lagging in their efforts.

In the mid-50s, Sperry fitted out F-80 fighter aircraft so that they could be flown automatically, and they served well in sampling the atmosphere after nuclear tests. But previous, late World War II attempts to automate the flight of larger combat aircraft, such as the B-24 and B-17 bombers, were not so successful for two reasons. First, the cost of extensive modifications was high. Second, the remote command and control electronics of that time were not up to handling that much aircraft and its myriad systems and subsystems.

The electronic art has come a long way since then.

The RPVs of today and tomorrow insert one or more operators into the command and control "loop" at an airborne, shipboard or ground control station. Working through sensors in the RPV, they can fly an entire mission from launch or takeoff to return for aerial or land recovery, or to the target, if it is a one-way weapon delivery mission. Surveillance missions can push the commander's vision into hostile environments — even far beyond the horizon — with data transmission links, small television cameras, digital computers and many other products coming out of the amazing advancements of the electronics industry. This gives him real-time information upon which to act.

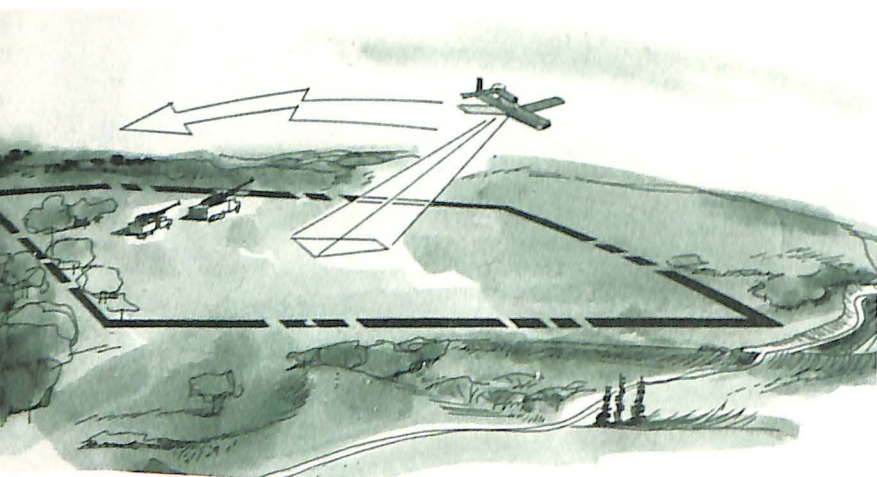
Such progress has made possible a widely growing family of ever more sophisticated maxi-, midi-, and mini-RPVs. In fact, there are so many programs and variations that it is impossible to cover all of them here, except in general terms.

The wide range of RPVs being studied and in some cases developed run the entire gamut from tiny minis to those weighing more than six tons and with speeds from the slow to supersonic. And in almost all cases a prime design objective is to minimize or eliminate the infra-red and radar profiles detectable by the enemy.

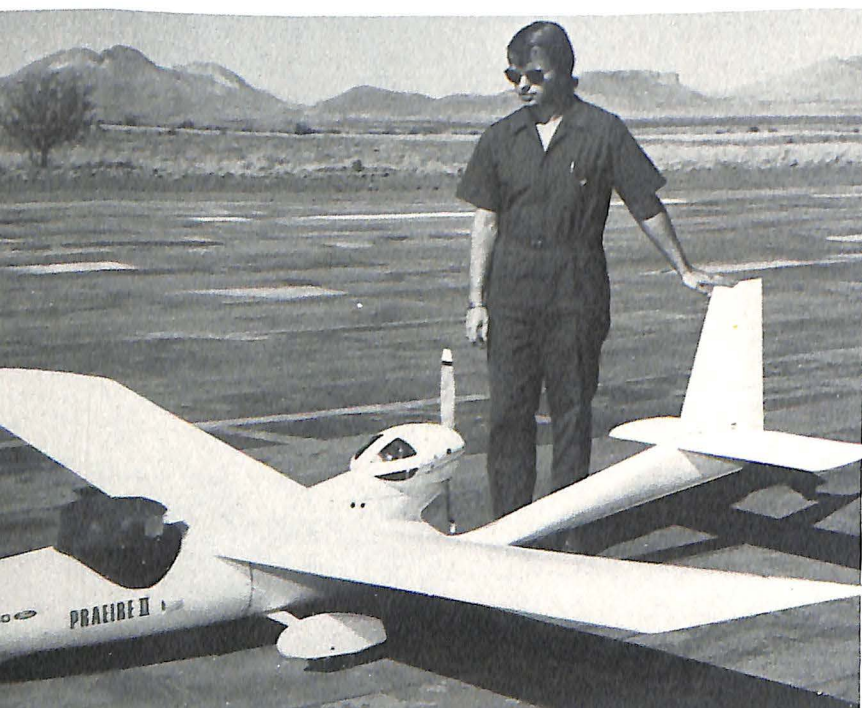
As in the manufacture of a modern military or civil



During a three-year program beginning late in 1968 McDonnell Douglas Corporation developed an 80-lb. mini-RPV for the U.S. Army. It was stuffed with subsystems, components and fuel. Since then the company has developed a Mark II prototype that could serve as a base for other RPVs for military and civilian purposes. The aircraft is designed to be catapult-launched in unprepared areas and recovered by flying it into a vertical net.



Long active in the field of controls, the General Electric Company is working on a ground system that "flies" the RPV, coordinating close support between manned aircraft and ground troops under all weather conditions. Among other projects are development of a new color television camera slightly larger than a package of cigarettes, and a mini-RPV surveillance radar capable of locating an identifying enemy artillery emplacements and battlefield surveillance over an area 10 kilometers square and close investigation over an area one kilometer square.



Development of highly portable, long-range lasers is a breakthrough in field target designation for guided weapons, both surface and air delivered. Philco-Ford Corporation's PRAEIRE II is a sleek plastic mini-RPV that can be fitted with television and laser or infra-red designators for daytime or nighttime duty.

aircraft, there is much more to an RPV and its propulsion system. Scores of companies throughout the 50 states provide essential systems and subsystems that often cost more than the vehicle that transports them.

The unmanned vehicle business has three principal product areas: cruise missiles, drones and targets, and remotely piloted vehicles. All of these areas are interrelated. For example, target or missile engines have grown into RPV engines. For a long time there seemed to be no impetus for manned aircraft engines to move into the RPV business. Today, however, manned turboprops are candidates for future reconnaissance missions, such as envisioned by the Air Force COMPASS COPE program.

Development of the small turboprop engine for the strategic sea-launched cruise missile probably will provoke more development of mini- and midi-RPVs. The cruise missile engine will consume much less fuel than do currently available small turbojet engines. This will have a payoff in smaller, lower cost vehicles performing missions similar to those performed by the maxi-vehicles now.

Two important technologies have been evolving during the last three years: 1) reliable engines and 2) low-cost engines.

Although sometimes confused, life and reliability are not the same thing. The rocket engines that launched the Apollo series were not very long-life engines, but they were very reliable.

The J100 turboprop engine was 100 percent reliable for about two years. That's very reliable. A target of 100 percent reliability for a short-life engine is not as unrealistic as a target of 100 percent reliability for an F-15 engine.

Short-life reliability is necessary in the jet engine for an RPV, but it only needs to be short-lived and low cost if it is in an RPV to be used on a one-way expendable mission.

In terms of their combat role, modern RPVs now flying, being tested, on the construction line or on the drawing boards include:

- Inexpensive, short-range vehicles for low-altitude battlefield surveillance and as laser target designators for strike aircraft or other RPVs. They represent difficult targets — small, fast and probably operating below radar screens.
- High-altitude, long endurance vehicles for continued detailed surveillance of small or large areas.
- Long-range, low-altitude RPVs for many purposes, varying from reconnaissance to surveillance to decoy for attack missions.
- High-speed RPVs to attack targets and to confuse enemy defenses, often working in concert with manned attack aircraft.

Among tactical roles now possible or probable near-term are electronic warfare (both positive jamming and passive chaff dispensing); tactical reconnaissance; weapon delivery. The fact that some high-speed versions can withstand maneuvers that generate a force 12 times that of gravity, while a pilot can take up to about half that much force briefly, forecasts the day when RPVs may be important teammates to manned fighter aircraft in the air-to-air combat and ground

attack roles. Working with manned aircraft and carrying a mix of payloads, including weapons, RPVs would give the enemy little choice of selective defense. He would have to try to get them all.

Aerospace industry experts foresee the time when a number of RPVs can be controlled by a single airborne, shipboard or ground station. "The development of secure, anti-jam communications and multiple simultaneous RPV control are important ingredients for achieving the full operation potential of the RPV," says David Shore, President of the National Association for Remotely Piloted Vehicles (NARPV), and RCA Vice President for Advanced Programs Development.

As for the immediate future, military and industry planners are looking ahead with great interest in a number of areas, such as:

- The Tactical Expendable Drone System (TEDS) which would provide a relatively low-cost vehicle that would be deployed in a large number on a one-way mission in support of Army or Marine tactical forces. The Army Variable Speed Training Target (VSTT/Harpoon) efforts have, in the last two years, precipitated a viable, low-cost TEDS which will be remotely piloted in some instances and pre-programmed in others. The intent would be to flood a combat area with low-cost RPVs which would saturate enemy radar capabilities. Some of these RPVs would have warheads and this would force the opposition to direct anti-aircraft and other combat forces toward all these vehicles.

- A multi-mission RPV that would be configured to accept modular prime mission equipment and an engine and airframe with sufficient flexibility to provide the performance necessary for its three missions: strike, reconnaissance and electronic warfare. A current modification will produce such an "interim" RPV, which will fill the gap until the specifically designed Advanced Multi-Mission RPV (AMMR) takes over, probably in the 1980s.

- The COMPASS COPE program that is designed to result in a high altitude sensor platform for battlefield reconnaissance, signal intelligence gathering, communication relay, photo reconnaissance, ocean surveillance and atmospheric sampling. Both The Boeing Company and Teledyne Ryan Aeronautical have produced competitive prototypes to meet performance goals of more than 55,000 feet of altitude, more than 20 hours endurance and capacity for a payload of between 700 and 1500 pounds. Both of these prototypes, with their narrow 80 to 90-foot wings, look a lot like sleek, sophisticated powered gliders, and it is easy to visualize a number of civilian applications for whichever one is selected as the production model.

Speaking at an AIAA RPV Technology Symposium in the U. S. recently John W. R. Taylor, Editor of the British "Jane's All The World's Aircraft," said: "... as we discuss (RPVs), and progress made to date . . . by comparison with what has been achieved in the U. S., the rest of the world is still in the age of the Wright Brothers." Noting that the U.S. neglected its aircraft leadership between the Wright's early progress and World War I, he said: "This must never happen again. The price of lost leadership today is one that the West could never afford to pay."

As one bumper sticker puts it: "RPVs ARE COMING!"



MANUFACTURING MEMBERS

Abex Corporation
Aerojet-General Corporation
Aeronca, Inc.
Avco Corporation
The Bendix Corporation
The Boeing Company
CCI Corporation
The Marquardt Company
Chandler Evans, Inc.
Control Systems Division of
Colt Industries
E-Systems, Inc.
The Garrett Corporation
Gates Learjet Corporation
General Dynamics Corporation
General Electric Company
Aerospace Group
Aircraft Engine Group
General Motors Corporation
Detroit Diesel Allison Division
The B. F. Goodrich Company
Engineered Systems Co.
Goodyear Aerospace Corporation
Heath Tecna Corporation
Hercules Incorporated
Honeywell Inc.
Hughes Aircraft Company
IBM Corporation
Federal Systems Division
ITT Aerospace, Electronics, Components
& Energy Group
ITT Aerospace/Optical Division
ITT Avionics Division
ITT Defense Communications Division
Kaiser Aerospace & Electronics Corporation
Lear Siegler, Inc.
Lockheed Aircraft Corporation
LTV Aerospace Corporation
Martin Marietta Aerospace
McDonnell Douglas Corp.
Menasco Manufacturing Company
Northrop Corporation
Philco-Ford Corporation
Pneumo Corporation
Cleveland Pneumatic Co.
National Water Lift Co.
Raytheon Company
RCA Corporation
Rockwell International Corporation
Rohr Industries, Inc.
The Singer Company
Aerospace and Marine Systems
Sperry Rand Corporation
Sundstrand Corporation
Sundstrand Aviation Division
Teledyne CAE
Teledyne Ryan Aeronautical
Textron Inc.
Bell Aerospace Company
Bell Helicopter Company
Hydraulic Research & Manufacturing Co.
Thiokol Corporation
TRE Corporation
TRW Inc.
United Aircraft Corporation
Westinghouse Public Systems Company



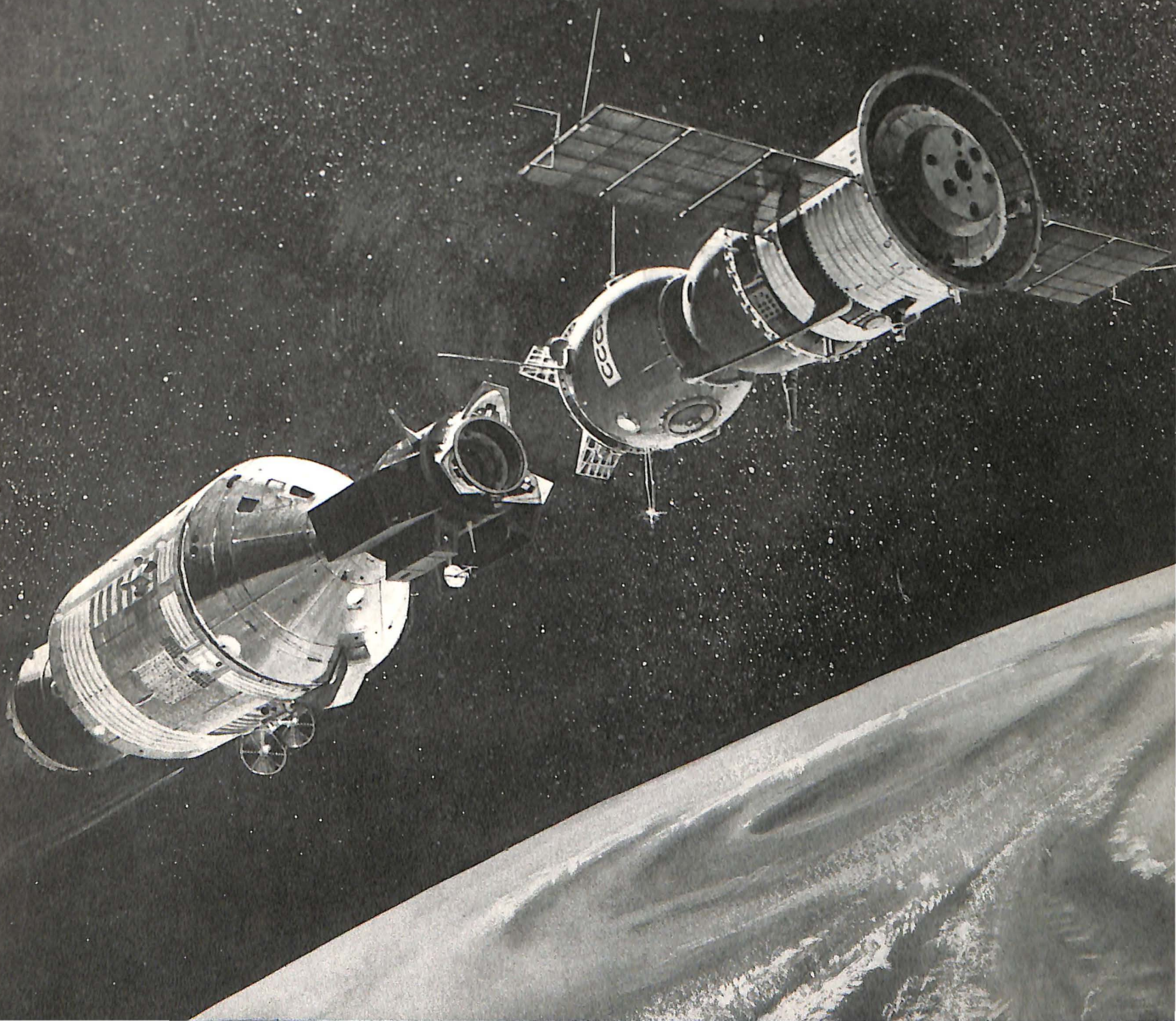
A Lockheed C-130 Hercules launches one of four pylon-mounted Teledyne Ryan Firebee RPVs. The National Aeronautics and Space Administration recently requested industry proposals for a study on civil uses of RPVs. (See *A New Breed of Super Servants: Remotely Piloted Vehicles*, p. 12).

aerospace

OFFICIAL PUBLICATION OF THE AEROSPACE INDUSTRIES ASSOCIATION

• JUNE 1975

APOLLO-SOYUZ: END OF AN ERA— START OF AN ERA

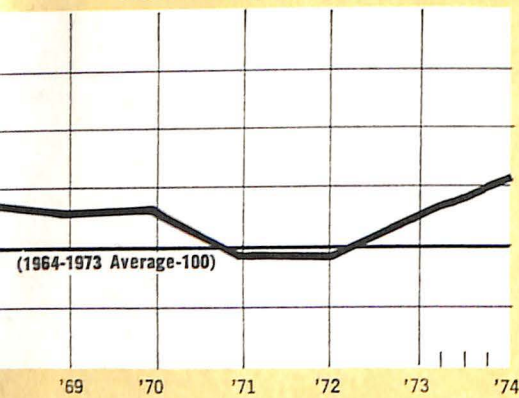


AEROSPACE ECONOMIC INDICATORS

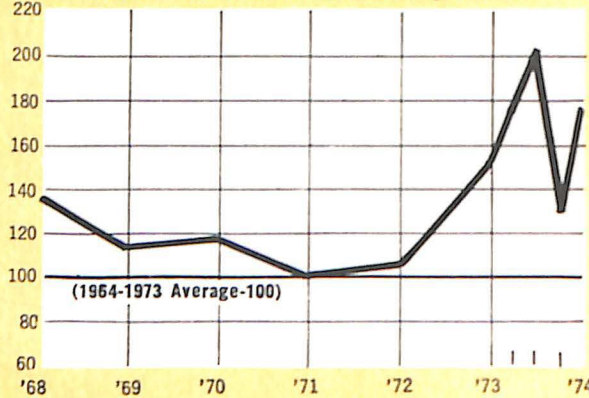
CURRENT

OUTLOOK

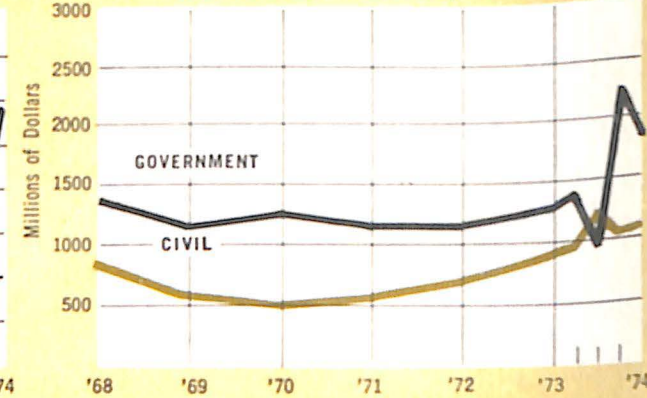
Total Aerospace Sales



Value of Civil Aircraft Shipments



New Orders — Monthly Average



— Aerospace obligations by Dept. of Defense and NASA.
— Non-government prime orders for aircraft and engines.

| ITEM | UNIT | PERIOD | AVERAGE 1964-1973 * | LATEST PERIOD SHOWN | SAME PERIOD YEAR AGO | PRECEDING PERIOD † | LATEST PERIOD |
|---|------------|-------------|---------------------------|---------------------------|----------------------------|-----------------------|------------------|
| AEROSPACE SALES: Total | Billion \$ | Annual Rate | 24.1 | 4th Quarter 1974 | 24.3 | 26.2 | 26.8 |
| | Billion \$ | Quarterly | 6.1 | | 6.5 | 6.3 | 7.1 |
| AEROSPACE SALES: Total (In Constant Dollars, 1958=100) | Billion \$ | Annual Rate | 15.8 | 4th Quarter 1974 | 15.6 | 15.2 | 15.1 |
| | Billion \$ | Quarterly | 4.0 | | 4.2 | 3.7 | 4.0 |
| DEPARTMENT OF DEFENSE | | | | | | | |
| Aerospace obligations: Total | Million \$ | Monthly | 1,194 | Dec 1974 | 927 | 1,636 | 1,309 |
| Aircraft | Million \$ | Monthly | 716 | Dec 1974 | 560 | 1,223 | 685 |
| Missiles & Space | Million \$ | Monthly | 478 | Dec 1974 | 367 | 413 | 624 |
| Aerospace outlays: Total | Million \$ | Monthly | 1,129 | Dec 1974 | 1,062 | 1,065 | 1,101 |
| Aircraft | Million \$ | Monthly | 669 | Dec 1974 | 576 | 624 | 593 |
| Missiles & Space | Million \$ | Monthly | 460 | Dec 1974 | 486 | 441 | 508 |
| Aerospace Military Prime Contract Awards: TOTAL | Million \$ | Monthly | 1,061 | Dec 1974 | 879 | 1,290 | 930 |
| Aircraft | Million \$ | Monthly | 667 | Dec 1974 | 316 | 856 | 569 |
| Missiles & Space | Million \$ | Monthly | 394 | Dec 1974 | 563 | 434 | 361 |
| NASA RESEARCH AND DEVELOPMENT | | | | | | | |
| Obligations | Million \$ | Monthly | 283 | Dec 1974 | 127 | 191 | 165 |
| Expenditures | Million \$ | Monthly | 287 | Dec 1974 | 163 | 213 | 217 |
| BACKLOG (55 Aerospace Mfrs.): Total | | | | | | | |
| U.S. Government | Billion \$ | Quarterly | 25.5 | 4th Quarter 1974 | 29.7 | 34.0 | 35.8 |
| Nongovernment | Billion \$ | Quarterly | 14.5 | | 16.7 | 19.5 | 20.9 |
| | Billion \$ | Quarterly | 11.0 | | 13.0 | 14.5 | 14.9 |
| EXPORTS | | | | | | | |
| Total (Including military) | Million \$ | Monthly | 249 | Dec 1974 | 547 | 660 | 749 |
| New Commercial Transports | Million \$ | Monthly | 77 | Dec 1974 | 197 | 271 | 334 |
| PROFITS | | | | | | | |
| Aerospace — Based on Sales | Percent | Quarterly | 2.7 | 4th Quarter 1974 | 2.8 | 2.9 | 2.3 |
| All Manufacturing — Based on Sales | Percent | Quarterly | 4.9 | | 5.7 | 5.7 | 4.8 |
| EMPLOYMENT: Total | | | | | | | |
| Aircraft | Thousands | Monthly | 1,213 | Dec 1974 | 960 | 982 | 973 |
| Missiles & Space | Thousands | Monthly | 669 | Dec 1974 | 517 | 543 | 537 |
| | Thousands | Monthly | 128 | Dec 1974 | 97 | 92 | 92 |
| AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS | | | | | | | |
| | Dollars | Monthly | 3.86 | Dec 1974 | 4.97 | 5.61 | 5.67 |

* 1964-1973 average is computed by dividing total year data by 12 or 4 to yield monthly or quarterly averages.

† Preceding period refers to month or quarter preceding latest period shown.

UBIQUITOUS AEROSPACE

By KARL G. HARR, JR.
President, Aerospace Industries Association



Karl G. Harr, Jr.

Understandably to most Americans the term "aerospace" represents swift transportation by air, exploring and utilizing space with manned and unmanned vehicles, and developing a myriad of sophisticated systems for national defense.

From time to time in this magazine we have documented the fact that the aerospace industry is also very much down to earth. You will find aerospace companies and the aerospace divisions of diversified corporations making technological contributions in such fields as medicine, education, mine rescue breathing devices, automotive skid controls, vehicular traffic control, new energy sources and, oh yes, experimental farming. In fact, the involvement of aerospace companies in hundreds of strictly non-aerospace endeavors amounted to \$5 billion in sales in 1974.

One field calling for innovation and systems management skills is transportation at or near the surface. A major feature in this issue relates how aerospace talent is tackling various approaches to moving people more efficiently, one of the major down-to-earth problems of our time.



aerospace

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COVER: The U.S. Apollo spacecraft maneuvers into position to dock with the Soviet Soyuz in a joint rendezvous-docking mission.

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;

Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

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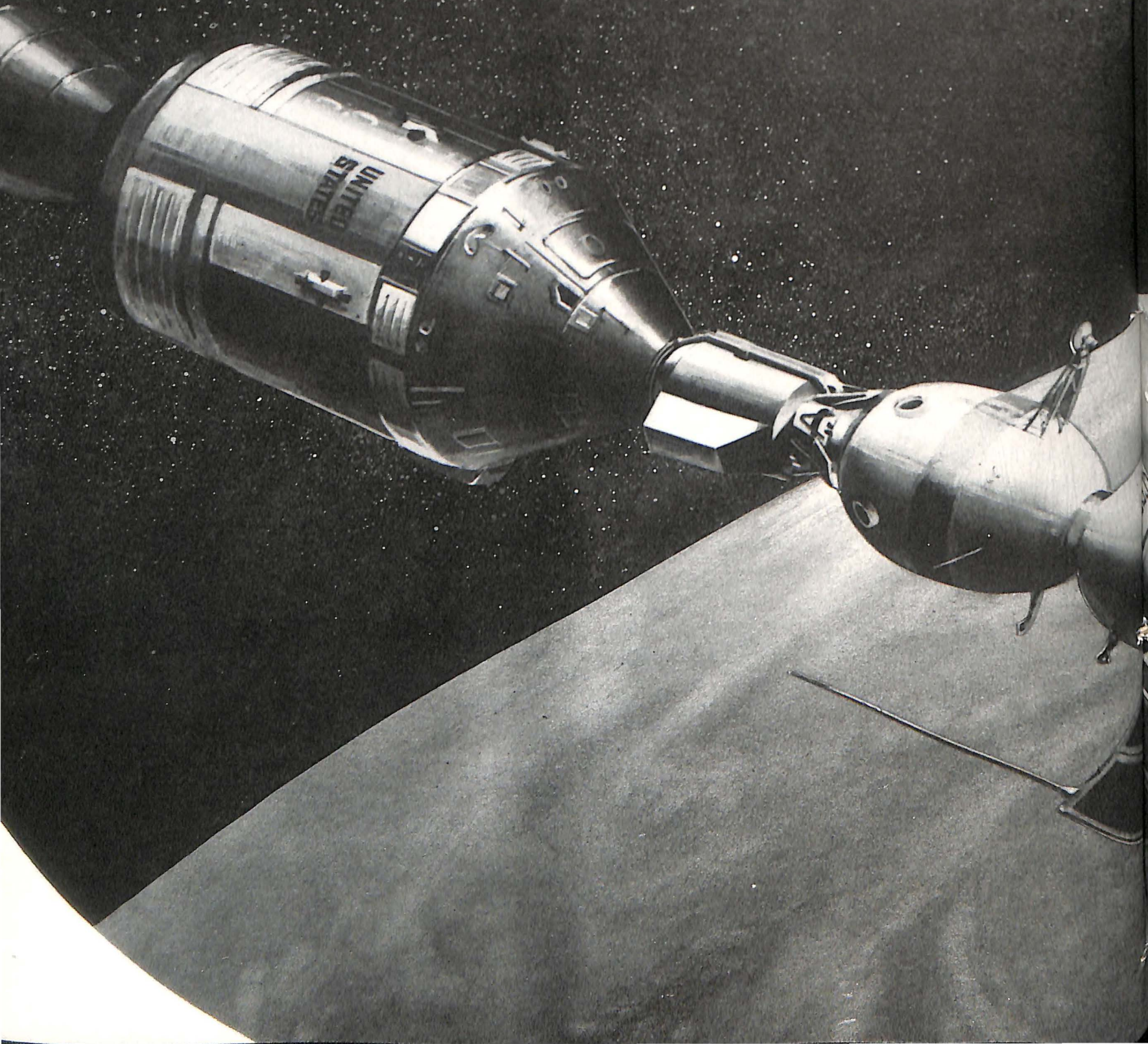
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APOLLO-SOYUZ: END OF AN ERA - S

By JAMES J. HAGGERTY





START OF AN ERA

The end of an era is at hand. It has been a magnificent era of incredible technological advance. It has witnessed man's boldest exploratory ventures. It has produced priceless new volumes of scientific knowledge. It has provided benefit to contemporary man in practical spinoff from rapidly advancing technology and this benefit will continue to accrue for generations to come.

It is the Apollo era that is ending. It was just 14 years ago — May 25, 1961 — that Project Apollo was formally launched with President Kennedy's declaration that the United States would put men on the moon within the decade. Now the last Apollo waits on its Kennedy Space Center pad for launch in mid-July; its mid-Pacific splash 10 days thereafter will write *finis* to the greatest technological program of all time.

"For all mankind" — the words etched on a plaque left behind by the first moonwalkers — was the guiding canon of Project Apollo. From the outset, it was American policy that Apollo's gains in science and technology would be shared with the world. So it is fitting that the Apollo program end on the same lofty note; the final flight represents another contribution of American technology toward improving the potential for world cooperation in space.

Known as the Apollo-Soyuz Test Project (ASTP), it is a joint venture of the United States and the Soviet Union, an initial step toward development of an international space docking system. Such a system will be invaluable in future years, when manned space flights become commonplace and other nations join the two great technological powers in sending human crews beyond

the atmosphere. It will allow spacecraft of different national origin to mate in space for cooperative experiments, or one nation's spacecraft to berth at another's space station. It also will make possible rescue of one nation's stranded astronauts by the most readily available spacecraft, regardless of the flag it flies.

There are more immediate gains to be realized from Apollo-Soyuz.

First, it gives NASA a continuity bridge between the Skylab missions — earlier intended to be the last use of Apollo hardware — and the era of the Space Shuttle, which will start in 1979. NASA believes that it is very important to "keep the momentum going" in manned space flight. It has put together an extraordinarily efficient government/industry/university team whose efficacy might be diminished by an overlong gap between actual operations. Apollo-Soyuz narrows the gap.

Secondly, the mission affords a last opportunity until the Shuttle starts flying to conduct man-directed investigations in space. Apollo-Soyuz includes a lengthy agenda of 27 experiments, five of them to be accomplished jointly with the Soviets.

Third, there is considerable benefit in terms of improved relations with the Soviet Union. From that standpoint, NASA officials say, the mission is already a success because U.S. and Soviet teams have worked side by side for three years in greater harmony than anyone expected. It hasn't always been roses, of course; there has been some desk-pounding and there have been huffy times. In the main, however, the Soviets have displayed a willingness to compromise that per-

mitted quick settlement of disputes. Says NASA's Apollo-Soyuz Test Project director Chester M. Lee:

"This operation has given us a window into the Soviet Union, some visibility we haven't had before — not just a closer view of their space program, but the whole Soviet system. And it's a two-way window — they have been in our homes, seen our standard of living and learned about our ways of doing things. ASTP has provided us an opportunity to establish communication and to develop greater understanding of each other — therefore, there is

disparate societies whose relations with each other have ranged from frigid to tepid — but never warm.

The docking phase will be highlighted by a symbolic handshake in space, televised to hundreds of millions around the world. Global TV has bonus value. Actually, the U.S. and the Soviet Union are cooperating on some 150 projects in art, education, science and agriculture, but few are aware of these joint efforts. Extensively televised, Apollo-Soyuz has "higher visibility." Members of both teams consider the impact on other nations important; in

nical interpreters will relay communications between the control centers in Houston and Moscow.

As for the flight crews, they had to learn the other tongue — for direct communication in space and for the most effective way of handling a possible emergency. They have worked hard at it and, according to a Johnson Space Center instructor, have developed a degree of competence roughly equivalent to that a college graduate has after four years of sound language training and hard work. That is more than adequate. During the flight, the



The Apollo-Soyuz team: left to right, Apollo command module pilot Vance Brand; Soyuz flight engineer Valeriy Kubasov; Soyuz commander Alexei Leonov; Apollo docking module pilot Donald K. "Deke" Slayton; Apollo commander Tom Stafford.

a contribution to detente."

Both sides have indicated readiness to consider further cooperation and therein may lie the greatest potential of ASTP.

"A compatible docking system gives us the basis for future joint ventures," says Lee. "Space exploration is expensive but cost-sharing brings down the cost to the individual nation and it might allow some very advanced projects — Mars, for instance. Perhaps a future Mars mission might involve not just the two countries but three or four or more."

The Apollo-Soyuz mission is an earth-orbital rendezvous and docking of two spacecraft, a type of operation which has been accomplished often by both nations. The difference is the dramatic meeting in space of crews representing two

theory, showing the rest of the world that the U.S. and the U.S.S.R. can work together in peace advances the cause of detente. One official puts it this way: "We may more readily believe it ourselves if we convince everyone else."

From the technical standpoint, the flight is principally a verification of a compatible docking system. Related aims include checking out procedures for transferring crews in space and testing the workability of mission coordination between two separate control centers with two different languages. Once, the members of the American and Soviet working groups started to learn the other nation's language. They found that the time factor — the three years allowed for pre-mission preparations — was insufficient to develop real competence. So tech-



Technicians put the finishing touches to Docking Module.

rule is "language of the listener;" the Soviets will address the Americans in English and the U.S. astronauts will speak Russian when talking to the cosmonauts.

The international cast of spacemen includes:

Thomas P. Stafford, Brigadier General, USAF, 45, commander of the Apollo, veteran of three space flights and five rendezvous operations. With just under 300 hours in space, Stafford is senior of the five spacemen in rank and experience;

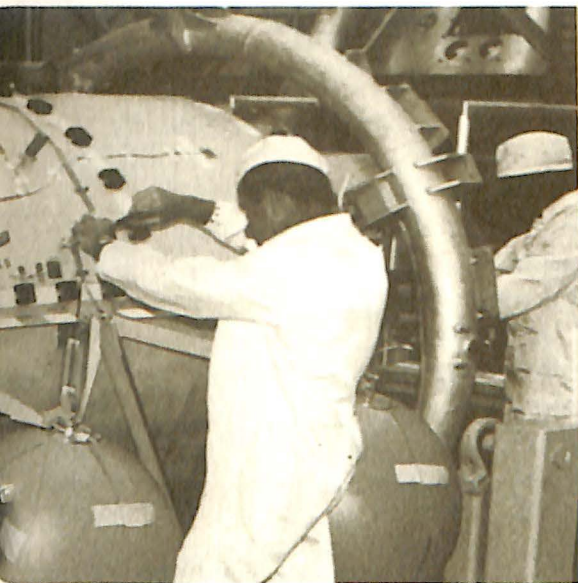
Vance DeVoe Brand, civilian, 44, Apollo Command Module pilot, a spaceflight rookie who has served on three Apollo backup crews;

Donald K. "Deke" Slayton, civilian, 51, Docking Module pilot, one of the original seven Mercury astronauts who was benched for physical reasons. Now restored to flight

status, Deke Slayton is going aloft for the first time 16 years after his selection as an astronaut;

Alexei Arkipovich Leonov, Colonel, Soviet Air Force, 41, commander of the Soyuz, veteran of the Voshhod 2 flight of 1965 in which he became the first man to conduct "extravehicular activity" or space-walking;

Valeriy Nikolayevich Kubasov, civilian, 40, Soyuz flight engineer, a veteran of the Soyuz 6 flight of 1969 in which he conducted the first welding experiments under the weightless and atmosphereless



odule in Rockwell International's clean room.

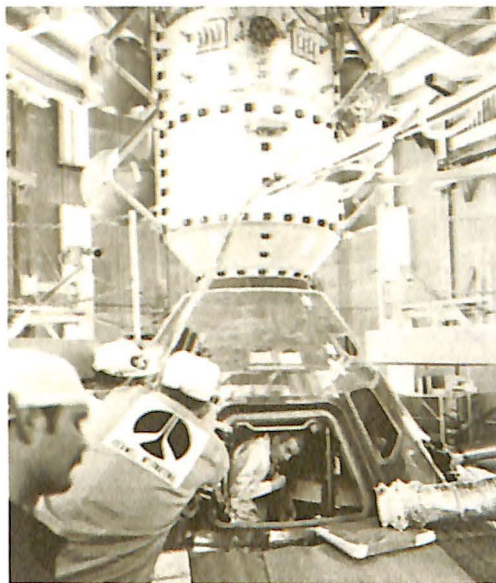
conditions of space.

The Apollo flight hardware consists of the familiar Command and Service Modules, both extensively modified for the dictates of this mission, plus a new segment called the Docking Module. Developed and built by Rockwell International's Space Division, Apollo prime contractor, the Docking Module is an airlock that fits between Apollo and Soyuz and allows crew transfers from one spacecraft to the other.

The need for this extra segment stems from the fact that Apollo and Soyuz have incompatible cabin environments—the former is pure oxygen at five pounds per square inch, the latter normally operates at earth sea level atmosphere, which is an oxygen/nitrogen mix at 14.7 pounds per square inch. These environments cannot be allowed to

mingle, hence, the airlock.

Ten feet long and five feet wide, the Docking Module is a cylinder that can be pressurized to match the environment of either spacecraft. An Apollo to Soyuz transfer goes this way: the astronaut enters the Docking Module, operates its controls to add nitrogen until the module's environment is the same as that of the Soviet spacecraft; then he opens the hatch at the Soyuz end of the Docking Module, the Soyuz crew open their hatch and the American astronaut can float into the Soviet craft (the crews will,



The Docking Module (top) is mated to the Apollo Command Module.

of course, be weightless during docked operations). A reverse transfer—Soyuz to Apollo—involves depressurization to Apollo equivalent. After this one mission, the Docking Module will no longer be needed, since future U.S. manned spacecraft—such as the Space Shuttle—will operate at earth sea level atmosphere and presumably the Soviets will continue to use that environment.

The other major new development in Apollo hardware is the docking mechanism, located at the end of the Docking Module which joins with Soyuz. Actually, the Apollo docking mechanism is one half of the common docking system; the other half being the fitting on Soyuz. The two mechanisms were jointly designed but are quite different, one electrical and one hydrau-

lic; nonetheless, they function as a single unit. The docking system compares loosely with the coupling blocks that link freight cars, except that the docking mechanisms are circular rings with a series of latches. During a docking, one spacecraft's docking mechanism is "active," the other passive. The active system grabs the other, they couple and the active mechanism's latches lock automatically, tightening the connection and creating a sealed tunnel linking the two spacecraft.

The Soviet Soyuz is a three module spacecraft. It has an Instrument Module which contains the subsystems required for power, communications, propulsion and other functions; a bell-shaped Descent Module, in which the cosmonauts descend to earth; and a larger, spherical Orbital Module, the crew's working quarters while in orbit. Once a three-place craft, Soyuz will carry only two cosmonauts on this mission.

Like Apollo, Soyuz was extensively modified for the joint project. Aside from the new docking system, the other major change was a very big alteration in the environmental control system. Where the Soviets normally operate at sea level environment throughout a mission, the modification will permit reducing pressure from 14.7 to 10 pounds per square inch during the period when the two spacecraft are docked. This facilitates crew transfers; without it, it would have been necessary for transferring spacemen to spend three hours in the airlock to avoid getting the bends. The modification represents something of a milestone in U.S.-Soviet space relationships; Soviet willingness to undertake this very costly narrowing of the pressure gap convinced the American team early in the program that the U.S.S.R. was really serious about the cooperative venture. As flight date nears, NASA officials are more impressed than ever about Soviet sincerity; they resent media comments suggesting that the U.S.S.R. is getting a bargain-rate technological education.

"That's a bum rap," says Glynn S. Lunney, Apollo Spacecraft Program Manager for NASA's Johnson Space Center at Houston. "I can't give you a figure as to the rubles they have spent; they don't tell us, we don't ask. But they have made a real commitment." Lunney mentions the modification of the Soyuz environmental control system, a change whose sole purpose was to improve the utility of the Docking Module; to the development of a new docking mechanism; and a variety of other Soyuz changes the mission necessitated. In addition, he points out, the U.S.S.R. flew two unmanned Soyuz missions and one manned flight to check out the modifications, where the U.S. flew no preliminaries. Finally, the Soviets are providing — for insurance of mission success — a backup spacecraft and launch vehicle; NASA is unable to do so, lacking both money and hardware. Says Lunney,

"It all adds up to a Soviet funding commitment at least as great as ours, possibly greater. They have been dedicated to this program and they have cooperated fully."

Here is what happens on Apollo-Soyuz:

First launch will take place at the Soviet launch base in Baikonur, some 1400 miles southeast of Moscow in Asian Kazakhstan. Soyuz will be boosted initially into an elliptical orbit. After two rocket-firing maneuvers, the orbit will be circularized at 140 statute miles altitude. There Soyuz will "wait" for Apollo.

Apollo will leave its Kennedy Space Center pad some seven and a half hours after the Soyuz launch. One hour after Apollo reaches orbit, it will start the "turnaround" maneuver. The turnaround is required because Apollo, at this point, is not yet a complete three-module spacecraft. The Docking Module cannot be mounted in its normal position at launch time, because that position is occupied by the launch escape tower, the emergency descent system which is later jetti-

soned. So the Docking Module is carried aloft within the Saturn IB launch vehicle and once in orbit it must be affixed to the Apollo CSM (Command and Service Modules).

The hookup will be accomplished in this manner: the Apollo CSM will separate from the launch vehicle and move some 50 feet away from it. Then, employing their rocket thrusters, the astronauts will turn the CSM around so that it faces the open end of the launch vehicle, the Docking Module's garage. Again using the thrusters, they will close the distance between the two vehicles and jockey the manned spacecraft until a probe in Apollo's nose slips into a drogue in the Docking Module. The latches will lock automatically, coupling the Docking Module to the CSM. The CSM will then back off slowly, pulling the Docking Module with it. Now a complete spacecraft, Apollo moves off in quest of Soyuz.

For the next two earth-days, Apollo will "chase" Soyuz as the two spacecraft revolve about the earth like a pair of racing cars on a circular track. Apollo, at the lower altitude, will complete a revolution quicker, thus will gradually catch up. Aided by the Soviet and American tracking networks, and by the control centers at Moscow and Houston, Apollo will perform a series of maneuvers which gradually narrow the altitude and plane differentials of the two spacecraft. About 50 hours into the mission, Apollo and Soyuz will be close enough for visual sighting; a flashing beacon on the Soviet craft will guide Apollo in the final phase of the rendezvous. Apollo will make most of the maneuvers because it has more than ample thrusting fuel while Soyuz must conserve its limited supply for post-docking maneuvers.

Some 52 hours after the initial launch, Apollo commander Stafford will nudge his spacecraft toward Soyuz, using an optical target on Soyuz as a guide to the first international space merger. With the Apollo docking mechanism active,

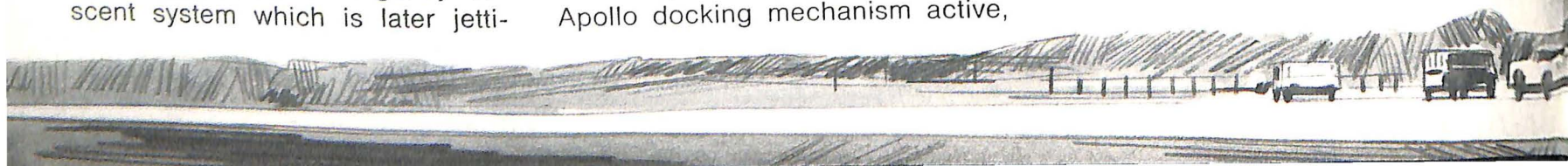
the two spacecraft will couple and lock together.

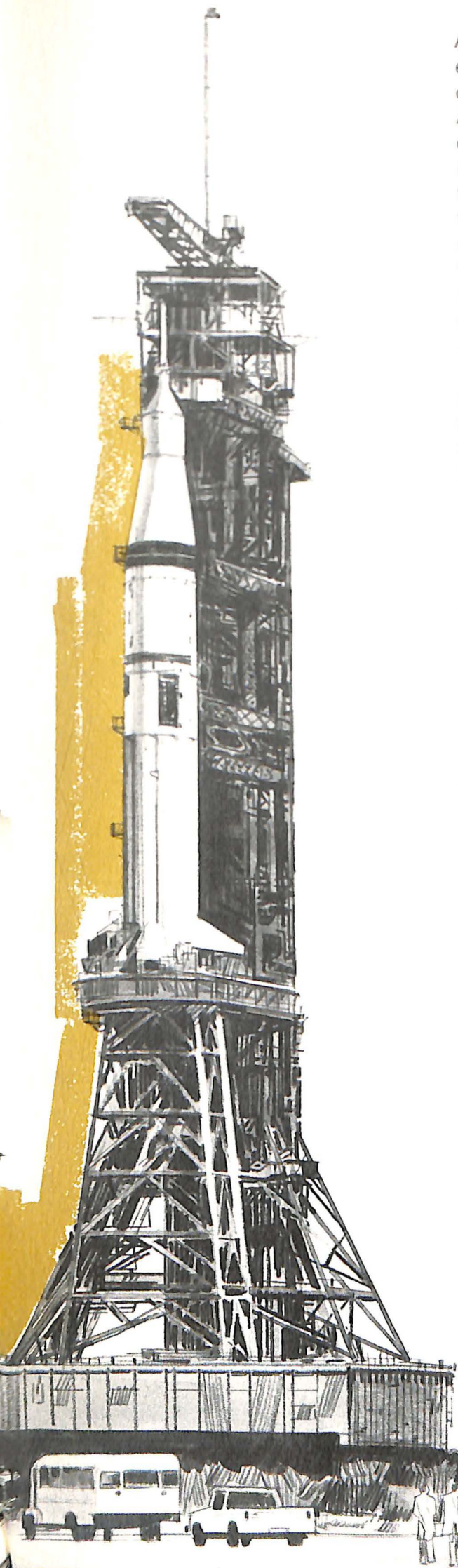
After a round of preliminary checks, the first crew transfer will take place. Astronauts Stafford and Slayton will enter the Docking Module, pressurize it to Soyuz equivalency and open the hatch leading to the Soviet craft. Then comes the symbolic handshake between commanders Stafford and Leonov, televised to earth by a camera mounted in the Docking Module.

There will be three more crew transfers after that, each astronaut and cosmonaut visiting the other nation's spacecraft at least once. The spacemen will perform a number of joint experiments during this time and at meal occasions each will host a "dinner party." The five will never get together in one place, however, because mission rules demand that one man remain in each spacecraft at all times to monitor the instrument displays.

After two full earth-days of joint operations, the spacemen will disengage their craft for one final joint experiment, called the "artificial solar eclipse." This experiment takes advantage of the fact that there will be two manned spacecraft in orbital proximity to make an investigation of the solar corona which is difficult to accomplish by other means. The corona, the circle of light that surrounds the sun's disk, is a million times fainter than the disk itself. Attempts to photograph it by earth telescopes or unmanned spacecraft have been only partially successful, since the intense radiation from the sun's disk tends to obscure the corona.

In this experiment, the spacemen will use one of the spacecraft —





Apollo — as an "occluding" or eclipsing device while the other crew takes pictures of the corona. Apollo will back off from Soyuz in direct alignment with the sun until it reaches a distance of 200 meters from the Soviet craft. At that distance, Apollo will block out the radiant solar disk, leaving visible to the Soyuz crew only the corona. It is hoped that the resulting photographs will be better than any yet acquired.

The joint mission ends with the eclipse, but both spacecraft will remain in orbit performing unilateral experiments. Leonov and Kubasov in the Soyuz will start their descent toward the end of their sixth earth-day in space. Their drop slowed initially by parachute and later by braking rockets, they will make a soft landing near the take-off point at Baikonur.

With a lengthier agenda of experimentation, astronauts Stafford, Brand and Slayton will continue in orbit for five earth-days after separating from Soyuz. They will conduct about a score of unilateral investigations, many of them extensions of experiments begun in the Skylab flights of 1973-74. The experiments are grouped in several categories: earth observations, part of a continuing Apollo/Skylab study in the fields of geology, hydrology, meteorology and oceanography; astronomy, including further study of soft X-rays and extreme ultraviolet sources; spacemedical, embracing several experiments in which biological samples will be studied to determine the effects of cosmic radiation on man; and medical technology, two "electrophoresis" experiments designed to dem-

Mounted on its transporter, the Saturn 1B/Apollo space vehicle moves to its launch complex at Kennedy Space Center.

onstrate the enhanced ability to separate living cells in zero gravity, which has possible clinical applications on earth.

Of particular interest is a group of seven experiments involving the "multipurpose electric furnace." The furnace, an improved, higher temperature version of one used in Skylab missions, provides a means of studying materials phase-changes under zero gravity conditions. This investigation is aimed at the possibility of materials processing or manufacturing in space. An example of the potential advantages is contained in the fact that defective crystals are a major cause of electronic device failure, especially semiconductor devices. Skylab tests, to be verified on the upcoming mission, showed that larger and more perfect crystals can be "grown" under the weightless conditions of orbital flight. "Application of this technology," says a NASA/Rockwell Apollo-Soyuz brochure, "should make it possible to produce more transistors per given area and integrated circuits with greater densities, and it may allow researchers to push integrated circuit technology to its ultimate performance."

At the start of the 10th earth-day, the Apollo astronauts will begin preparations for the descent to earth. The Docking Module and the Service Module will be discarded; with a retrofiring of its rocket thrusters at approximately 220 hours after the mission's beginning, the Apollo Command Module will de-orbit and drop to the familiar splash in the Pacific Ocean. It will be the last splash, for the water-recovery technique will be used no more; future U.S. manned spacecraft, starting with the Space Shuttle will make surface landings on wheels, like an airplane.

Hopefully this last Apollo flight ends one era and launches a new one, an era of peaceful exploration of space and ever-broadening international cooperation—"for all mankind."

Aerospace is Involved-

Transportation at the Surface

AEROSPACE certainly is the:

■ Huge aircraft that can whisk 300 passengers across the United States in some five hours;

■ Towering launch vehicle and its spacecraft that can put men on the moon and bring them back;

■ Satellites that study Earth's resources and weather, bring distant events into your living room, lower the cost of long distance telephone calls;

■ Reconnaissance aircraft that can fly from New York to London in less than two hours;

■ Missiles, bombers, superior fighter aircraft and other weapons and weapon systems that the nation decides it needs for its defense;

■ Business and personal aircraft that provide pleasure or quick, convenient, productive travel for busy people;

■ Helicopters that can do so many things quicker and better than any other vehicle, from rescuing accident victims to serving off-shore oil rigs to logging timber inaccessible by road.

The aerospace industry is all this and much more.

It is deeply involved in activities that range from agriculture to oil and mineral exploration.

Take just one field — transportation on or near the surface of the Earth. As illustrated in this article, a majority of the member companies of the Aerospace Industries Association are deeply involved in this vital area of development.

Transportation and energy are prime concerns of our country today and of the two, transportation may bear the more immediate urgency.

Leaving aviation aside for the moment, land transportation — road or rail, long-haul or short-haul — is more critical to more people. And the more congested the population centers become, the more urgent is the need.

We must be able to move large loads of people and things rapidly, efficiently, safely and, in the case of passengers, comfortably. This means within cities, around cities and their suburbs, between cities and across the country.

But today no one means of transportation will serve all purposes or areas. Essential is a mix that provides a balanced transportation system. If an individual can fly 1,000 miles from one major airport to another in a couple of hours and then find that he has spent more time on the ground getting to and from the airports than he did in the air, the system obviously is not a system — or it has some badly antiquated segments.

What is good between cities thousands of miles apart or even 300 to 500 miles apart is not necessarily the answer for a megalopolis, a sprawling metropolis, or even a medium-sized city.

The relatively short-haul of large numbers of people and things quickly, comfortably and conveniently becomes a greater requirement daily. The transportation of masses of people in the spreading urban areas is the most critical of the transportation problems.

Tokyo, Japan, in the early '50s was a sprawling city of millions with hordes of bicycles, three-wheeled "cyclos" and a growing number of automobiles. But for the masses there at that time, Tokyo had an efficient spoked-wheel system of trains and subways that served the great majority efficiently. In one typical suburb, for instance, it was a three-block walk to the train station (a train every five minutes or so), a three-minute ride to the heart of a suburban shopping area; a quick connection and a 15-minute subway ride to the basement of any of the major department stores along the heart of the downtown Ginza shopping district. All this



A

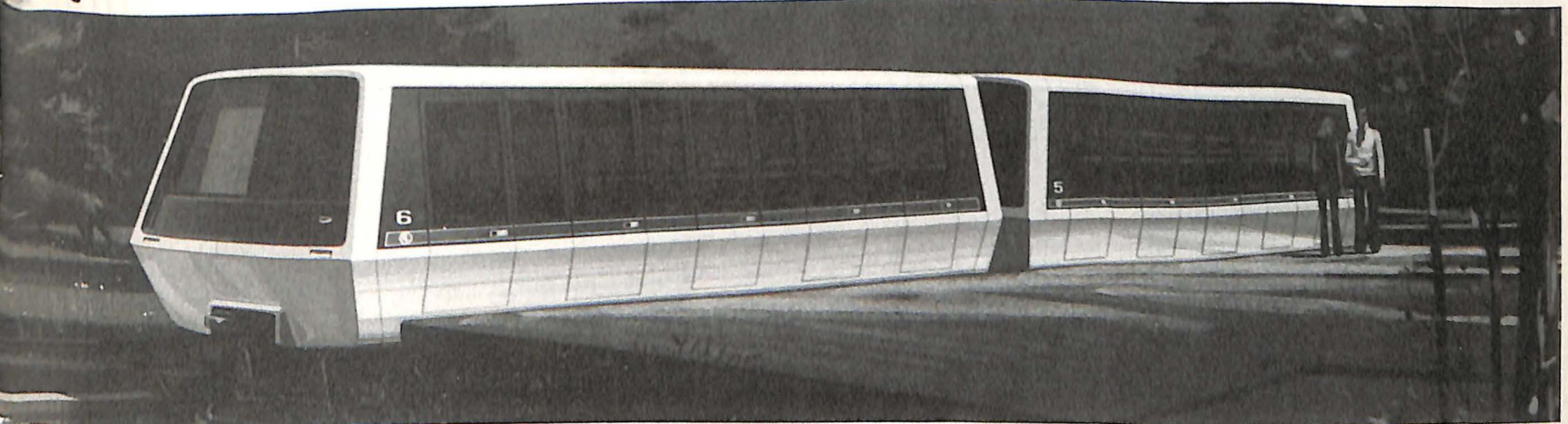


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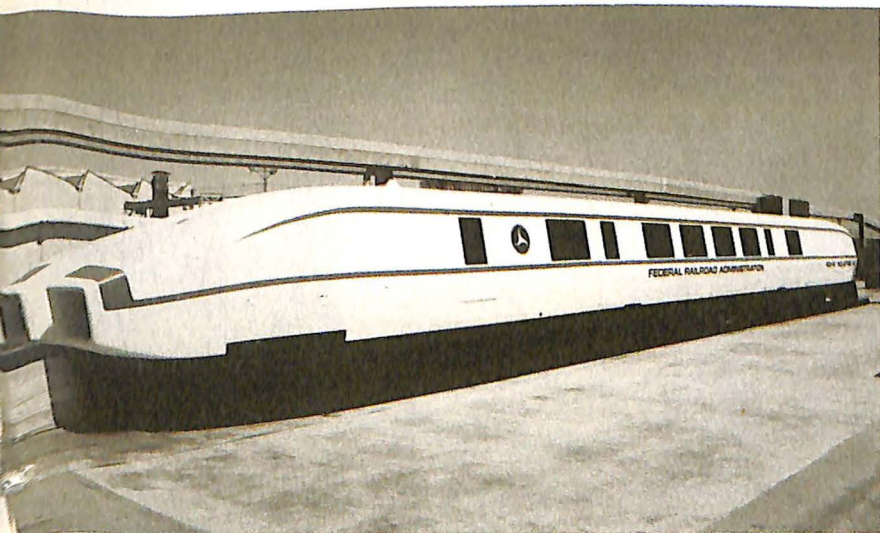
- A. The Lockheed Missiles and Space Company Twister[®] Dragon Wagon[™] eight-wheel-drive load hauler can travel high speed turnpikes or take off across country in terrain impassable for conventional vehicles. It can haul an 80-ton oil exploration crew above the Arctic Circle, or carry men and equipment to fight remote forest fires.
- B. A part of transportation is construction and delivery of goods. In these situations there must be communications. Among such aerospace industry firms providing communications is the Martin Marietta Corporation digital paging system, no bigger than a pack of cigarettes. The Corporation also builds a recovery system for oil spills.
- C. The Westinghouse Electric Corporation electronically controlled, fully automatic passenger shuttle system, makes cars available every minute or so at airports in Tampa, Seattle-Tacoma (and soon Miami), and the new Busch Gardens at Williamsburg, Va. The Tampa system has logged 1,460,000 miles and carried more than 40 million passengers since it started operations in 1971.
- D. A system that includes wheels that ride against the side of the guideway and is equipped with a unique lateral suspension system that minimizes swaying motion is the heart of the Bendix Animal Domain Ride at the new Metropolitan Toronto Zoo. Bendix also is supplying power generators and controls for the Bell Surface Effects Ship (SES) and frequency converters for the Boeing Patrol Hydrofoil Missile (PHM) ship.
- E. The Rohr Industries ROMAG magnetically levitated vehicle is designed to carry 80 passengers at 300 miles-per-hour. Rohr also is delivering an order of 300 high-speed cars for the new Washington, D. C., Metro subway, and is deeply involved in developing rapid transit, Personal Rapid Transit (PRT), better buses and Navy SES ships.
- F. This Garrett Corporation propulsion/Grumman Corporation "train" travels on a thin cushion of air above a concrete guideway. It is designed with a second generation linear induction motor for speeds up to 300 mph. Garrett AiResearch, concentrating on propulsion, braking and car design, is working on an Advanced Concept Train (ACT-1) prototype for the Department of Transportation.



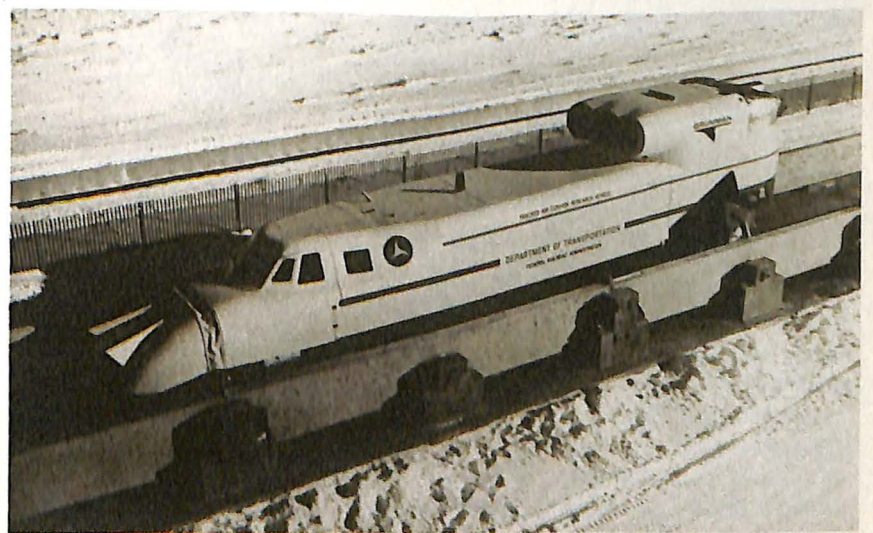
C



D



E



F

half the time and with none of the bother of trying to drive and park.

Some aerospace technologies are immediately applicable to new and better means of surface transportation. Others have to be developed, and that is why the companies, and the Government, are spending money on research and development and on pilot systems in many transportation areas.

Tremendous strides have been or are being made in applying aerospace technology to increasing productivity in transportation and, of course, to the benefit of the public. Some of these major accomplishments have been made with little fanfare and public notice. Others, still pushing forward the leading edge of technology, have been criticized because of their costs and because of other problems. But then, it is probable that first piano wasn't in perfect tune and needed a number of technological achievements that, at that time, were regarded as technological breakthroughs."

It would require a thick book to cover all that the high-technology aerospace industry is doing in the field of transportation for now and the future.

Essentially the relationship between the distance to be traveled and the speed and frequency of appropriate transportation are the governing factors.

This tends to point to Personal Rapid Transit (PRT) subsurface, surface or overhead vehicles in congested downtown areas, at sprawling airports, on extensive college campuses and even, perhaps, in ultralarge shopping centers. PRTs might even travel a heavily populated suburb delivering passengers who will use a faster means of transportation between suburbs and city.

PRT systems already are in being and operating over relatively short distances. These are fully automated cars that operate in or on various types of guideways to pick up, transport and discharge passengers in the downtown areas of medium-sized cities; at places like the new Busch Gardens Zoo at Williamsburg, Va., or at the big international airports at Tampa, Dallas/Fort Worth, Houston and Seattle/Tacoma. Airport PRTs are shuttling passengers, baggage, and in some instances cargo and mail, between main and satellite terminals designed to take care of the traffic of the vastly increased number of air travelers up to the year 2000 and beyond.

At the next level most major metropolitan areas, at least at this time, probably can be served best by a combination of transit buses and high-speed rail vehicles in a care-



G

G. This Canadian Coast Guard air cushion vehicle (ACV), or "hovercraft," made by Bell Aerospace Canada, can break up ice-jams on rivers, and is being tested as a transportation system serving Quebec's lower north shore communities. Bell also is developing a 2000-ton SES prototype for the Navy.

H. Except for the comfort and quiet you might not know that your next ride on a Greyhound MC-8 Americruiser is powered by a 350-horsepower Detroit Diesel Allison gas turbine engine driving through an Allison fully automatic transmission. Allison turbines or diesel engines also power other forms of surface transportation.

I. This Sperry Rand Corporation control panel, with map and symbol displays, will make it possible for traffic engineers to control car movements on the new Washington, D. C., Metro transit system.

J. Driven at high speed by an advanced linear induction motor (LIM) and levitated about a foot above a guideway this quiet, non-polluting Raytheon Company "Magneplane" may be the land transportation of the future for short to medium distances (cities 300 to 500 miles apart). Here a model is readied for a run on an MIT test track.

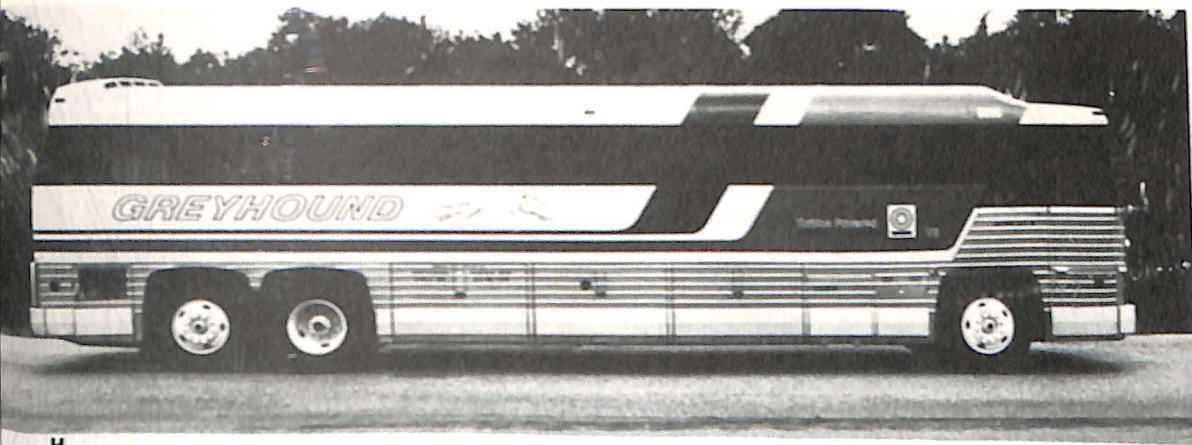
K. Grumman hydrofoils, such as the Flagstaff I driven by Garrett AiResearch jet turbines and capable of speeds of 50 mph, were tested under combat conditions in Southeast Asia. A larger Flagstaff II, capable of 60 mph speed over waves up to eight feet and with a foil-borne range of 940 nautical miles is under development.

L. RCA two-way mobile radio systems are important elements of ground transportation systems that ensure that fresh concrete and crews get to the site where they are needed, as for instance in the construction of the Washington, D. C., Metro subway system.

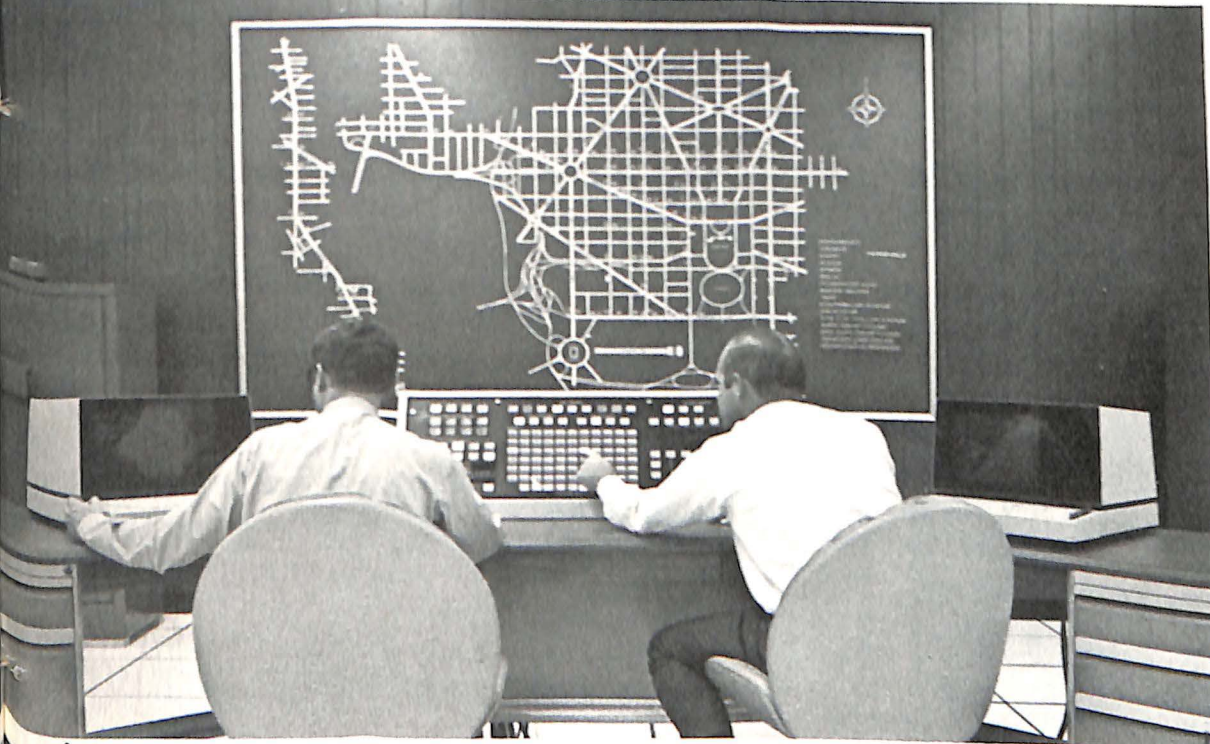
M. The Boeing Company, a leader in the fields of automated Personal Rapid Transit (PRT), Advanced Concept Trains (along with Garrett propulsion) and U. S. Navy Patrol Hydrofoil Missile (PHM) ships, builds commercial jetfoil craft that carry as many as 284 passengers at more than 50-mph in virtually all sea conditions as well as rapid rail transit vehicles for Chicago, Boston and San Francisco.



J



H



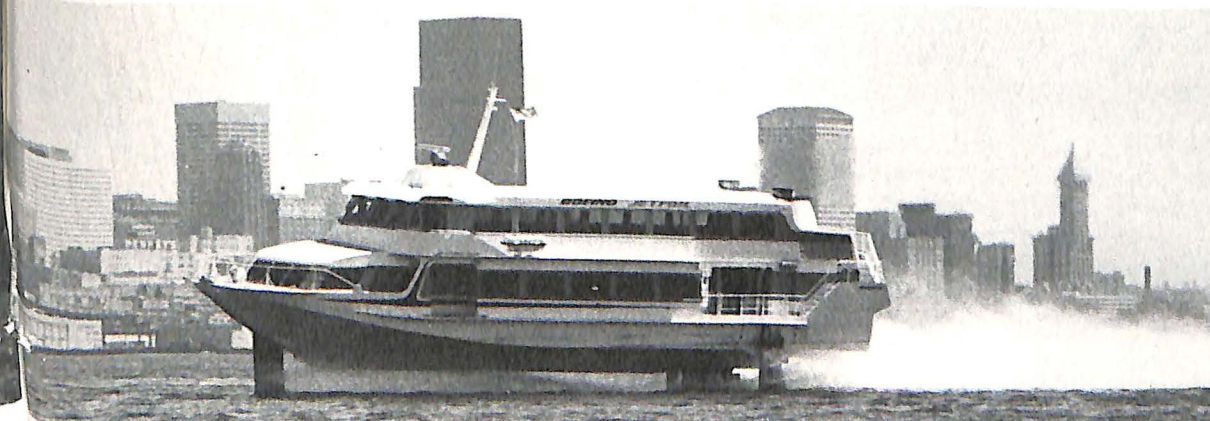
I



K



L



M

fully planned mix. This really is an extension of the old commuter train, combined with the trolley or jitney bus. In fact, essentially it is the concept of the Bay Area Rapid Transit (BART) system now being smoothed out to serve the San Francisco Bay area efficiently.

At the third level is the guided or tracked air cushion or magnetically levitated train-like vehicle capable of smooth, virtually pollution-free transportation at from 150 to 300 miles-per-hour, probably on an elevated guide-way or guide-rail. With a 10-minute stop at two intermediate stations a 250-mph train could go from downtown San Francisco to San Louis Obispo to Los Angeles to downtown San Diego in something like two hours. And given the same conditions the trip from downtown Washington, D.C., to downtown Boston by way of Baltimore, Philadelphia and New York should be less than two hours.

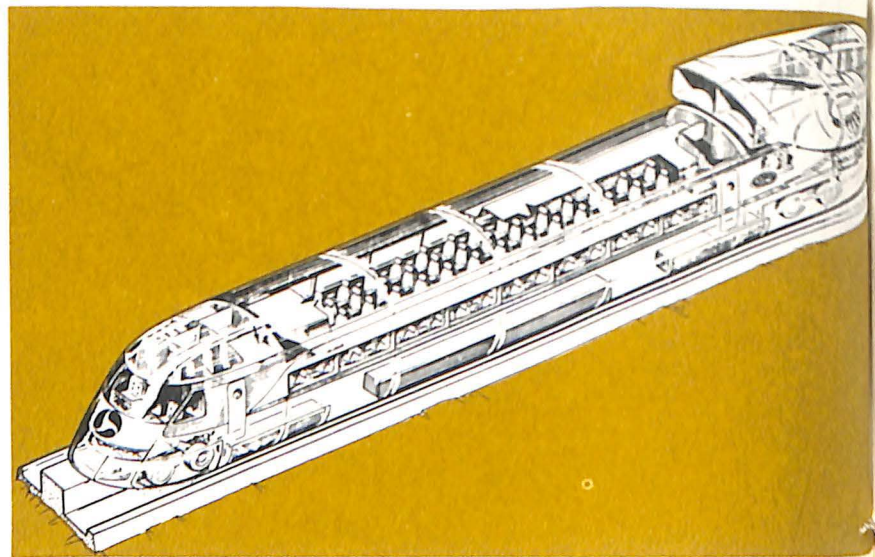
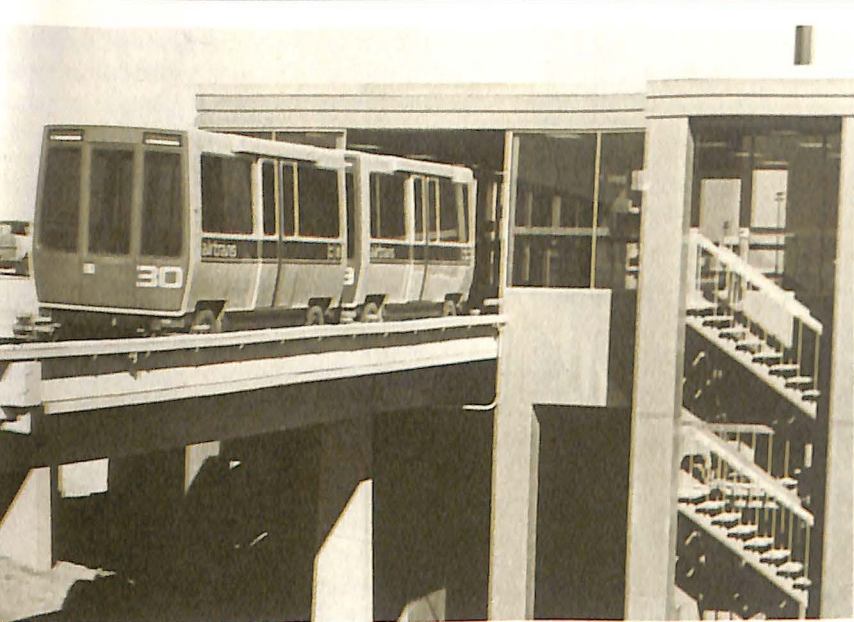
Such a trip would be great, of course, but it wouldn't be part of a transportation system unless there were efficient, integrated modes of rail, bus and PRT transportation systems operating within each city on the route.

Guidance of land vehicles can be provided by guideways, a center guide-rail or an overhead monorail. These on, over or below the surface traffic installations will not be unsightly and can save on both construction and land acquisition costs by using the sides or center strips of land already committed to major ground highways and boulevards.

Although adequate transportation is essential today and for the future — and it can be provided — this is not to say that it can be provided without a psychological wrench or perhaps some other type of adjustment for citizens as they accommodate themselves to new transportation installations. But is a quiet, low emission monorail or surface rail system less esthetically tolerable than more and wider ribbons of concrete and bridges, intricate highway interchanges, and special bus lanes?

Propulsion may come from jet engines, conventional ground or aircraft engines, electricity from track or guideway or from linear induction motors in which the guide rail reacts with electricity produced on board to levitate and to pull the vehicle forward at speeds only possible because there is no friction other than that of the atmosphere. "No friction" also means lower costs from start to finish, including maintenance.

Water covers some three-quarters of the Earth's surface, and the aerospace industry is busy in this environment, as well.



- N. The system that moves passengers, crews, baggage, mail around the huge Dallas-Fort Worth Regional airport is called "Airtrans" by LTV Aerospace Corporation. Such systems, centrally controlled and automatically operated, are essential at major airports today. The vehicles, rubber-tired, with power from the side guideway, can carry 9000 people, 6000 bags and 70,000 pounds of mail and cargo per hour.
- O. Oil is an essential source of energy, but accidents happen. Goodyear Aerospace Corporation has developed this "bottom tension" oil containment boom to prevent spread until the oil can be recovered. It also makes 10-foot high, three-foot wide tires for huge vehicles.
- P. Container-carriers and loaded barge-carriers are specialties of General Dynamics, as is this new concept of a Liquid Natural Gas (LNG) tanker that will transport 125,000 cubic meters of LNG across oceans at super-cold temperatures.
- O. This is an Aeronutronic Ford design for the Department of Transportation that could provide a magnetically suspended, high-speed rapid transit vehicle in the near future. Cruising about one foot above a guideway the "jet aircraft without wings" would serve cities 300 to 500 miles apart at speeds up to 300 mph.
- P. The Aerojet Liquid Rocket Company is the "baseline" company providing propulsion power for the Boeing Patrol Hydrofoil Missile ship. It also is providing the water jets and pumps for the 2000-ton air cushion Surface Effects Ship prototypes being built by Bell and Rohr for Navy evaluation.
- S. A "Powerjet 20" engine by Rockwell International's Rocketdyne Division powers the commercially successful, 50-mph Boeing jet hydrofoil, now in commercial use. Rockwell also is designing a 40,000-hp water jet and propulsion drive system for the Bell Aerospace and a Lockheed prototype 2000-ton surface effects ship for Navy evaluation.

Roll-on, Roll-off ships can accept large numbers of pre-loaded trailers and transport them across the ocean. And container ships can be loaded with pre-packaged containers for similar long voyages with minimum handling.

Now we have huge ships that can accommodate fully loaded barges. The ships sail to Europe, stop outside the harbor, unload the barges which then use the ports and waterways to deliver their goods. Busy harbors are not choked, and turn-around time is cut to a minimum, saving not only time (as much as eight days on a transatlantic round-trip voyage), but money. That's productivity.

Next is the liquid natural gas (LNG) ship. These ships must be able to accept liquid natural gas at extremely low temperatures and maintain those temperatures all the way across the ocean for delivery to storage facilities. There the gas can be packaged for delivery, or re-converted to a gas and distributed to heat homes, cook food, keep the wheels of industry turning. The answer to problems like these come directly from aerospace and government research and development.

Perhaps the most visually exciting developments in the marine environment are the Surface Effects Ships (SES) and the hydrofoils. World-wide applications of such ships are easy to visualize.

Hydrofoil ships, whose underwater "wings" or foils lift the hull out of the water for greater speed and stability, already are being produced commercially for applications such as carrying 284 passengers at more than 50 miles-per-hour between Hong Kong and Macao and among the Hawaiian Islands.

Hydrofoils also have great defense possibilities with the U.S. Navy, which is contracting for Patrol Hydrofoil Missile (PHM) ships that will ride up to 12 feet above the surface, serving as swift fleet protection, assault support and target bombardment platforms.

Surface Effect Ships actually are more than ships. Using a variety of propulsion systems they create a cushion of air so that they are lifted off the surface from an inch to a foot. They can cover water, beaches, swamps, snow, ice and relatively flat terrain at great speeds because there is no ground friction. In fact, Admiral Elmo R. Zumwalt, former Chief of Naval Operations, after a ride on an SES (which already can reach speeds of more than 90-miles-per-hour) said that the day of the 100-knot navy is at hand. Already the U.S. Navy has aerospace firms competing in the design, development and testing of

2000-ton SES vehicles.

An SES serves outlying islands in Canada; is standing by the Yukon River in the far Northwest just in case the natural ice bridge over the river, so essential to the development of the Alaska pipeline from the north slope, should go out; others are breaking up ice-jams that used to cause rivers to flood land and homes in Canada north of the St. Lawrence river. The future applications of such vehicles are innumerable — from delivering feed to livestock stranded on snow-blanketed plains to serving out-of-the-way towns where tides are too high or there are inadequate shipping and docks.

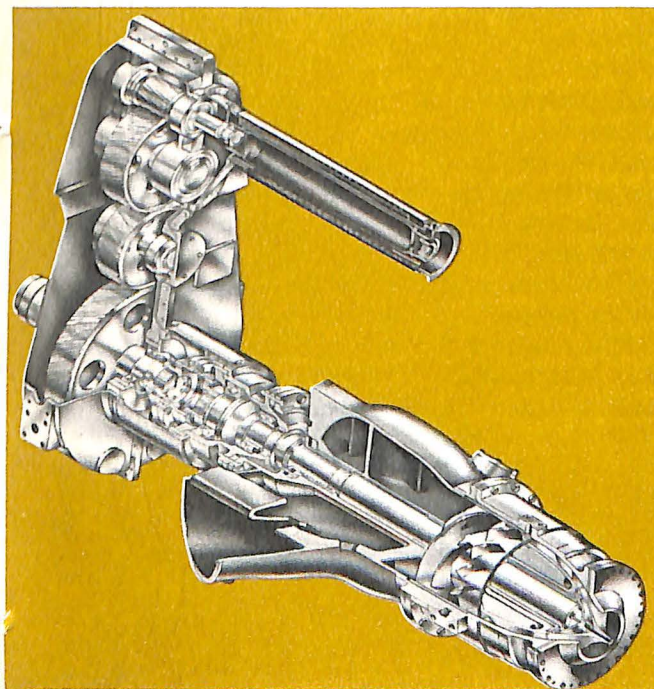
These new generations of water vehicles will be propelled by a variety of systems — turbojet or reciprocating engines providing power for underwater propellers, for jets of water, ducted above-deck propeller fans, or even straight turbojet drive. Hydrofoils and SES vehicles will require different mixes of power and propulsion, but the family of turbojet, diesel and other engines is growing so greatly that there is an engine or a combination of engines for almost any power-generating and/or propulsion use.

New off-road vehicles for construction, logging and other difficult tasks are being developed, and it has been estimated that a new family of towing vehicles could cut air pollution by 85 percent, reduce noise significantly and save untold gallons of fuel used by taxiing aircraft at Los Angeles International Airport alone.

And behind all of this are the electronic command and control systems to monitor, guide and regulate the ever-increasing flow of traffic on city streets and highways. These are the "black boxes," the visual displays, the automation and remote controls that can keep transportation on schedule, regulate lights, signs and other control systems — keep people and things moving.

A Department of Transportation spokesman has said: "We must continue to seek better mass transit technology, and we very much need new ideas—especially ones that have favorable cost/benefits relationships and that from the user's standpoint offer attractive alternatives to the private automobile. To cite a specific need, if any (one) could come up with what amounts to a 'lovable bus' we would willingly award the Department's equivalent of the Nobel Prize."

From the standpoint of technology, more and better transportation is on the way — not only in the air, where great strides have been made, but near or on the surface where people-moving has become such a critical problem.





Careers in the Aerospace Industry

Editor's Note: The following general introduction to the subject of careers in the aerospace industry stems from the many requests for career information received by the Association from students, teachers and others. In limited space, it is at best an overview and cannot therefore provide an insight into the hundreds of rewarding job categories which aerospace activity envelops.

Firms that engage in the research, development and production of aircraft, missiles, spacecraft and associated equipment make up what is known as the "aerospace industry." In 1974, almost one million people worked in the industry; the bulk of them in the manufacture and assembly of complete aircraft, aircraft engines, propellers, and auxiliary parts and equipment; the remainder in missiles and spacecraft and in companies that make electronic equipment and instruments for aircraft, missiles, and spacecraft. Thousands of workers in other industries produced parts, machinery, and equipment used in the manufacture of aerospace vehicles. Also, thousands of federal workers were engaged in aerospace related work, because the government is a major purchaser of the industry's products.

Nature of the Industry

Although there are many kinds of aircraft, missiles, and spacecraft, they all have the same basic components: a frame to hold and support the rest of the vehicle, an engine or engines to propel the vehicle, and a guidance and control system.

Types of aircraft vary from small personal or business planes that cost not much more than an automobile, to multi-million dollar jumbo transports and supersonic fighters.

Missiles are chiefly for military use. Some are capable of traveling only a few miles, others have intercontinental ranges of 7000 miles or more.

Most of the country's spacecraft are built for the National Aeronautics and Space Administration and the Department of Defense to explore outer space or to monitor conditions within the earth's atmosphere.

Major aircraft, missile and spacecraft firms contract with government or private business to produce an aerospace vehicle. As contractors, they are responsible for managing and coordinating the entire systems development. Scientists and engineers, usually in a laboratory environment, continuously work on expanding the technological base needed for new products. When sufficient technology is in hand the firm's engineering department commences with preliminary design and development testing. When the design has been proved, final design drawings and specifications for the product are prepared and go to the production department where planners work on the many details regarding machines, materials, and operations needed to manufacture the vehicle. Production includes designing and producing the tools and fixtures needed to produce thousands of parts and accessories that make up an aerospace vehicle. Parts and components are inspected and tested many times before being assembled, and completed systems are examined for conformance to specifications. Before a finished vehicle is delivered, it is checked out by a team of inspectors and flight-tested.

Aircraft, missiles, and spacecraft manufacturers generally make many components of a craft and do final

assembly work. However, because there are so many specialized components that make up the complete systems, much of the work is subcontracted to other firms. There are thousands of subcontractors involved in the production of parts that go into aerospace vehicles. Some subcontractors make parts or supplies such as bearings, rocket fuels, or special lubricants. Others produce sub-assemblies such as communication or guidance equipment, or major components such as jet engines.

Because of the complex and changing nature of aerospace technology, firms need workers with many different job skills that vary according to their fields of interest.

Occupations in the Industry

Professional and Technical Occupations. Research and development (R&D) are vital to the aerospace industry. Efforts are being made to develop vehicles with greater speeds, ranges, and reliability. Engines with more power and new sources of rocket propulsion such as nuclear and electric energy are being investigated and may be available in the future. Metals and plastics are continually being explored for wider capabilities, as are electronic guidance and communication systems. The pace of discovery in aerospace technology is so rapid that some equipment becomes obsolete while still in an experimental stage or soon after being put into production.

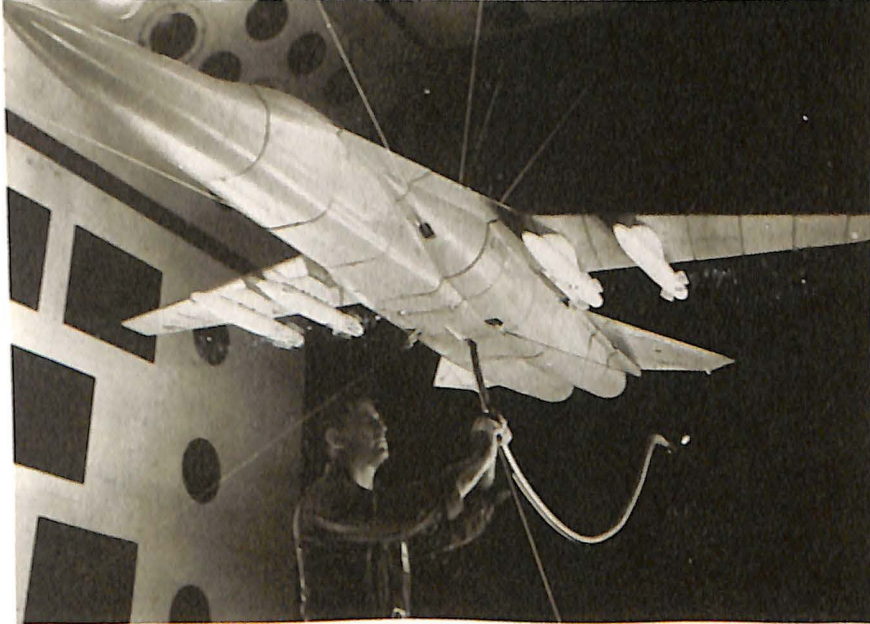
Emphasis on R&D makes the aerospace industry an important source of jobs for technical personnel. Almost one-fourth of all employees are engineers, scientists, and technicians, a considerably higher proportion than in most other manufacturing industries.

Many kinds of engineers and scientists work in the aerospace industry. Electronic, electrical, aerospace, chemical, nuclear, mechanical, and industrial engineers are among the larger engineering classifications. Scientists in the industry include physicists, mathematicians, chemists, metallurgists, and astronomers. Aerospace engineers and scientists work in a wide and varied range of applied fields such as materials and structures, energy and power systems, and space sciences.

Among the many types of workers assisting scientists and engineers are technicians such as draftsmen, mathematics aides, and engineering and science technicians. Engineers and scientists also work with other technical personnel such as production planners, who plan the layout of machinery, movement of materials, and sequence of operations for efficient manufacturing processes, and technical illustrators who help prepare manuals and other technical literature describing the operation and maintenance of aerospace products.

Administrative, Clerical, and Related Occupations. Managerial and administrative jobs generally are comparable to similar jobs in other industries, except that they are often filled by engineers, scientists, and other technical personnel. People in these jobs include executives responsible for the direction and supervision of research and production and officials in departments such as sales, purchasing, accounting, and industrial relations. The industry also employs many thousands of clerks, secretaries, stenographers, typists, tabulating machine and computer operators, and other office personnel.

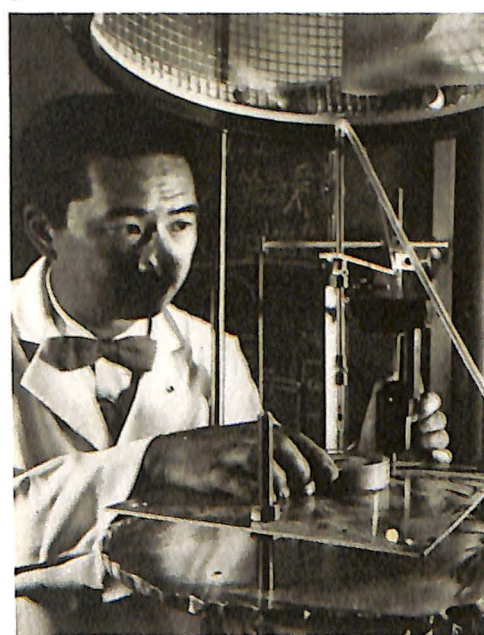
Production Occupations. About one-half of all workers in the aerospace industry have plant or production-related jobs. Production workers can be classified in the following groups: Sheet metal work; machining and tool fabrication; other metal-processing; assembly and installation; inspecting and testing; flight checkout; and materials handling, maintenance, and custodial.



A



B

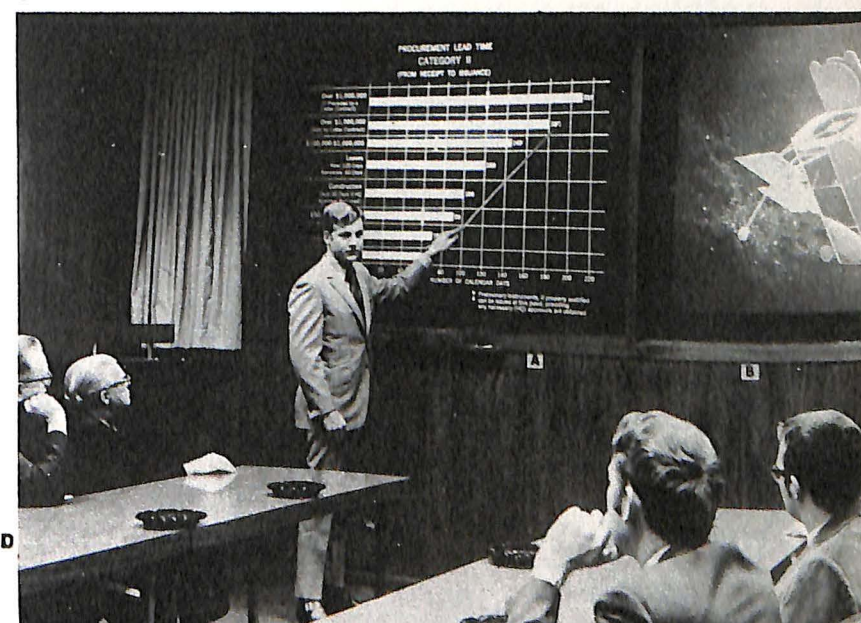


C

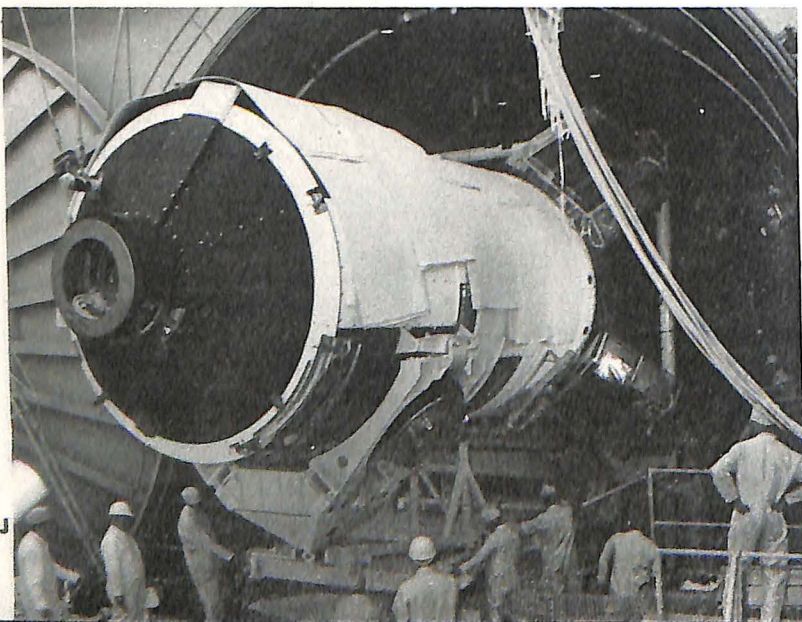
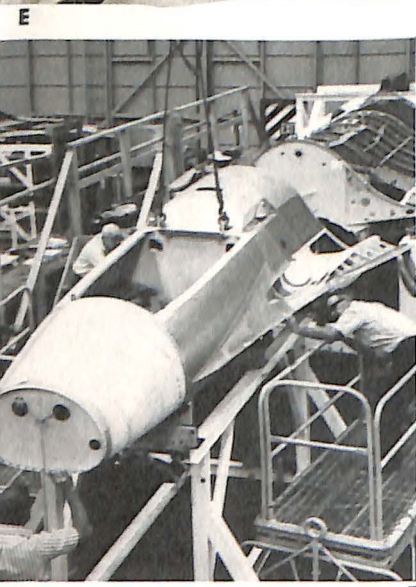
Aerospace **engineers** (A&B) play a vital role in America's aerospace activities. Engineers working in the aircraft field are usually called aeronautical engineers. Those in the field of missiles, rockets, and spacecraft often are referred to as astronautical engineers. Aerospace engineers usually have degrees in both fields.

In aerospace the **scientist** (C) is a key man in Research and Development (R&D). He directs himself to the discovery of new products and processes. While the engineer applies his skill to solving specific problems with known facts, the scientist probes the unknown. He seeks to know "why?" rather than "how?"; and he attempts to present the rules upon which the engineer may build.

Managerial positions (D) in aerospace are often filled by engineers, scientists, and other technical personnel who are responsible for the direction and supervision of research, development and production.



D



Employment in the Industry

From December 1968 to December 1971, aerospace employment dropped from 1,403,000 to 924,000. It then proceeded to climb to 973,000 by December 1974. Current estimates indicate that during 1975, aerospace employment will decrease by 2.8 percent — to 946,000 at year end.

Production worker employment is expected to decrease from 483,000 in December 1974 to 463,000 by year end 1975 — a decrease of 4.2 percent, while scientists and engineers decrease from 166,000 to 163,000 or down 1.8 percent, and technicians remain steady at 67,000 during the same period of time. The employment of clerical, administrative and maintenance personnel is expected to decrease by 1.6 percent, from 257,000 to 253,000.

It is estimated that 55,400 people, including 6900 scientists and engineers, will be employed in the final assembly of transport aircraft at the end of 1975. This estimate compares with 63,600 workers at the end of 1974, and a high in recent years of 126,200 reached at the end of 1968. These figures do not include transport-related employment of subcontractors and engine manufacturers.

Employment in missiles, space vehicles and parts is predicted to remain at 209,000 at the end of 1975, the same as 1974. The area of "other related products," which includes other aerospace and non-aerospace products manufactured in plants primarily devoted to aerospace, will remain steady at about 210,000 employees.

Aerospace jobs exist in almost every state. The largest concentration is in California. Other states with large numbers of aerospace jobs include New York, Washington, Connecticut, Texas, Florida, Ohio, Missouri, Pennsylvania, Massachusetts, Kansas, Alabama, Maryland, New Jersey, and Georgia.

By geographic regions, total aerospace employment is expected to show an increase of 8.7 percent in the South Atlantic area; however, this gain is offset by the declines in other regions. The largest decline — 6.5 percent — is predicted for the Pacific area.

AEROSPACE INDUSTRY EMPLOYMENT

By Occupational Classification
December 1968 to December 1975
(Employment in Thousands)

| Month and Year | AEROSPACE EMPLOYMENT | | | | |
|----------------|----------------------|--------------------|------------------------|-------------|------------|
| | TOTAL | Production Workers | Scientists & Engineers | Technicians | All Others |
| Dec. 1968 | 1,403 | 738 | 221 | 81 | 363 |
| Dec. 1969 | 1,295 | 658 | 203 | 72 | 362 |
| Dec. 1970 | 1,069 | 528 | 167 | 67 | 307 |
| Dec. 1971 | 924 | 448 | 159 | 60 | 257 |
| Dec. 1972 | 944 | 473 | 168 | 65 | 238 |
| Dec. 1973 | 962 | 484 | 164 | 66 | 248 |
| Mar. 1974 | 950 | 474 | 163 | 66 | 247 |
| June 1974 | 962 | 481 | 165 | 67 | 249 |
| Sep. 1974 | 976 | 482 | 168 | 67 | 259 |
| Dec. 1974 | 973 | 483 | 166 | 67 | 257 |
| June 1975* | 951 | 464 | 165 | 67 | 255 |
| Dec. 1975* | 946 | 463 | 163 | 67 | 253 |

* Forecast

The aerospace industry continued to be one of the nation's primary employers of scientists and engineers for R&D. In 1974, the nation employed 360,000 scientists and engineers for R&D; aerospace accounted for nearly 20 percent of the total with 70,300 workers in this category.

Production workers' earnings in the aerospace industry are higher than those in most other manufacturing industries. In 1974, for example, production workers in plants making aircraft and parts averaged \$5.40 an hour; production workers in all manufacturing industries as a whole averaged about \$4.40 an hour.

Training

A college degree in engineering or in one of the sciences usually is the minimum requirement for working as an engineer or scientist in the aerospace industry. A few workers obtain these jobs without a college degree, but only after years of work experience and some college-level training. An undergraduate preparing for a career as an aerospace engineer or scientist should get as solid a background as possible in mathematics and physics. More specialized fields of the industry require graduate school education or on-the-job training.

An increasing number of technical occupations such as draftsmen and electronics technicians require two years of formal education in a technical institute or community college. Others may qualify through several years of diversified work experience.

Production jobs require many skill levels. Some less skilled jobs that require repetitive work can be filled by workers with little or no training and can be learned quickly on the job. More skilled jobs require some combination of job related experience, high school or vocational education, and on-the-job training. Many workers often start at trainee level positions and work their way up to the more skilled occupations.

Apprenticeship programs are sometimes available for craftsmen such as machinists, tool and die makers, sheet-metal workers, aircraft mechanics, or electricians. The programs vary in length from three to five years depending on the trade and during this time the apprentice handles work of progressively increasing difficulty. Besides on-the-job training, the apprentice receives classroom instruction in subjects related to the craft.

Because complex and rapidly-changing products require highly trained workers, aerospace plants sometimes support formal training to supplement day-to-day experience and help workers advance more rapidly.

Outlook

Employment in the aerospace industry is expected to rise above recent levels by the mid-1980's. Thousands of jobs will open each year because of the growth expected in the industry, and to replace workers who retire, die, or transfer to jobs in other industries. Job opportunities should be most favorable for highly-trained workers such as scientists, engineers, and technicians. Less skilled and unskilled workers will also be needed to fill entry level production positions.

Growing demand for civilian aircraft products is an important element underlying the expected increase in aerospace employment. The increasing mobility of the population should encourage expanded use of large wide-bodied commercial aircraft and development of rapid air-taxi operations between major urban centers. Increased business flying, expanded use of helicopters for such tasks as medical evacuation and traffic reporting, and exports of aircraft to foreign nations are some of the other major factors influencing the growth of civilian aircraft manufacturing.

A large proportion of aerospace products are primarily for national defense and to advance the nation's goals in space. Therefore, the industry's future depends largely on the level of federal expenditures. Changes in these expenditures usually have been accompanied by sharp fluctuations in aerospace employment.

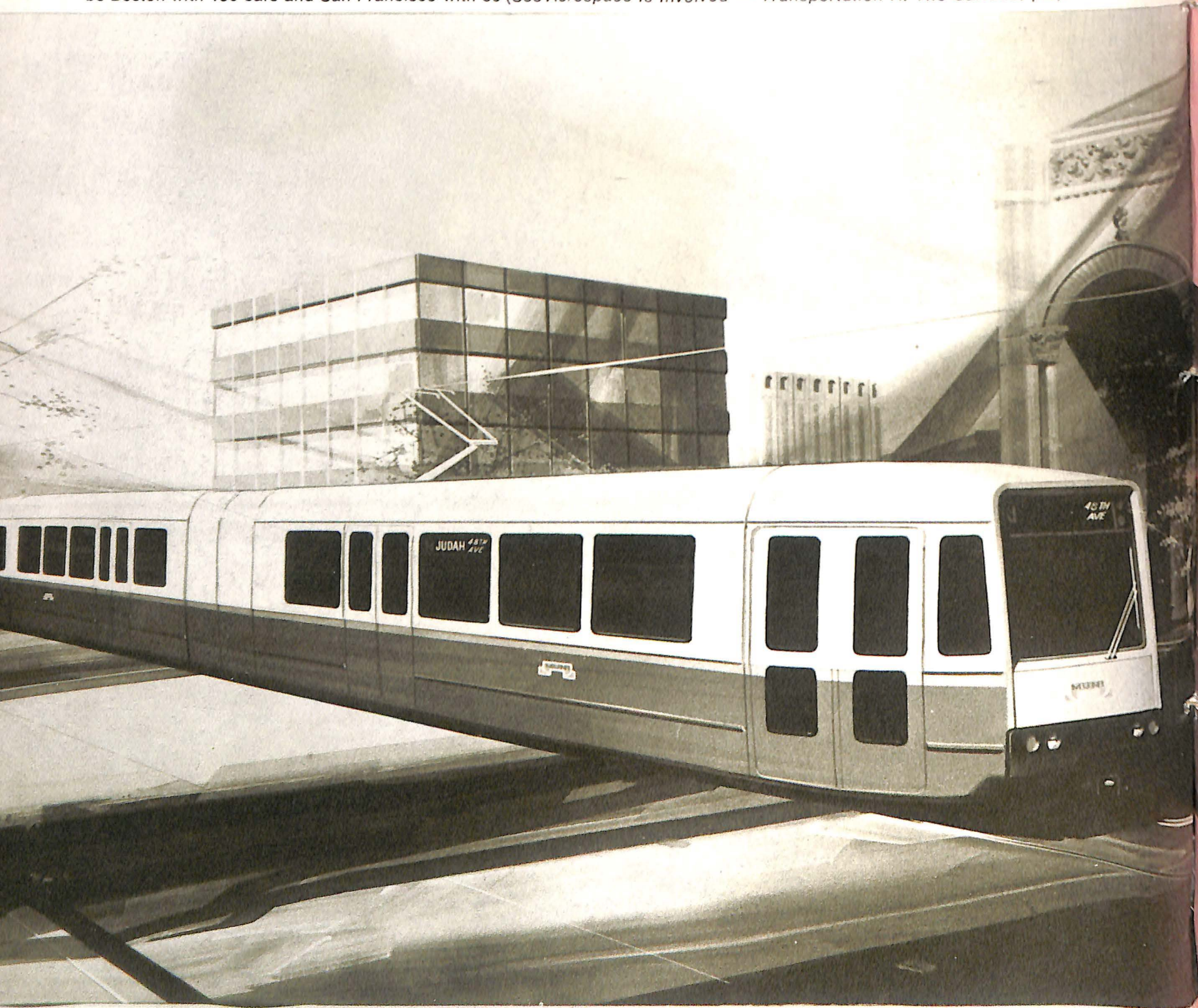


MANUFACTURING MEMBERS

Abex Corporation
Aerojet-General Corporation
Aeronca, Inc.
Aeronutronic Ford Corporation
Avco Corporation
The Bendix Corporation
The Boeing Company
CCI Corporation
The Marquardt Company
Chandler Evans, Inc.
Control Systems Division of
Colt Industries
E-Systems, Inc.
The Garrett Corporation
Gates Learjet Corporation
General Dynamics Corporation
General Electric Company
Aerospace Group
Aircraft Engine Group
General Motors Corporation
Detroit Diesel Allison Division
The B. F. Goodrich Company
Engineered Systems Co.
Goodyear Aerospace Corporation
Heath Tecna Corporation
Hercules Incorporated
Honeywell Inc.
Hughes Aircraft Company
IBM Corporation
Federal Systems Division
ITT Aerospace, Electronics, Components
& Energy Group
ITT Aerospace/Optical Division
ITT Avionics Division
ITT Defense Communications Division
Kaiser Aerospace & Electronics Corporation
Lear Siegler, Inc.
Lockheed Aircraft Corporation
LTV Aerospace Corporation
Martin Marietta Aerospace
McDonnell Douglas Corp.
Menasco Manufacturing Company
Northrop Corporation
Pneumo Corporation
Cleveland Pneumatic Co.
National Water Lift Co.
Raytheon Company
RCA Corporation
Rockwell International Corporation
Rohr Industries, Inc.
The Singer Company
Aerospace and Marine Systems
Sperry Rand Corporation
Sundstrand Corporation
Sundstrand Aviation Division
Teledyne CAE
Teledyne Ryan Aeronautical
Textron Inc.
Bell Aerospace Company
Bell Helicopter Company
Hydraulic Research & Manufacturing Co.
Thiokol Corporation
TRW Inc.
United Technologies Corporation
Westinghouse Public Systems Company

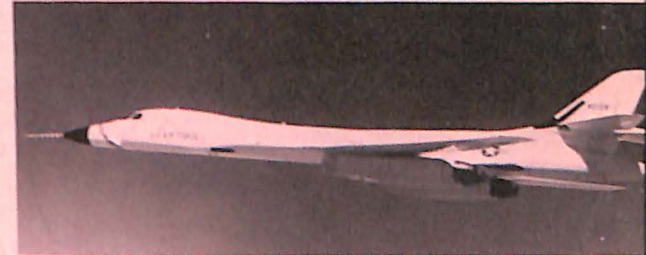
RETURN REQUESTED

The Boeing Vertol Company and The Garrett Corporation are building the first new streetcar-type vehicles in 20 years, with better propulsion and controls that will give a significantly smoother ride for passengers. First beneficiaries will be Boston with 150 cars and San Francisco with 80 (See *Aerospace Is Involved — Transportation At The Surface*, p.8).

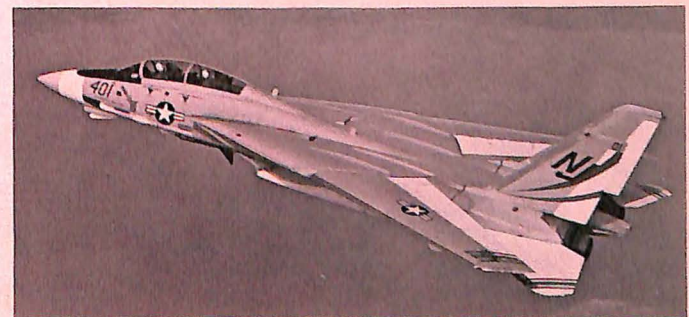
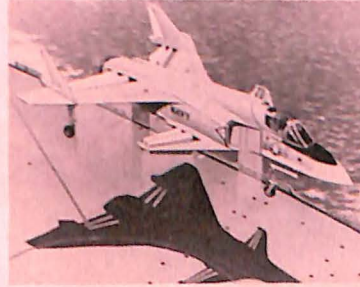
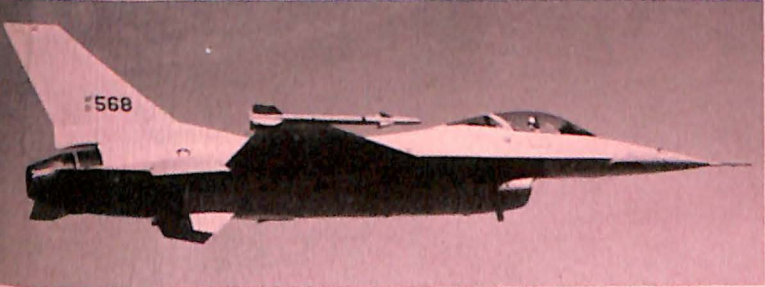


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Military Aircraft - THE NEW GENERATION

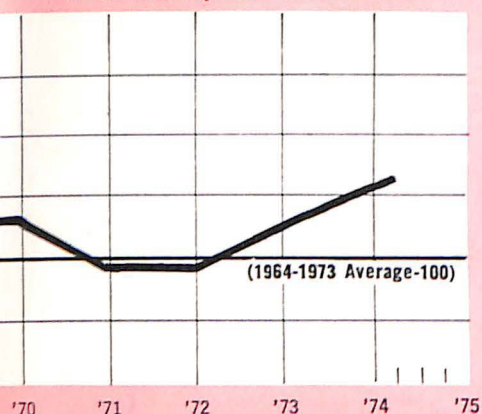


ROSPACE ECONOMIC INDICATORS

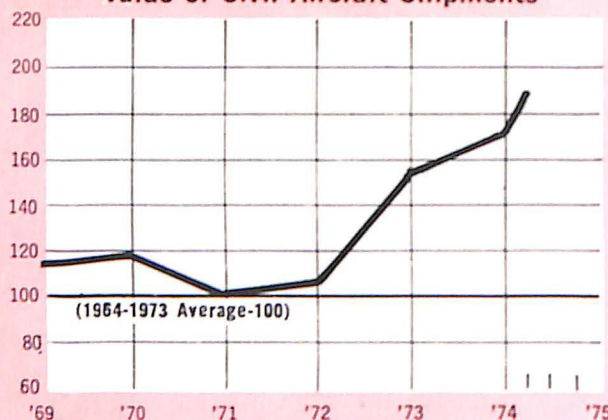
CURRENT

OUTLOOK

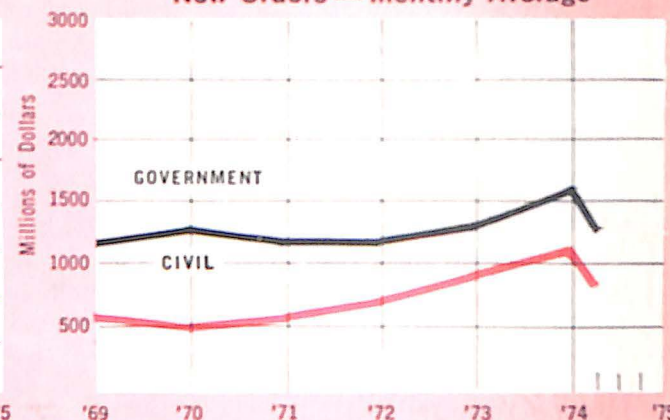
Total Aerospace Sales



Value of Civil Aircraft Shipments



New Orders — Monthly Average



— Aerospace obligations by Dept. of Defense and NASA.
— Non-government prime orders for aircraft and engines.

| ITEM | UNIT | PERIOD | AVERAGE 1964-1973 * | LATEST PERIOD SHOWN | SAME PERIOD YEAR AGO | PRECEDING PERIOD † | LATEST PERIOD |
|---|------------|-------------|---------------------------|---------------------------|----------------------------|-----------------------|------------------|
| AEROSPACE SALES: Total | Billion \$ | Annual Rate | 24.1 | 1st Quarter | 24.9 | 26.8 | 27.5 |
| | Billion \$ | Quarterly | 6.1 | 1975 | 6.2 | 7.1 | 6.9 |
| AEROSPACE SALES: Total (In Constant Dollars, 1958=100) | Billion \$ | Annual Rate | 15.8 | 1st Quarter | 15.2 | 15.1 | 15.1 |
| | Billion \$ | Quarterly | 4.0 | 1975 | 3.8 | 4.0 | 3.8 |
| DEPARTMENT OF DEFENSE | | | | | | | |
| Aerospace obligations: Total | Million \$ | Monthly | 1,194 | Mar 1975 | 1,049 | 1,272 | 1,045 |
| Aircraft | Million \$ | Monthly | 716 | Mar 1975 | 691 | 902 | 651 |
| Missiles & Space | Million \$ | Monthly | 478 | Mar 1975 | 358 | 370 | 394 |
| Aerospace outlays: Total | Million \$ | Monthly | 1,129 | Mar 1975 | 1,109 | 1,129 | 1,239 |
| Aircraft | Million \$ | Monthly | 669 | Mar 1975 | 615 | 664 | 745 |
| Missiles & Space | Million \$ | Monthly | 460 | Mar 1975 | 494 | 465 | 494 |
| Aerospace Military Prime Contract Awards: TOTAL | Million \$ | Monthly | 1,061 | Mar 1975 | 772 | 785 | 665 |
| Aircraft | Million \$ | Monthly | 667 | Mar 1975 | 517 | 509 | 421 |
| Missiles & Space | Million \$ | Monthly | 394 | Mar 1975 | 255 | 276 | 244 |
| NASA RESEARCH AND DEVELOPMENT | | | | | | | |
| Obligations | Million \$ | Monthly | 283 | Mar 1975 | 215 | 216 | 227 |
| Expenditures | Million \$ | Monthly | 287 | Mar 1975 | 253 | 286 | 315 |
| BACKLOG (55 Aerospace Mfrs.): Total | Billion \$ | Quarterly | 25.5 | 1st | 30.6 | 35.5 | 35.2 |
| U.S. Government | Billion \$ | Quarterly | 14.5 | Quarter | 17.3 | 20.9 | 21.0 |
| Nongovernment | Billion \$ | Quarterly | 11.0 | 1975 | 13.3 | 14.6 | 14.2 |
| EXPORTS | | | | | | | |
| Total (Including military) | Million \$ | Monthly | 249 | Mar 1975 | 757 | 782 | 772 |
| New Commercial Transports | Million \$ | Monthly | 77 | Mar 1975 | 294 | 379 | 397 |
| PROFITS | | | | | | | |
| Aerospace — Based on Sales | Percent | Quarterly | 2.7 | 1st | 3.4 | 2.2 | 2.6 |
| All Manufacturing — Based on Sales | Percent | Quarterly | 4.9 | Quarter | 5.6 | 4.8 | 3.7 |
| | | 1975 | | | | | |
| EMPLOYMENT: Total | Thousands | Monthly | 1,213 | Mar 1975 | 950 | 933 | 931 |
| Aircraft | Thousands | Monthly | 669 | Mar 1975 | 509 | 506 | 506 |
| Missiles & Space | Thousands | Monthly | 128 | Mar 1975 | 99 | 91 | 92 |
| AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS | Dollars | Monthly | 3.86 | Mar 1975 | 5.22 | 5.72 | 5.76 |

* 1964-1973 average is computed by dividing total year data by 12 or 4 to yield monthly or quarterly averages.

† Preceding period refers to month or quarter preceding latest period shown.

Rational Answers to National Problems

By KARL G. HARR, JR.
President, Aerospace Industries Association



Karl G. Harr, Jr.

Among current national problems, the likelihood of a continuing unacceptable high rate of unemployment is receiving increasing attention within government and in the national media.

In the period immediately ahead various options will be explored in the search for the best methods of solving this critical aspect of economic recovery. This search will be complicated by widely-divergent opinion as to the income and job-creating potential of the public sector as compared with the private sector.

That issue will not be debated here. The private sector — business and industry, aerospace included — asks only that solutions to economic dilemmas including unemployment, be arrived at rationally. If done in this fashion, the private sector believes that the resulting public policies will place upon it the prime responsibility for restoring old jobs and creating new ones.

Business and industry believe that rational considerations of economic facts will lead government to adopt economic policies which will enable the non-government work force to expand, to prosper, and, incidentally, to pay taxes to support the many government programs considered vital to our society.

Among the many areas where industry asks policymakers to look at the facts is exports. U.S. exports involve hundreds of thousands of jobs in the U.S. A NAM-Business Roundtable survey examined the effects of exports by 290 companies on U.S. employment. The data, released last month, shows that 458,000 jobs in these companies were directly attributable to their exports. And an equal number of supporting jobs in other industries were dependent on such exports. One more fact: this survey only covered 21 percent of the \$142 billion of U.S. exports of goods and services in 1974.

An important element of our export performance in the past three years has been the formation of DISCs, Domestic International Sales Corporations. The DISC program as discussed in this issue relates its contribution to our competitive efforts in foreign trade. Suffice it to say that the trade experts calculate that at least 450,000 additional jobs in the United States are attributable to these specialized corporations.



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By Senator Frank E. Moss, Chairman
Senate Committee on Aeronautical and Space Sciences

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The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;


Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

AEROSPACE is published by the Aerospace Industries Association of America, Inc., the national trade association of the designers, developers and manufacturers of aircraft, missiles, spacecraft, their propulsion, navigation and guidance systems and other aeronautical systems and their components.

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Military Aircraft - THE NEW GENERATION



Numerous inquiries received by this association strongly demonstrate a keen public interest in the "new generation" aircraft programs now in various stages of development, testing and production for the Army, Navy and Air Force. All of these programs contribute to the major U.S. goals of peace and international stability by helping to maintain the world-wide military equilibrium that is the *sine qua non* of peace.—Editor

The basic document that spells out our national defense requirements is the annual *Report of The Secretary of Defense to The Congress*. It covers in both broad-gauged rationale and fine detail where we are and where we are going in our national defense posture, our commitments to allies, and assessments of potential aggressors. This article, however, is limited to reporting on major new *military aircraft* systems.

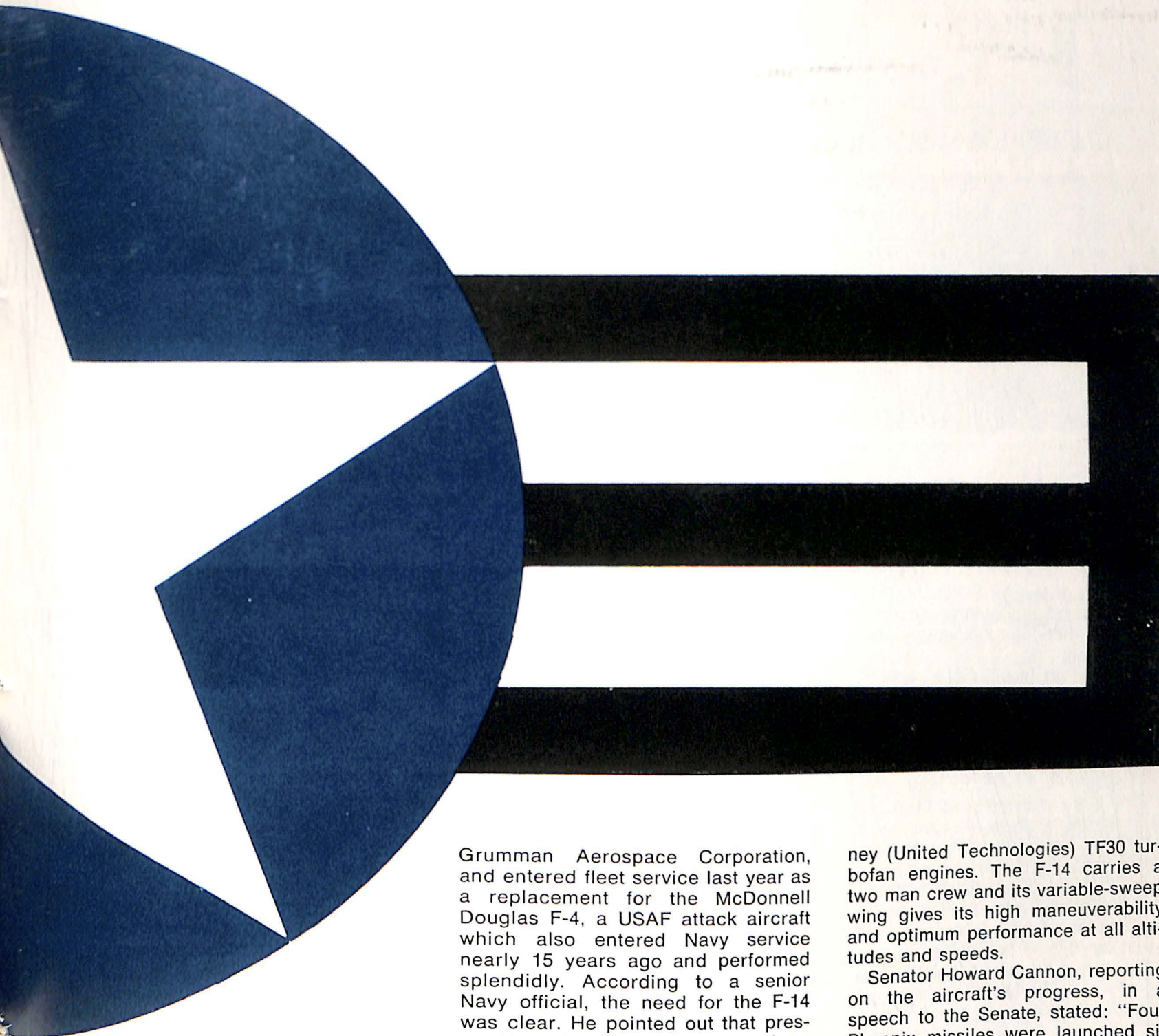
Secretary of Defense James R. Schlesinger lucidly and eloquently sets the stage for his report in the opening chapter:

"I am sensitive to the fact that national security is not a product that brings explicit and tangible benefits to us, although most of us are acutely aware when it is absent. As Sir John Slessor once noted: 'It is customary in democratic countries to deplore expenditure on armament as conflicting with the requirements of the social services. There is a tendency to forget that the most important social service that a government can do for its people is to keep them alive and free.'

"It is also common to allege that the Defense Budget contains some

inner momentum of its own, that is it has a Parkinsonian tendency to expand independently of external threats (although the perceived growth is in current and highly inflated dollars). Few of us give ear to some of our most trenchant critics in Congress who acknowledge that the Department of Defense is the best managed in government.

"Obviously, this Department can always improve the efficiency of its performance, but we will never reach zero defects. In any event, the United States can afford both increased social programs and an adequate pos-



ture of defense; the two objectives are not incompatible and we do not have to trade one for the other."

This "adequate posture of defense" includes these following aircraft programs which include five fighters, a new bomber, an attack aircraft, an airborne command post, an airborne warning and control system, a medium short takeoff and landing (STOL) transport and two new helicopter programs.

F-14. This is the Navy's supersonic, carrier-based aircraft, designed from inception as an air superiority fighter. It is built by the

Grumman Aerospace Corporation, and entered fleet service last year as a replacement for the McDonnell Douglas F-4, a USAF attack aircraft which also entered Navy service nearly 15 years ago and performed splendidly. According to a senior Navy official, the need for the F-14 was clear. He pointed out that present Navy fighters had become obsolete while the Soviets had introduced four new fighter aircraft whose performance exceeded our best model. "The problem," he said, "is clear and so is the solution. We must have a new fighter superior in air combat to present and postulated Soviet fighters, for close-in visual encounters and for stand-off all-weather conditions. In addition, the new fighter must be able to defeat the enemy air threats to naval forces, bombers and missiles." The result was the F-14, which carries a Phoenix missile built by Hughes and a Hughes AWG-9 fire control system. It is powered by two Pratt and Whit-

ney (United Technologies) TF30 turbofan engines. The F-14 carries a two man crew and its variable-sweep wing gives its high maneuverability and optimum performance at all altitudes and speeds.

Senator Howard Cannon, reporting on the aircraft's progress, in a speech to the Senate, stated: "Four Phoenix missiles were launched simultaneously and shot down four targets simulating enemy fighters. This had never been done before. The Phoenix intercepted a target at 80,000 feet and Mach 2.2.

"The F-14/Phoenix has looked down at three targets below 5,000 feet and shot them down, which has never been done before. On one of the shots the F-14 was at 20,500 feet and launched a missile at a target 20.2 miles away simulating an enemy cruise missile at less than 500 feet and scored a direct hit."

F-15. This new USAF air superiority fighter, built by McDonnell Douglas, was delivered to the Tactical Air



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1. U. S. Navy Grumman F-14
2. U. S. Air Force McDonnell Douglas F-15
3. U. S. Air Force General Dynamics F-16
4. U. S. Navy McDonnell Douglas / Northrop F-18
5. U. S. Navy Rockwell International XTV-12A
6. U. S. Air Force Rockwell International B-1
7. U. S. Air Force Boeing E-3
8. U. S. Air Force Boeing E-4

Command in November 1974. It is operational.

Secretary of the Air Force John L. McLucas, testifying before the Senate Armed Services Committee, recently stated:

"This aircraft (the F-15) is needed to give us all-weather superiority against all challengers. Effective tactical air warfare in support of ground forces depends on maintaining, at a minimum, local air superiority.

"The F-15 was designed from the beginning to optimize its counterair capability. Because of its inherent aerodynamic and avionic performance it also possesses an excellent air-to-surface strike potential. In its flight test program, which has been underway for nearly three years, the F-15 has met or exceeded all of our expectations. We are encouraged by its reduced cost of ownership compared to contemporary operational fighters. The aircraft is durable and requires only moderate maintenance. In fact, the radar in the F-15 that flew to the 1974 Farnborough Air Show went 72 flights before maintenance was required—a performance many times better than current fighters achieve."

The key factors in designing a maneuverable, combat-capable fighter are low wing-loading, high thrust-to-weight ratio and supporting weapons. These features were exploited to produce an aircraft with superb air-to-air combat capability.

The F-15 is powered by two Pratt & Whitney F11-PW-100 turbofan en-

gines producing about 25,000 pounds of thrust. The attack radar system to detect low flying targets, was developed by Hughes, and General Electric was selected to build the aircraft's cannon armament. It also carries Raytheon Sidewinder and Sparrow missiles.

F-16. This General Dynamics air combat fighter, following selection as a new U.S. Air Force fighter, also was purchased by Belgium, Denmark, the Netherlands and Norway to modernize their air forces.

Secretary McLucas, in announcing the selection of the F-16, provided this background on the requirement:

"... This airplane goes back to the lightweight fighter prototype program which we expected to run for about two years and to culminate in a flight test (program) of about a year, and which would demonstrate a number of advantages in advanced fighter concepts through a prototype program which we did not have the confidence at that time to go directly into production.

"We wanted to do the lightweight fighter program then to give us that confidence and to give us the option of later making a decision to put a lower-cost fighter in the inventory... We felt that it would be good to have in the high-low mix of aircraft something like the air combat fighter."

The USAF/General Dynamics air combat fighter is a "fighter pilot's fighter" in the classic sense. It makes extensive use of advanced technol-

ogy. Usually, the incorporation of advanced technology has tended to increase complexity and cost. The technologies applied to the F-16 have been selected and incorporated in a fashion that reduced the weight of the airplane by several thousand pounds, thereby reducing the basic cost.

The avionics and other subsystems incorporate built-in self test features to reduce the time and manpower required for isolation and replacement on the flight line. These and other features allow the F-16 to be supported with 64 percent fewer direct maintenance personnel than other fighters. The F-16 is powered by a single Pratt & Whitney F100 turbofan.

F-18. This aircraft, basically an adaptation of the F-17, is the Navy's air combat fighter. The aircraft is a McDonnell Douglas (prime) and Northrop project. The F-18 is a single-place, twin jet fighter. The primary missions are fighter escort and interdiction. Weaponry consists of the Raytheon Sparrow and Sidewinder missiles and a 20mm cannon mounted in the nose. It is capable of all-weather carrier operations. It is powered by two General Electric F404 turbofans, a modified version of the General Electric J101 used in the F-17.

Dr. Malcolm Currie, Director of Defense Research and Engineering, made this statement recently before the Senate Committee on Government Operations:



"There are two significant points to be made in the development of the F-16 and F-18. One is the importance of having options in future defense planning. One great benefit of the high-low mix approach is that having both types of aircraft in production simultaneously provides us with the opportunity to increase or decrease the production of either in proportion to changes in the emerging threat.

"Second, we have found that there is nothing so effective in holding costs down as the existence of ongoing competition between manufacturers. This has been recognized explicitly by the Commission on Government Procurement. Development of the F-16 and F-18 provides a stimulus to keep costs down on the F-14 and F-15, while the existence of the F-14 and F-15 assures that the costs of the F-16 and F-18 cannot increase very much.

"Moreover, both the F-16 and F-18 in some measure compete with one another . . . To be able to achieve this level of competition in our fighter aircraft is a situation we have not had for over 20 years—and it is now available with virtually no increase in the overall cost of ownership. This is an opportunity for the American business tradition to work by itself. I feel the pay-off will be substantial."

XFV-12A. Two of these aircraft are now under construction for the U. S. Navy by Rockwell International. The first of the aircraft is scheduled to make its first flight in mid-1976. The

XFV-12A Vertical/Short Takeoff and Landing (V/STOL) Technology Prototype program objective is to demonstrate the feasibility of a new V/STOL concept which integrates propulsion, lift, and control in a high performance aircraft. It is powered by a Pratt & Whitney F401-PW-400.

Dr. Malcolm Currie, Director of Defense Research & Engineering, in a recent statement, said that "continuation of research and advanced development effort in the V/STOL area is justified by the potential high payoff of combining technologies to achieve a combat-useful and affordable vehicle. I intend to continue a moderate effort in V/STOL research and development to create the technological opportunities for advanced development of a form of V/STOL combat aircraft."

B-1. The main mission of this USAF Rockwell International bomber aircraft is a replacement for the Boeing B-52, which has been in the inventory of the Strategic Air Command since 1953. The B-1 is to provide a deterrence into the 21st century. The aircraft is part of a strategy that requires a retaliatory force of sufficient strength and diversity to preclude an enemy attack. This strategy is known as TRIAD, and the B-1 is one leg of the stool. The other legs are submarine-launched nuclear missiles and land-based Intercontinental Ballistic Missiles (ICBM). Engines for the B-1 are General Electric's F101 turbofans, rated at 30,000 pounds of thrust. Prime nuclear weapon is the

Boeing Short Range Attack Missile (SRAM).

The B-1 program is guided by three main philosophies:

- Design to cost.
- Test before buy.
- Try before buy.

Design to cost means that if some aspect of the program appears to be driving costs up, studies are made to determine the reasons and alternate ways to solve the problem. One example of this was the reduction of titanium, an extremely efficient but expensive metal, in the B-1 airframe. It was determined that titanium content could be reduced to approximately 20 percent of the airframe weight without jeopardizing the B-1's mission of fatigue life.

Test before buy is probably best exemplified by the amount of wind tunnel testing done on the B-1 configuration before its first flight. More than 22,000 hours of wind tunnel time was completed before the B-1's first flight late last year.

Try before buy is a concept adopted by the Department of Defense in early 1970. Under this concept, the B-1 is developed and built under a research and development program and tested before any decision to go into full production is made.

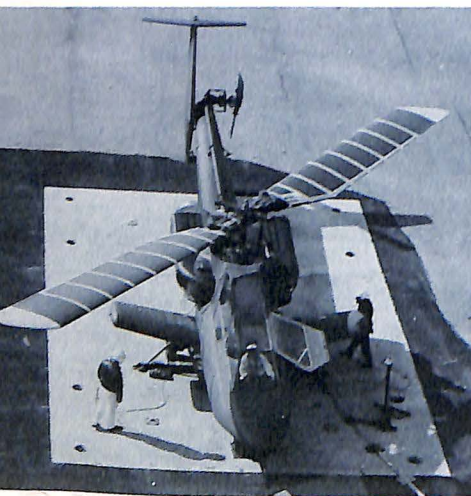
Secretary Schlesinger, in his comprehensive report to Congress, said: "We have again examined the entire bomber modernization problem and the results have been provided to the Congress. Of the six 'equal



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12.



14.



15.

- 9. U. S. Air Force/Boeing YC-14
- 10. U. S. Air Force/McDonnell Douglas YC-15
- 11. U. S. Army/Sikorsky YUH-60
- 12. U. S. Army/Boeing Vertol YUH-61
- 13. U. S. Army/Bell YAH-63
- 14. U. S. Army/Hughes YAH-64
- 15. U. S. Air Force/Fairchild Industries A-10

cost' alternative forces examined against the estimated threat in the late 1980s, those including the B-1 appear to be the most cost-effective. Because of its greater speed and greater ability to withstand the effects of nuclear detonations, it will have a distinctly shorter airfield escape time than the B-52; and because of its smaller radar cross-section and its ability to fly at very low altitudes at high subsonic speed, it should have a much better capability to penetrate improved Soviet air defenses.

"Moreover, because of its wider range of air speed options and larger number of internal weapon spaces, the B-1 will provide considerably greater employment flexibility than the B-52, thereby enhancing our ability to execute a wide range of options in response to potential enemy actions. In short, the B-1 provides us with a weapon system which is least sensitive to potential increases in the threat."

Airborne Warning and Control System (AWACS E-3A) and Advanced Airborne Command Post (AABNCP E-4).

AWACS is an Airborne Warning and Control System, designed to provide battle management in the conduct of air warfare. The distinguishing technical feature of AWACS is the radar technology by Westinghouse Electric permitting detection and tracking of targets at extremely long range, operating at all altitudes over land and water despite ground clutter—the radar energy reflected from the ground.

AWACS is installed in a production jet transport, the Boeing 707-320. The aircraft carries an externally mounted rotodome. Communications gear aboard the aircraft provide for reception, recording, display, transmissions, and relay of a wide variety of signals.

Secretary McLucas said: "We learned in Southeast Asia that with the fast, relatively long-range jet aircraft, a commander needs an improved ability to monitor and direct large scale air operations. In Central Europe the difficulties are much greater because there the environment would be one of high aircraft density and variety.

"The AWACS E-3A is able to provide this improved surveillance and control capability. With its exceptionally capable radar, the AWACS can detect hundreds of aircraft. . . . It also will be configured to detect and track ships at sea."

The Advanced Airborne Command Post utilizes the Boeing 747 (E-4), which provides a significant increase

in space and greater endurance at payloads up to 135,000 pounds. These gains permit accommodation of highly sophisticated data processing and communications, and a major increase in essential personnel to conduct those world-wide command and control functions vital to national security.

A top USAF official described the requirement this way. "With advances in command, control and communications equipment, we have been trying to get the most effective and survivable command post possible for the National Command Authorities (NCA) and the Strategic Air Command (SAC) Commander. The Advanced Airborne Command Post will provide the greatly increased capability required by the NCA to assess damage, monitor status of forces, evaluate enemy intentions, and allow selection of a controlled response."

A-10. This single-place aircraft powered by two General Electric TF34-100 turbofans each with 9,000 pounds of thrust, was specifically designed for the close air support mission. The A-10 is the first Air Force aircraft to be developed strictly to deliver aerial firepower in support of friendly ground forces. It is built by Fairchild Industries.

Secretary McLucas states: "Providing combat air support of ground troops has been a primary mission of tactical air forces since World War I. In Europe, one of the most challenging tasks for air support is to help counter the Warsaw Pact's numerical advantage in armor. In the A-10, we have an aircraft that has been designed specifically for the destruction of enemy ground power, including armor.

"... The A-10 has demonstrated that it has all the necessary attributes of an excellent combat air support system, including extended loiter time, a lethal weapons load, survivability, responsiveness to ground commanders' needs. The A-10 can operate from forward, austere bases, and can do so with a large, versatile, ordnance load. (This includes the General Electric 30mm GAU-8 gun that can penetrate even heavy armor).

"Because it is highly maneuverable, it is effective even under low clouds in poor visibility, conditions that are often encountered in Central Europe."

Advanced Medium STOL Transport (AMST). Two companies are building prototypes of the Air Force AMST. They are the Boeing YC-14, powered by two General Electric CF6-50 tur-

bofans, each developing 50,000 pounds of thrust, and the McDonnell Douglas YC-15, powered by four Pratt & Whitney JT8D-17 turbofans, each developing 16,000 pounds of thrust.

The Boeing design will employ a concept called Upper Surface Blowing (USB), using the thrust from the aircraft's engines to blow air over the wings and flaps, creating powered lift. The McDonnell Douglas prototype is designed with externally blown flaps and other high-lift technology devices. The externally blown flap system is an arrangement which lowers wing flaps directly into the engine exhaust, increasing the aerodynamic lift on the entire wing.

Secretary McLucas said: "Our present tactical transport, the C-130, cannot meet all current or future tactical aircraft requirements. Further, by the mid-1980s, most of the C-130 force will be between 20 and 30 years old, and will require either expensive modification or replacement. The AMST is designed to accommodate the Army's new larger equipment, carry about two and a half times the C-130's payload, operate from shorter runways, and be air refueled to help meet strategic airlift surge requirements."

Utility Tactical Transport Aircraft System (UTTAS). Two companies are testing prototypes for the Army's UTTAS helicopter. Sikorsky Aircraft is flying the YUH-60 prototypes, and Boeing Vertol is flying the YUH-61A. Both models are powered by two General Electric T700 turbine engines of more than 1,500 shaft horsepower each. The UTTAS is basically a replacement for the Bell Helicopter UH-1 (Huey) series, one of the most successful systems ever fielded by the Army.

Norman R. Augustine, Assistant Secretary of the Army (Research and Development), and Lt. General Howard H. Cooksey, Acting Deputy Chief of Staff for Research, Development and Acquisition, recently explained to the Senate Appropriations Committee the background to the UTTAS prototype program:

"Continuous improvements and refinements, many based on combat experiences, will insure its (Huey) usefulness to our Army and those of our allies well into the 1990s. The aircraft, because of the 1950 technology it represents, possesses some innate shortcomings which cannot be rectified by product improvement. Hot weather and high altitudes, such as were frequently encountered in Southeast Asia, severely limit its passenger-carrying capacity, often to one or two combat-laden soldiers.

"UTTAS will be capable of carrying a combat loaded 11-man squad in virtually any climatic conditions or altitudes in which the Army is likely to operate. It can maneuver agilely at nap-of-the-earth altitudes and is virtually invulnerable to 7.6mm fire. Its main and tail rotors are designed to withstand impact with branches and small obstructions, and the airframe is engineered to progressively deform under crash impact forces, enhancing the chances of survival for the crew, passengers and the aircraft itself.

Advanced Attack Helicopter (AAH).

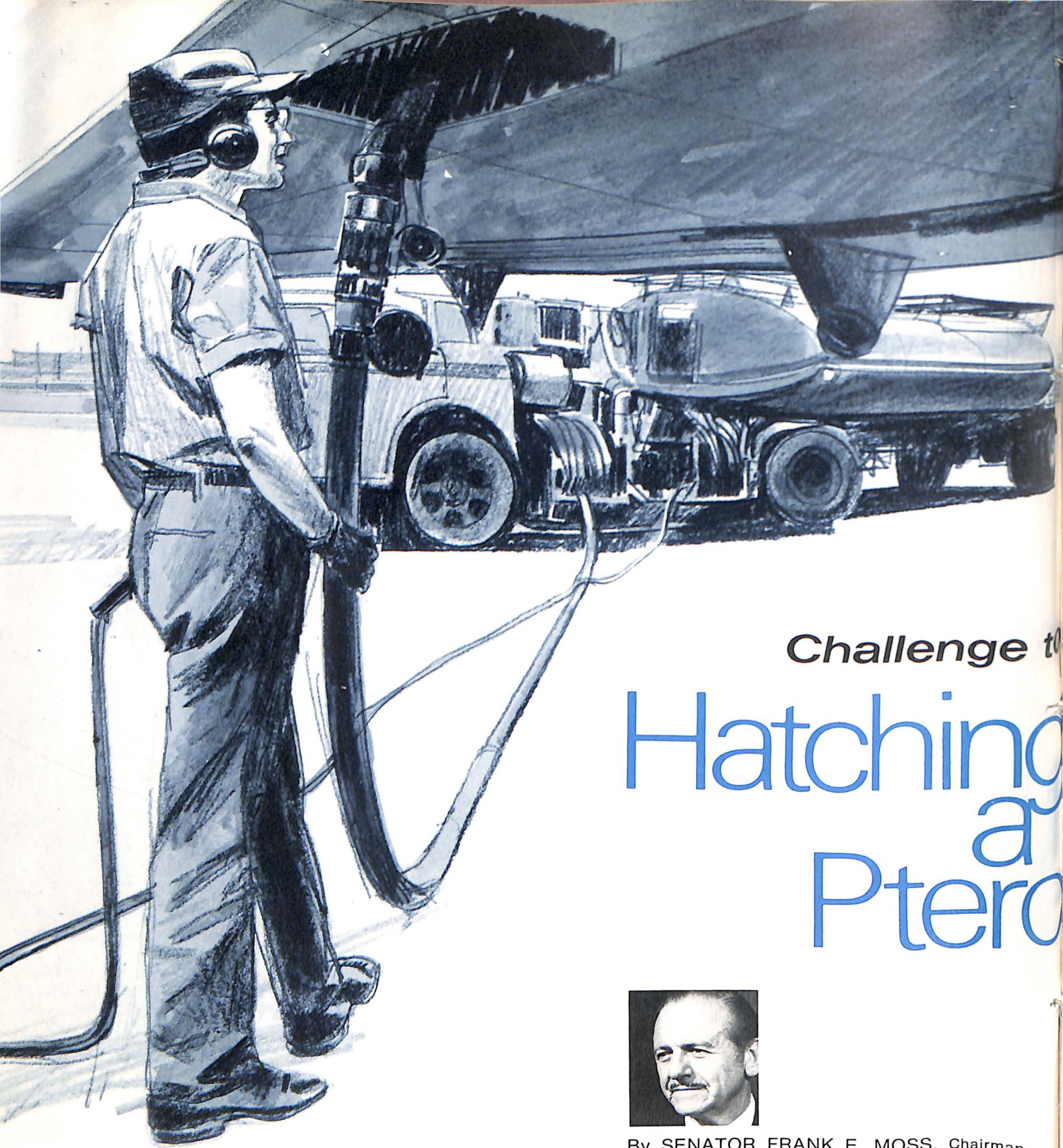
There are two companies engaged in prototype work for the Army's AAH program. The Bell Helicopter entry in the competition is the YAH-63, and Hughes Helicopters is building the YAH-64. Both are powered by two General Electric T700 engines, common with those of the Army's UTTAS candidates.

A senior Army official, testifying on the program, said: "One of the few quantitative advantages which the Army possesses over the Soviets is in the area of attack helicopters. The AAH program proposes to exploit our superiority in this area with the introduction of a fast, highly maneuverable, highly survivable aerial weapon system as a deterrent to the Soviet and Warsaw Pact armor threat.

"Armed with the combat proven TOW missile system (built by Hughes), this aircraft will be able to take advantage of natural cover and terrain features, in total darkness, to deliver extremely accurate missile and cannon fire against tanks and other targets. The night and adverse weather capability it will possess is especially critical in light of the Warsaw Pact's propensity for night operations and the unfavorable weather conditions likely to be encountered in European warfare.

"The aircraft's armor, redundancy of critical systems, and other design features, in addition to its innate elusiveness, will provide it with a strong chance of survival in the event of hits from a variety of anti-aircraft, armor piercing and incendiary projectiles."

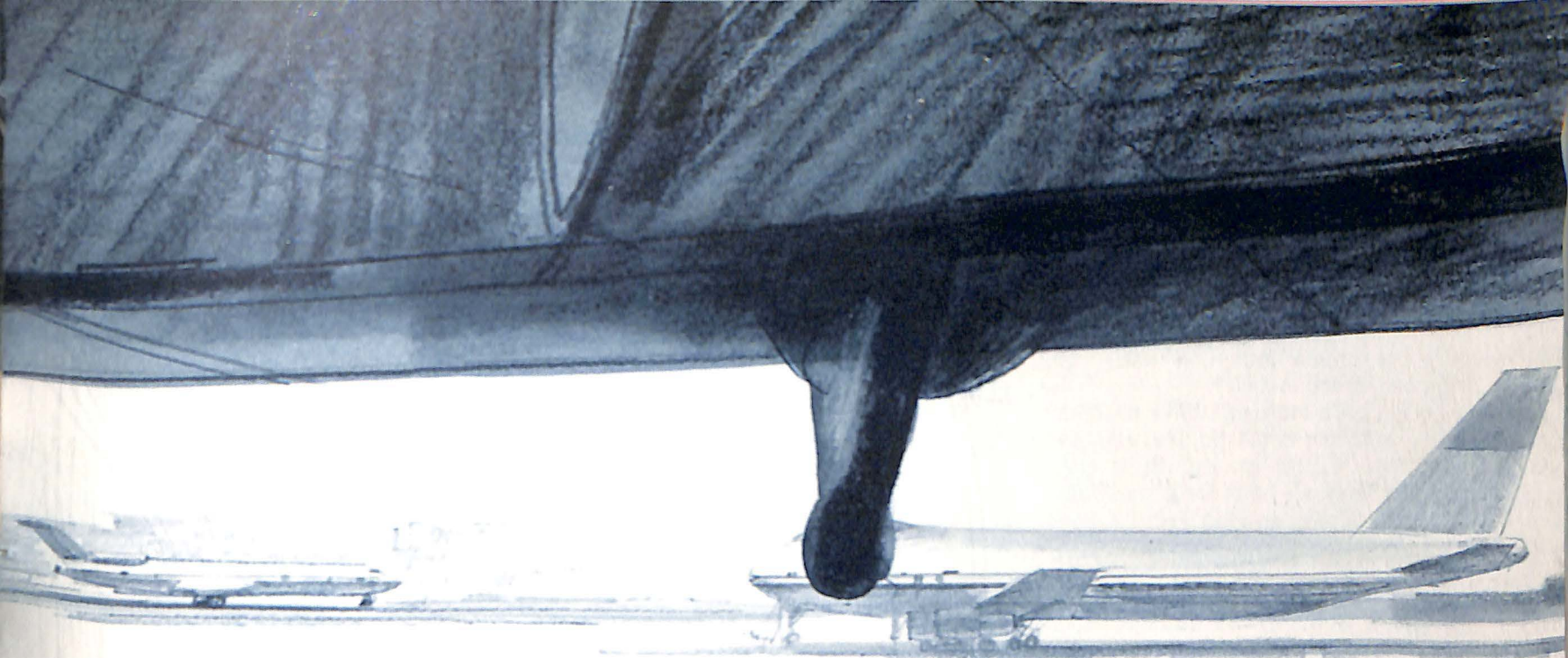
This is an impressive line-up of high-performance and special-performance aircraft, demonstrating the aerospace industry's response to national security requirements. A vital incentive to technological superiority, the key card, is the highly competitive nature of the aerospace industry. In all cases, the aircraft selected, or to be selected, for production went through the toughest crucible of all: competition.



Challenge to
**Hatching
a
Pterod**



By SENATOR FRANK E. MOSS, Chairman
Senate Committee on Aeronautical and Space Sciences



Senator Moss is one of the most knowledgeable proponents of U.S. leadership in aviation and space—aerospace. In this article he looks at the exciting future of commercial air transport and general aviation, if current improvement efforts and long-range research continue.—Editor

Aviation—

Leaner Saur

Scientists recently discovered, in Texas naturally, the fossilized remains of the world's largest flying creature—a reptile called the pterosaur. Its wingspan was over 50 feet, greater than most fighter planes. The problem was, this jumbo buzzard dined on dead dinosaurs, which gradually became a rather scarce aviation fuel, even in prehistoric Texas. Soon thereafter, the pterosaur declined.

I'm concerned that history may repeat itself. Texas and the world around fear that the day is coming when oil may go the way of the dinosaur—an ironic historical twist. How can we continue feeding our twentieth century pterosaurs? Perhaps the answer is to hatch a new generation of them, a leaner, more fuel efficient version.

Encouraging Future

Four months ago I wrote Dr. Fletcher, the Administrator of NASA, (National Aeronautics and Space Administration) asking him if NASA could establish, in collaboration with industry, a technology demonstration goal to make possible a much more fuel-efficient generation of commercial aircraft. NASA's response has been most encouraging. In recent testimony before the Senate Committee on Aeronautical and Space Sciences, NASA officials expressed their preliminary assessment: if a fuel efficiency program is pursued suc-

cessfully, commercial aircraft produced in the late 1980's could be designed to use 50 percent less fuel than the present fleet.

Some observers have said that the most dramatic reductions in aviation fuel consumption are achievable without modifying the basic aircraft design at all. They point to our very inefficient use of commercial aircraft.

It is true that if passenger load factors were to reach only 70 percent, fuel savings would be 25 percent better than pre-oil-crisis days. And the installation of high density seating in our transports could further boost the overall efficiency.

Improvement Means Competition

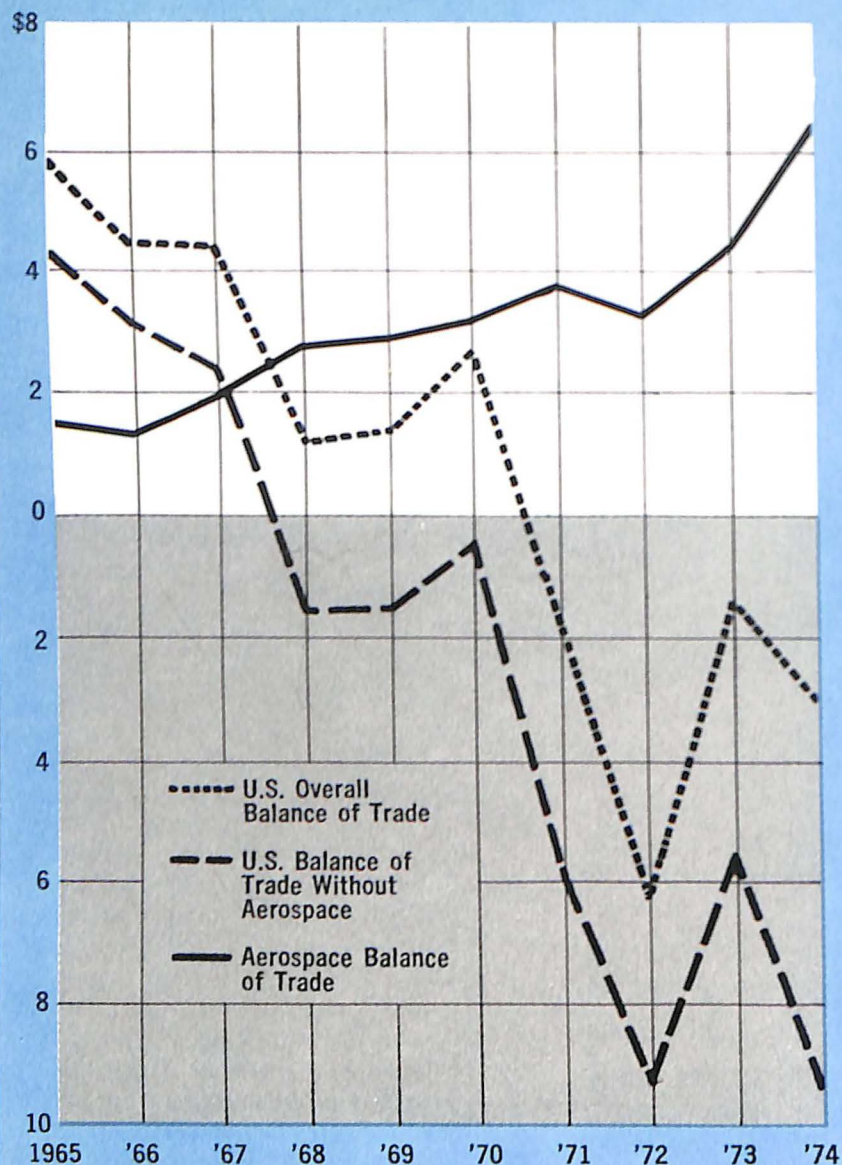
Current CAB regulation prohibits air fare competition between the airlines, but competition still exists in the form of route scheduling wars and accommodations contests—wider seats, newer movies, shorter skirts.

Under this regulation we get quick reliable service from the airlines but we pay for it through lower load factors and higher fares. Recent events in Washington, such as National Airlines' proposal for a variety of fares for a given trip, suggest that load factors may rise dramatically in the next decade because of regulatory changes.

However, two considerations undercut, I think, the value of this approach:

AEROSPACE AND THE U.S. BALANCE OF TRADE 1965-1974

(In Billions of Dollars)



During the last 10 years the United States has gone from a plus balance of foreign trade of \$7.6 billion in 1964 to a \$3.0 deficit in 1974. In fact, in only one of the last five years have we achieved a positive foreign trade balance, which is so essential to our economic well being. Notably, without the significant contributions of the high-technology aerospace industry (some 80% of the aircraft flying for free-world airlines are U.S.-made) our country would have had a negative balance of trade for seven of the last 10 years. This emphasizes the need for government and industry to put the strongest possible support behind the effort to continue as the world's leader in the fields of advanced research and high technology.

- The prospect of regulatory change is uncertain and speculative; and mainly,

- It doesn't lead to better aircraft.

If we put our effort into developing more fuel efficient aircraft, we accomplish several goals:

- We save fuel;
- We cut the operations costs of the airlines;
- We create jobs and stimulate the aerospace industry;
- We get a more attractive product for export and domestic use, and, by the way, export of aircraft is the backbone of our hope for a favorable balance of payments.

One other point to note—you may have asked yourself what is NASA doing getting into energy conservation?

Isn't that ERDA's (Energy Research and Development Administration) responsibility?

NASA/Industry Role

The answer is that NASA and industry have always been involved in the search for fuel efficiency. Every decrease in aircraft weight, decrease in drag or improvement in engine efficiency is a step in the right direction. The airplane is such an interdependent system that no agency *but* NASA is equipped to tinker with it.

So what kind of improvements does NASA foresee when they set this remarkable goal of a 50 percent improvement?

First, NASA engineers tell me that the use of the supercritical wing alone will result in a 10-15 percent overall economy improvement. The interesting thing about the supercritical wing is that the rising cost of fuel has changed its attraction altogether.

Originally it was seen as a means of achieving supercritical cruise speeds—that is, cruise speeds closer to the sound barrier.

But now rising fuel costs make higher speeds less appealing. Yet, an ancillary benefit of the supercritical wing is that the wing is fatter than conventional ones by about 50 percent. Because it's *fatter*, it can be made *lighter*. Unfortunately, this same concept does not apply to people.

But being lighter the wing can be lengthened to increase the wingspan. And as every aeronautical engineer knows, for reasons not altogether clear to most Senators, a bigger wingspan improves the aircraft efficiency and fuel economy.

The Value of Research

To me the supercritical wing is a

perfect example of the productivity of research. Research showed us how to change the wing shape into a simpler, lighter, and cheaper configuration that yields 10-15 percent more fuel economy. It's the closest thing I know of to getting something for nothing but some R&D dollars.

The second innovation that NASA will apply to the fuel stretching generation of aircraft is the winglet. I'm told that this is just a small vertical plate added to the wing tip. Apparently, engineers have sought the right shape and size of the winglet for many years, believing that drag could be reduced. None ever worked. But at last, researchers have discovered just the right combination. Tests of current versions show a 5 percent increase in aircraft fuel economy for very little additional weight to the aircraft and we think the winglet can be retrofitted to current aircraft. So

they too will save money. It makes you wonder if aeronautics isn't more magic than science. After all, the alchemist of the Middle Ages and the aeronautical engineer seek the same end—to convert commonplace metal into gold. In the case of the winglet, we'll use aluminum to make black gold.

Composite Material Advantages

The third candidate for the next generation of aircraft are advanced composite materials which are twice as strong yet lighter than conventional materials. As you know, these consist of fibers of graphite, boron or nylon embedded in plastic-like material.

This technological breakthrough gives a double barreled energy benefit. First, the weight savings will lead to an estimated 10-15 percent overall fuel savings. And second, manufac-

turing a pound of composite material requires only 15 percent of the energy required to manufacture a pound of aluminum and less than 2½ percent of the energy needed to produce a pound of titanium. So with composite materials we save energy as we make them and as we use them.

NASA says that the obstacle right now is the lack of flight experience with this material and its cost. But the cost is dropping fast as more composites are produced. To gain flight experience with composites, many transports in service today are fitted with selected parts made of composites in order to evaluate them. From what I've seen, the move from metal to composites in aircraft will be as significant as was the jump from fabric to metal.

Another advancement will come in propulsion systems in the next generation of aircraft. I would have expected that we have already pushed jet engines to their limits considering that today's transports get three times the fuel economy of the 1958 jets. After all, current automobiles get worse mileage than those of 1958. Yet another 5-10 percent improvement is expected to come from reduced clearances, better seals and other black magic.

And NASA claims that we have on the horizon more advanced engines with the "preheated combustor inlet air concept" which may lower fuel consumption by another 10-20 percent over current turbofans.

"Fly By Wire"

One last innovation that may find its way into our next fuel-sipping generation of aircraft is what NASA calls "active controls" or "fly by wire" systems.

I must confess that "fly by wire" left me cold for a while. Even if it is quadruply redundant, I'd feel a lot safer with good old-fashioned link rods and hinges between the pilot's hands and the rudder and elevator. However, an engineer pointed out to me that the control surfaces on the 747—which I think is a pretty safe airplane—are moved hydraulically because a man doesn't have the strength to move them with muscle. I've decided that perhaps "fly by wire" is no worse than "fly by hose."

One thing for sure, fly by wire is here to stay.

An Air Force General recently told me that the F-16 and probably every Air Force fighter from now on will be fly by wire. But, he said, the biggest payoffs from this system are in store for transports, not fighters.

Fly by wire lets you build smaller and lighter airplane tails and even to relax the requirements on where the center of gravity is—so more cargo can be carried. The plane flies more smoothly, too. So there's less weight, less drag and more payload. NASA claims that the direct benefits alone of fly by wire and active control systems will give 5 percent better fuel economy.

Laminar Air Flow

Now if we rub our NASA crystal ball a little harder we can see even further into the future of aviation—beyond the 1980's. Sometime ahead engineers may discover a long-sought "cure" for the aeronautical equivalent of the common cold—that is, turbulent airflow, which saps the fuel efficiency of aircraft. If the airflow over the wings, fuselage and tail can be kept smooth (the engineers call it "laminar"), then fuel economy will jump by 20-40 percent. That's a bigger gain than that promised by any other single innovation.

In the 1960's such laminar airflow was achieved on an experimental aircraft by sucking air through thousands of holes on the wing. It worked for a while, but I'm told the holes eventually clogged up with dust.

There are many other schemes to achieve this laminar airflow, but so far none work. Considering the imagination of these NASA engineers, I fully expect that one day we'll get this whopping improvement in fuel economy through laminar flow control.

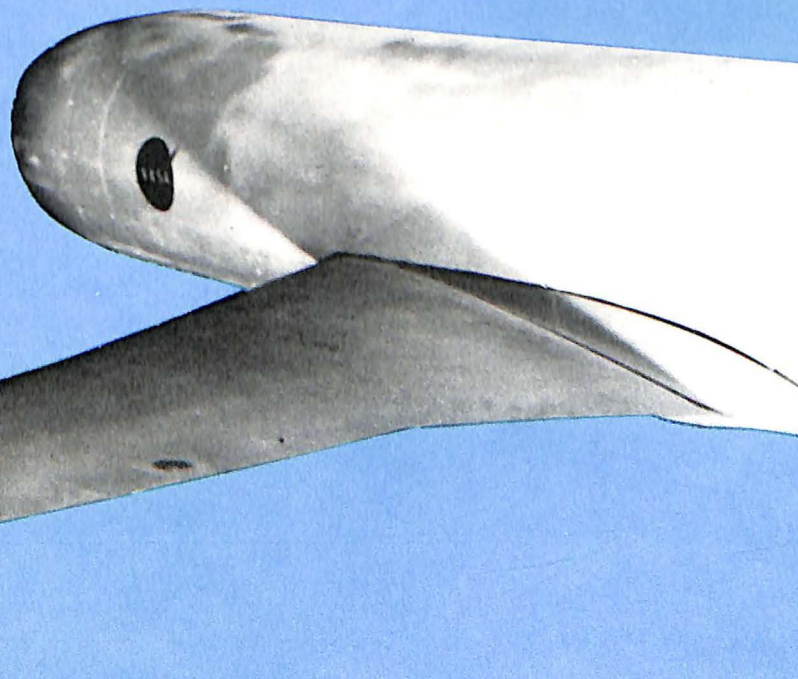
And Flying Wings

Another vision of the future includes gigantic flying wings carrying payloads up to six times that of the 747. The idea is to store the cargo inside the wing so that the load is distributed evenly instead of being concentrated in a fuselage. This way the

Tests of the "winglet", a small vertical plate added to the wing tip, show that it helps to reduce drag, producing fuel economy.

WING VORTEX DIFFUSER

PROVIDES UP TO
5% IMPROVEMENT
IN AERODYNAMIC
EFFICIENCY



wing can be made lighter. Of course the wing would have to be about 10 feet thick, but then that's not so tough—even Howard Hughes' plywood Spruce Goose had an 11 foot thick wing.

Hydrogen May Be The Fuel

Finally, decades from now we probably will have other fuels for aircraft besides petroleum. Of particular interest is hydrogen, because pound for pound it (liquid hydrogen) has three times the energy of petroleum. Assuming storage problems can be worked out, hydrogen looks like an excellent aviation fuel.

Getting that much hydrogen may look difficult now but, who knows, by then we may have a total hydrogen economy. I do believe that hydrogen will play an increasingly important role in our economy. First, to power the space shuttle; later, as an energy storage medium that powers fuel cells as energy is required. Eventually, deuterium, a form of hydrogen, will be the fuel for fusion plants. Hydrogen itself might be transported as

natural gas is today and used as a substitute for petroleum in airplanes and ground transportation.

But enough of worrying about our descendants' problems. Besides these far off visions of aviation, I've given you a glimpse of what NASA thinks we can actually put into the commercial aircraft built in 1985 to conserve fuel—perhaps 50 percent less fuel. Of course, this is just a goal; I don't know if we'll reach it or not but two things are certain—first, the generation of commercial aircraft built in 1985 or so will be significantly more fuel efficient than what we have today, and second, if we don't give NASA the money it needs for aircraft fuel efficiency research now, we'll be giving it to the Arabs as petrodollars later on.

NASA can stimulate new jobs for Americans, encourage design of better aircraft for U.S. export and cause a significant reduction in our dependence on oil imports from the Arabs. I'd say that's a bargain I'd say I would pay NASA even more than they can save us in oil imports

just to keep those dollars in our pockets and out of a sheik's money-belt.

Safety Always Comes First

But there is one condition on my support of this aircraft fuel efficiency effort. I'm wholeheartedly behind it, except that I would never want to see it become the bargaining chip for lowering safety standards or for serious degradation in our aircraft environmental goals.

In the past, in the commercial aircraft industry, safety has never taken a back seat to aircraft performance. I see no reason to mar that record now. I consider the environmental standards to be in the same category as safety. This may look like we're putting the aircraft manufacturers in the middle of a tug of war, but in reality everyone is pulling them in the same direction—toward a more desirable and saleable aircraft.

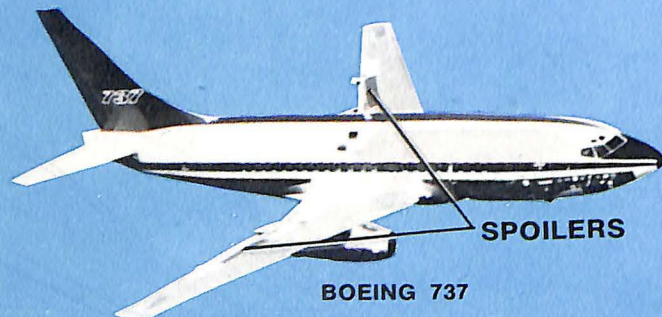
Finally, I want to mention a segment of aviation that has long been overlooked. General aviation aircraft flew 80 million passengers last year

Secondary structural components made of composite materials are in operational use today on the aircraft shown. Later composites will comprise primary structures yielding even greater benefits.

COMPOSITE STRUCTURES FOR TRANSPORTS



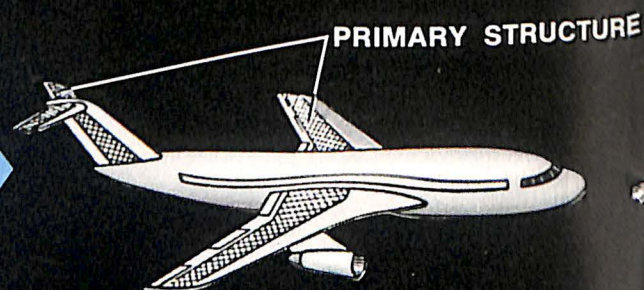
LOCKHEED L-1011



BOEING 737



MCDONNELL DOUGLAS DC-10

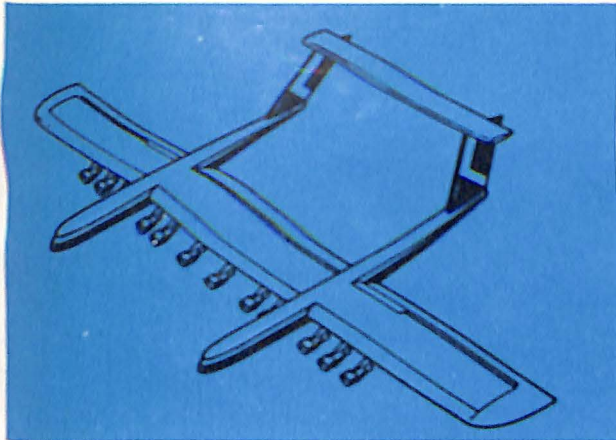


MAJOR BENEFITS

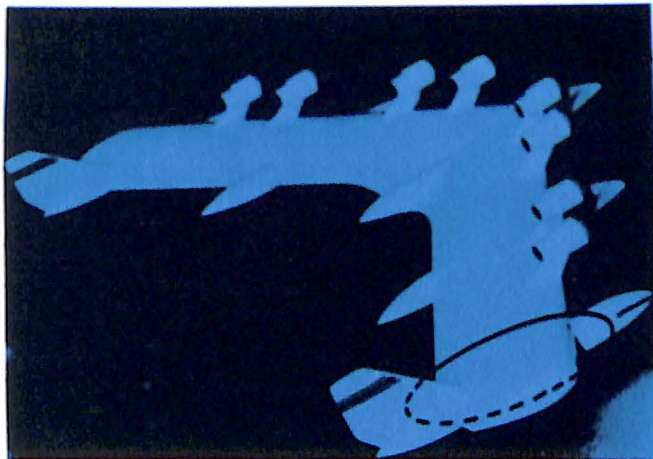
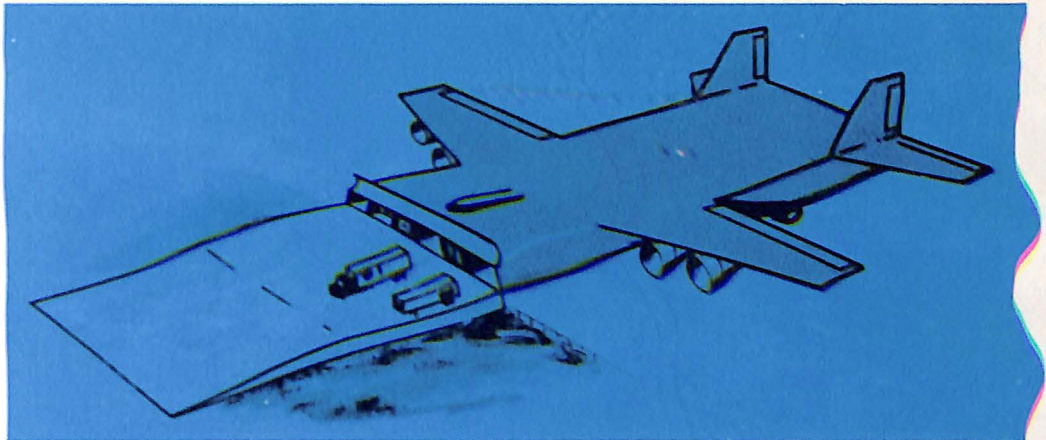
- Reduced Weight
- Cheaper Manufacturing Techniques
- Reduced Maintenance
- Longer Fatigue Life

CARGO AIRCRAFT CONCEPTS

SPAN LOADERS



FUSELAGE LOADERS



- INCREASED PAYLOAD
- EASED CARGO HANDLING
- FUEL CONSERVATIVE

—it is a fundamental transportation mode in many parts of our country. And one-third of the light planes produced in the U.S. are exported, so general aviation aircraft are also an important part of our technological exports.

Because of its wide-spread use and export, I believe the light plane should be included in the fuel efficiency program.

I was much disturbed last month by a NASA official's statement that the basic technology present in the light plane has not changed since the late 1940's. In other words, we're just beginning on the learning curve in general aviation.

The general aviation manufacturers are of course much smaller in size than the air transport manufacturers and so their research budgets are far smaller as well. For this reason, I believe NASA can be of even greater assistance to general aviation in improving fuel economy as well as with other problems. Already, Piper Aircraft Company, working with NASA in a NASA-funded project, has put the supercritical wing on one of its light planes for tests. Engineers estimate that they will get a 10 percent saving in fuel and in addition

a smoother ride and safer climb capability.

Hydrogen In Your Fuel?

Another big problem for general aviation is meeting the tough 1979 EPA emissions standards for aircraft piston engines. You may have heard that NASA has been experimenting with the injection at the carburetor of very small amounts of hydrogen with the gasoline in automobile engines. The hydrogen is obtained by bleeding a little gasoline off and catalytically cracking it in a small device attached to the engine. Not only are the emissions reduced, but fuel economy is improved as well—mainly because the engine can be run much leaner than normal. This system looked so good on automobiles that NASA has begun experimentation with light aircraft engines. Researchers found that not only are the aircraft engine emissions drastically reduced, but because of the leaner fuel mixture, fuel economy may be 20 percent greater at cruise power settings. So it appears that environmental pollution controls and fuel economy don't have to be mutually exclusive on light planes at least.

Now I want to point out here that these two examples of NASA contributions to general aviation—the supercritical wing and hydrogen injection—were adapted from NASA efforts in other areas. Let's face it, it's hand-me-down technology. That's great if it works, but I'd like to see NASA treat general aviation, not as an afterthought, but rather as commercial aviation's twin. I'm not suggesting that the research funding for each should be equal but I do think that it's time general aviation received some primary attention.

In closing, I just want to lay to rest some fears that I may have caused. You see the chief argument surrounding the pterosaur today is whether it flapped its wings or merely glided—in other words whether it had a propulsion system. When NASA and industry hatch the next generation, a more fuel efficient generation of pterosaurs, I can assure you that they will have propulsion systems, whether or not the prehistoric version did. Up to now increases in propulsion efficiency have been far and away the chief reason for improvements in aircraft efficiency; I hope that (we) will continue to lead the effort to hatch a leaner pterosaur.

There is a lesson to be learned from the experience

HIGHER EXPORTS =



DISC....

MORE JOBS

Some trade matters make the news. The export of grain, for example, is currently in the headlines. But many aspects of trade not only attract minimal notice but also appear esoteric to the uninitiated. Such is the case with DISC, an acronym meaning Domestic International Sales Corporation. Because of its relevance to the growth of U. S. trade, we herewith present a digest of views recently gleaned from Congressional hearings and discussions with analysts of DISC's role in the competitive arena.—*Editor*

For most of 1974 and the first half of 1975 the economic news was depressing. Real productivity declined for the first time in years. Unemployment reached record highs. Capital investment lagged. Real profits were down.

Most of the leading indicators of national economic vitality were bad, but there was one extraordinary exception. From 1972 to the present, the volume of U.S. exports grew at an unprecedented rate. While there has been much press coverage which leads one to believe the growth has been primarily in agricultural products, the fact is that the greatest increases in foreign sales have been in high-technology products—products which have maximum multiplier effects on Gross National Product (GNP), primary and secondary employment, real wages, and in terms of federal tax revenues.

The fact that this superior export performance occurred in a period of general economic decline makes it important that we examine the reasons for it, to determine to what extent, if any, this growth can be attributed to conscious public policy. The lessons might be applied to other aspects of our economic life.

In the years following World War II, U.S. surpluses of exports over imports afforded the United States considerable latitude in carrying out its foreign policy. They made possible a continuing program of economic assistance to developing nations and of military aid to our allies. They made possible the establishment of vital defense installations and the stationing of American forces overseas to fulfill mutual defense alliances.

Because of these heavy, non-trade commitments against dollar reserves, there was a lingering concern over the years about maintaining our total balance of payments. The trade balance itself, however, was a dependable source of foreign exchange. As the President's Commission on Inter-

national Trade and Investment reported in the summer of 1971, the private-sector economy of the United States "has been carrying a burden of government payments abroad quite disproportionate to that of any other country in the world."

But by the early 1970's it had become clear that the superior trade position so vital to maintaining America's economic strength at home and foreign policy strength around the world was evaporating.

In late 1971, the state of U.S. export trade came under critical review in the Congress — as part of its consideration of the President's economic recommendations of August 15, 1971. The findings were unsettling. While the total dollar volume of exports was rising somewhat, largely because of inflationary costs, the U.S. share of total world export trade in manufactured goods was in steep decline. Only 10 years earlier, in 1960, we were furnishing over 25 percent of all the manufactured goods exported by the 15 major industrialized nations of the world. But by August of 1971 that share had dwindled to less than 19 percent, and the rate of decline was accelerating.

American businessmen found it advantageous, and often essential, to their ability to compete in world markets, to locate new manufacturing facilities in foreign countries or to enter into joint ventures with foreign firms.

It was abundantly clear that, among the reasons for the deteriorating U.S. trade position, were the various systems of border taxes and export rebates that had evolved among our trading partners during those years when the United States held a substantial trade advantage. These were taxes on the value added during the manufacture of a product (for example, wire into nails) which were given back to the manufacturer if the product were exported. It could be said that we were not in a position to protest at the time these systems were adopted. But the pendulum had swung too far. The subsidies and tax advantages afforded foreign manufacturers and exporters by their governments were being used not to strike a balance in their trade relations with the U.S., but to press for superiority. They were successful.

The Commission on International Trade and Investment Policy noted in its report to the President: "Our



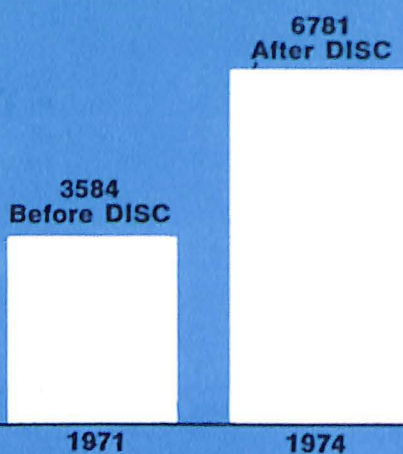
DOMESTIC INTERNATIONAL SALES CORPORATION (DISC) AND THE FMC CORPORATION

(FMC Corp. is a widely diversified U.S. manufacturer with operations in 33 states)

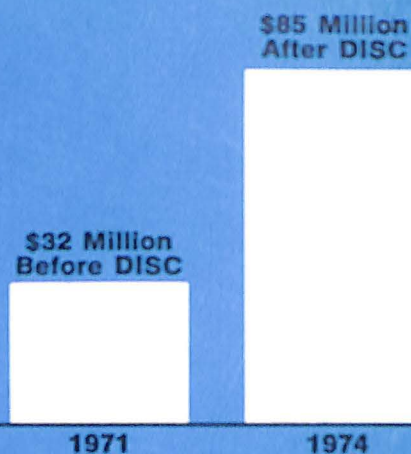
FMC Exports



Export Related Jobs



Federal Income Tax Revenues Resulting from FMC Exports



problems were further compounded by various foreign government measures, particularly in the field of taxation, which artificially improved the trade position of other countries. Many of these measures in fact constitute direct or indirect subsidies."

In 1970 the Treasury Department devised a program for offsetting these foreign subsidies and for providing American exporters a fair means of competing in foreign markets. The "Domestic International Sales Corporation" (DISC) provisions, which allowed for a deferral of federal income taxes on earnings from export sales, had been incorporated into trade legislation passed by the House of Representatives late in 1970. Because of the controversial nature of some of the bill's other provisions, the Senate Finance Committee was unable to complete action on it before final adjournment of the 92nd Congress.

The DISC concept was revived the following year during the consideration of the Revenue Act of 1971. It worked its way through the legislative process in an atmosphere of uncertainty about its potential impact on our trade balance. It was strongly opposed by some because they felt the public benefit did not outweigh the revenue cost of the tax deferral feature. Others opposed it because they saw it as a "tax windfall" for businesses already involved in export trade.

Because of these reservations, the Treasury proposal was amended by the House of Representatives to allow for deferral of export income only to the extent that such income

exceeded previous export earnings. In the Senate, the Finance Committee's version eliminated the complex incremental export income provisions and, instead, limited DISC application to 50 percent of qualified DISC income. A 10-year limit was imposed on deferrals, and this was further restricted on the Senate floor to five years.

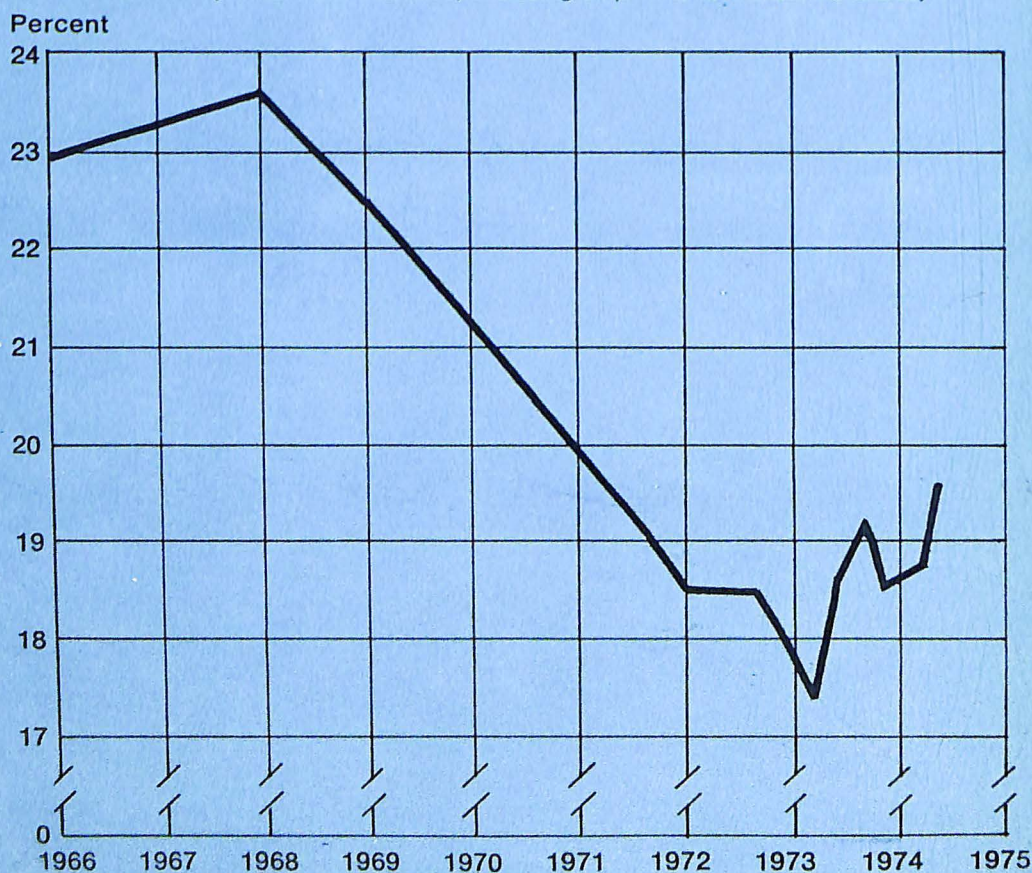
Conference action on the bill resolved the basic conflicts between the House and Senate versions in a

way which retained the best features of both and eliminated those provisions which would have discouraged U.S. businesses from using the DISC incentive. The final result allowed deferral, without time limit, for 50 percent of qualified export income if 95 percent of such income were used in export-related activities.

In addition to the DISC offset provision, the Revenue Act of 1971 reenacted the seven percent investment tax credit for new plant and

UNITED STATES EXPORTS OF MANUFACTURED GOODS AS A PERCENTAGE OF WORLD EXPORTS OF MANUFACTURED GOODS (Standard International Trade Classification 5-8)

(Percentage based on current rates of exchange. World exports defined as exports of 15 major industrial countries, excluding shipments to the United States)



Source: U.S. Dept. of Commerce, *Commerce Today*, June 1975.

equipment and provided the statutory basis for the 20 percent Asset Depreciation Range (ADR) system.

These three provisions narrowed somewhat the substantial gap which had developed over the years in the export incentive and capital recovery treatment afforded U.S. businesses in relation to their foreign competitors, but they by no means closed the gap entirely.

By itself, DISC only partially offset the total tax advantages enjoyed by many foreign companies on their export business. Border tax rebates in those countries with value-added taxes constitute total tax forgiveness on export-related income. Systems of tax credits and direct subsidies achieve the same result in other countries. In some cases, our products must compete with those of government-owned or controlled enterprises where taxation and other normal competitive factors are completely absent.

By the same token, the seven percent investment tax credit and the flexible depreciation provisions of ADR went only part way in putting U.S. businesses on an equal footing with foreign competitors in terms of capital recovery for new plant and equipment. We still rank lowest among the major industrialized nations in this respect.

In spite of the continued disparity between export incentives and capital recovery methods here and abroad, it is interesting to see what U.S. businesses have done since the Revenue Act of 1971 was enacted.

The U.S. Treasury Department has issued two reports on the operations of DISC, covering calendar years 1972 and 1973.

During 1972, 41 percent of export income was DISC related, amounting to \$21.9 billion in foreign exchange. As a measure of DISC effectiveness, the Treasury report shows that the growth rate of DISC-related export sales was 32.6 percent for the period compared to 23.4 percent for all exports. Results for 1973 were comparable.

The Department of Commerce has projected these impacts to current export rates and concludes that the increase in U.S. exports directly attributable to DISC will be as high as \$9 billion in 1974 alone. A conservative multiplier increases this value to \$27 billion in gross national product. The Commerce study shows that em-

Support from Painted Post

The leadership of Local Union 313, IUE, of Painted Post, New York, recently expressed itself on DISC in these terms:

"The purpose of DISC was to encourage American industry to improve export performance which in turn would increase the number of jobs here in the United States.

"We believe the DISC program has been a success. Additional employees have been hired at the Plants we represent as a direct result of the DISC program."

ployment in export-related business is increasing at a rate five times that of other segments of the economy, meaning 450,000 jobs in 1975 that otherwise would not be available. And there will be a net gain in federal tax revenues (after deducting all DISC tax deferrals) of more than \$1 billion.

These figures apply only to that portion of U.S. export trade which government agencies can properly credit to the DISC incentive. That share is growing each year. The importance of our total export trade is best demonstrated by recent figures cited by Secretary of Commerce Rogers C. B. Morton which indicate that more than 2.5 million workers in this country are directly employed in the production of export goods, and for every \$1 billion increase in exports, we add at least 50,000 new jobs to the U.S. economy.

A common thread runs through the testimony of those who favor an aggressive U.S. trade posture. It is that there is a lesson to be learned from the experience of DISC and its incentive effect in reversing the trend of a declining U.S. share of world exports of manufactured products. The lesson is that U.S. businesses can and will produce the world's finest products at competitive prices, if given half a chance. DISC works to give them an edge, but only about half as much of an edge as their foreign competitors enjoy.

With Congress now involved in another review of federal income tax policy, proponents of DISC urge its retention along with a thorough analysis of the relationship between capital recovery tax provisions and long term productivity. They urge that care be taken not to strike out at new, well thought out programs like DISC which are only beginning to prove their worth.



MANUFACTURING MEMBERS

Abex Corporation
Aerojet-General Corporation
Aeronca, Inc.
Aeronutronic Ford Corporation
Avco Corporation
The Bendix Corporation
The Boeing Company
CCI Corporation
The Marquardt Company
Chandler Evans, Inc.
Control Systems Division of
Colt Industries Inc.
E-Systems, Inc.
The Garrett Corporation
Gates Learjet Corporation
General Dynamics Corporation
General Electric Company
Aerospace Group
Aircraft Engine Group
General Motors Corporation
Detroit Diesel Allison Division
The B. F. Goodrich Company
Engineered Systems Co.
Goodyear Aerospace Corporation
Heath Tecna Corporation
Hercules Incorporated
Honeywell Inc.
Hughes Aircraft Company
IBM Corporation
Federal Systems Division
ITT Aerospace, Electronics, Components
& Energy Group
ITT Aerospace/Optical Division
ITT Avionics Division
ITT Defense Communications Division
Kaiser Aerospace & Electronics Corporation
Lear Siegler, Inc.
Lockheed Aircraft Corporation
LTV Aerospace Corporation
Martin Marietta Aerospace
McDonnell Douglas Corp.
Menasco Manufacturing Company
Northrop Corporation
Pneumo Corporation
Cleveland Pneumatic Co.
National Water Lift Co.
Raytheon Company
RCA Corporation
Rockwell International Corporation
Rohr Industries, Inc.
The Singer Company
Sperry Rand Corporation
Sundstrand Corporation
Sundstrand Aviation Division
Teledyne CAE
Teledyne Ryan Aeronautical
Textron Inc.
Bell Aerospace Company
Bell Helicopter Company
Dalmo-Victor Company
Hydraulic Research & Manufacturing Co.
Spectrolab
Thiokol Corporation
TRW Inc.
United Technologies Corporation
Western Gear Corporation
Westinghouse Public Systems Company

AEROSPACE INDUSTRIES ASSOCIATION

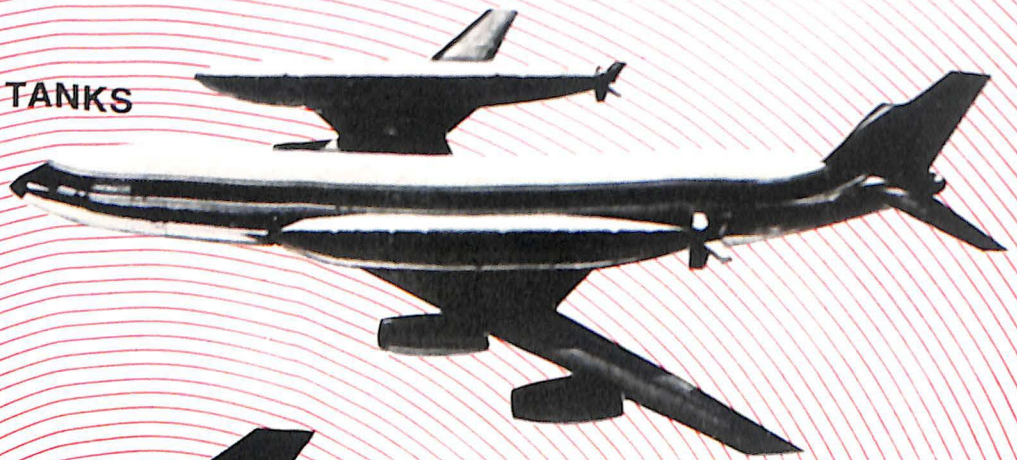
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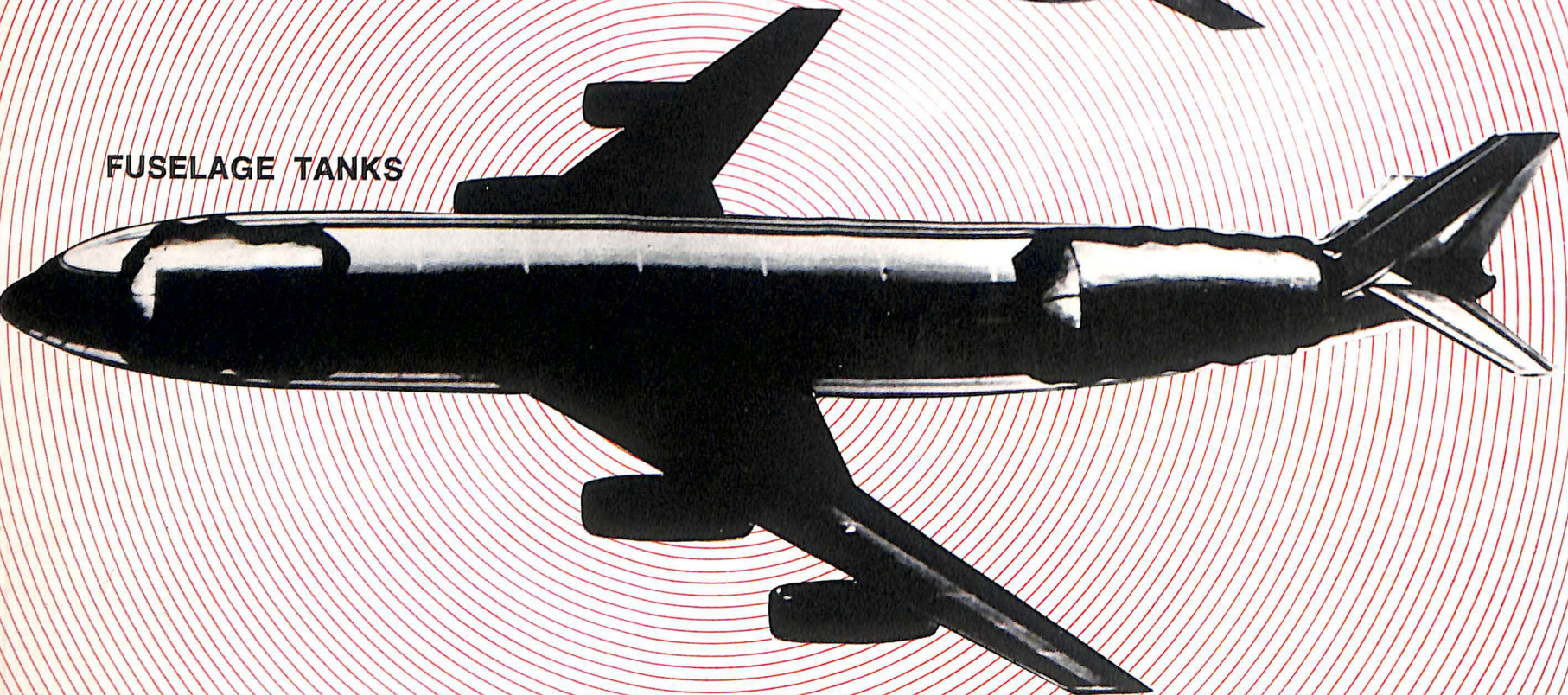
Hydrogen, pound for pound, produces three times the energy of petroleum. It appears to be an excellent aviation fuel, assuming storage problems can be worked out. (See *Challenge To Aviation—Hatching A Leaner Pterosaur*, p. 8).

HYDROGEN-FUELED TRANSPORT AIRCRAFT CONCEPTS

WING TANKS



FUSELAGE TANKS

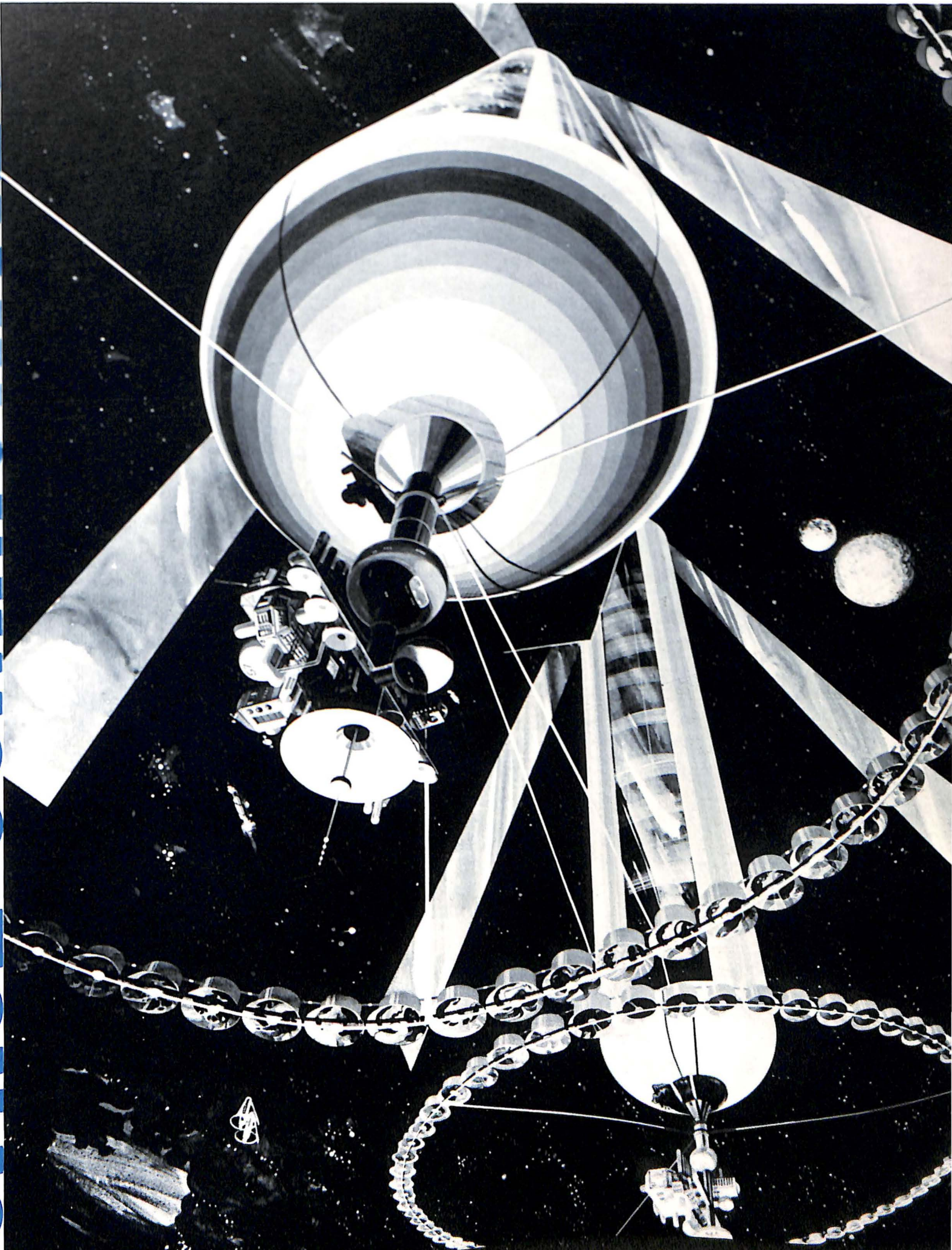


aerospace

OFFICIAL PUBLICATION OF THE AEROSPACE INDUSTRIES ASSOCIATION • DECEMBER 1975

NEXT FRONTIER

SPACE COMMANDERS



GERARD K. O'NEILL

AEROSPACE ECONOMIC INDICATORS

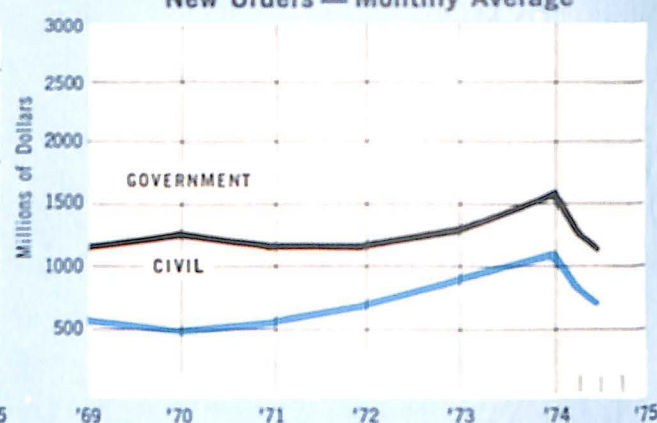
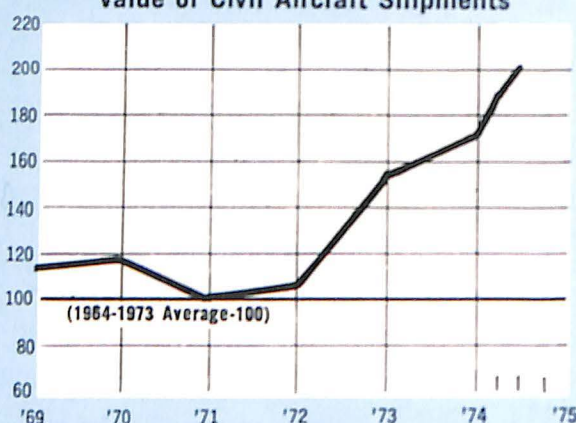
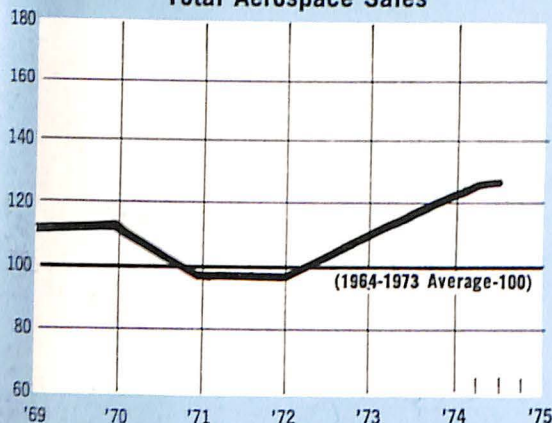
CURRENT

OUTLOOK

Total Aerospace Sales

Value of Civil Aircraft Shipments

New Orders — Monthly Average



— Aerospace obligations by Dept. of Defense and NASA.
— Non-government prime orders for aircraft and engines.

| ITEM | UNIT | PERIOD | AVERAGE 1964-1973 * | LATEST PERIOD SHOWN | SAME PERIOD YEAR AGO | PRECEDING PERIOD † | LATEST PERIOD |
|---|------------|-------------|---------------------------|---------------------------|----------------------------|-----------------------|------------------|
| AEROSPACE SALES: Total | Billion \$ | Annual Rate | 24.1 | 2nd Quarter | 25.5 | 27.5 | 27.6 |
| | Billion \$ | Quarterly | 6.1 | 1975 | 7.2 | 6.9 | 7.3 |
| AEROSPACE SALES: Total (In Constant Dollars, 1958=100) | Billion \$ | Annual Rate | 15.8 | 2nd Quarter | 15.2 | 15.1 | 15.0 |
| | Billion \$ | Quarterly | 4.0 | 1975 | 4.3 | 3.8 | 4.0 |
| DEPARTMENT OF DEFENSE | | | | | | | |
| Aerospace obligations: Total | Million \$ | Monthly | 1,194 | June 1975 | 1,060 | 887 | 1,399 |
| Aircraft | Million \$ | Monthly | 716 | June 1975 | 629 | 668 | 833 |
| Missiles & Space | Million \$ | Monthly | 478 | June 1975 | 431 | 219 | 566 |
| Aerospace outlays: Total | Million \$ | Monthly | 1,129 | June 1975 | 1,197 | 1,183 | 1,161 |
| Aircraft | Million \$ | Monthly | 669 | June 1975 | 643 | 662 | 705 |
| Missiles & Space | Million \$ | Monthly | 460 | June 1975 | 554 | 521 | 456 |
| Aerospace Military Prime Contract Awards: TOTAL | Million \$ | Monthly | 1,061 | June 1975 | 825 | 628 | 1,269 |
| Aircraft | Million \$ | Monthly | 667 | June 1975 | 502 | 386 | 732 |
| Missiles & Space | Million \$ | Monthly | 394 | June 1975 | 323 | 242 | 537 |
| NASA RESEARCH AND DEVELOPMENT | | | | | | | |
| Obligations | Million \$ | Monthly | 283 | June 1975 | 360 | 178 | 250 |
| Expenditures | Million \$ | Monthly | 287 | June 1975 | 328 | 222 | 108 |
| BACKLOG (55 Aerospace Mfrs.): Total | Billion \$ | Quarterly | 25.5 | 2nd | 29.9 | 35.2 | 33.5 |
| U.S. Government | Billion \$ | Quarterly | 14.5 | Quarter | 16.2 | 21.0 | 20.3 |
| Nongovernment | Billion \$ | Quarterly | 11.0 | 1975 | 13.7 | 14.2 | 13.2 |
| EXPORTS | | | | | | | |
| Total (Including military) | Million \$ | Monthly | 249 | June 1975 | 704 | 685 | 681 |
| New Commercial Transports | Million \$ | Monthly | 77 | June 1975 | 305 | 252 | 269 |
| PROFITS | | | | | | | |
| Aerospace — Based on Sales | Percent | Quarterly | 2.7 | 2nd | 3.3 | 2.6 | 3.1 |
| All Manufacturing — Based on Sales | Percent | Quarterly | 4.9 | Quarter | 6.0 | 3.7 | 4.7 |
| | | | | 1975 | | | |
| EMPLOYMENT: Total | Thousands | Monthly | 1,213 | June 1975 | 962 | 939 | 934 |
| Aircraft | Thousands | Monthly | 669 | June 1975 | 514 | 514 | 509 |
| Missiles & Space | Thousands | Monthly | 128 | June 1975 | 103 | 91 | 92 |
| AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS | Dollars | Monthly | 3.86 | June 1975 | 5.36 | 5.87 | 5.97 |

* 1964-1973 average is computed by dividing total year data by 12 or 4 to yield monthly or quarterly averages.

† Preceding period refers to month or quarter preceding latest period shown.

WILL WE BECOME COLONISTS?

By KARL G. HARR, JR.
President, Aerospace Industries Association



Karl G. Harr, Jr.

On the eve of our Bicentennial, this is the stimulating question raised by the illustration on the cover and the article in this issue by Professor Gerard K. O'Neill.

We in aerospace share the nostalgia and sense of accomplishment inherent in celebrating the 200th anniversary of a most remarkable nation. It is with a sense of pride that we review the significant milestones from the Wright Brothers to the world-wide air transportation network of today and from the crude rockets of Dr. Robert Goddard to the footprints of Apollo astronauts on the moon.

What we most particularly see in the Bicentennial is its challenge to look to the future not only as a matter of self interest but also from the perspective of a somewhat troubled earth. Given our many problems, we commend seeking tomorrow's answers to them through the same imaginative pioneering that has contributed so much to today's high standard of living.

Continuing that contribution in the future may well be productive communities in space which will help solve specific problems on mankind's behalf. Granted, for many, it seems a "way out" idea. But, for its time, wasn't the Declaration of Independence?



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Cover: This concept shows how a space colony would appear to a resident returning home from a holiday on Earth. The space colonies are being approached by a spaceship 20 miles away.

The purpose of AEROSPACE is to:

Foster understanding of the aerospace industry's role in insuring our national security through design, development and production of advanced weapon systems;

Foster understanding of the aerospace industry's responsibilities in the space exploration program;

Foster understanding of civil aviation as a prime factor in domestic and international travel and trade;

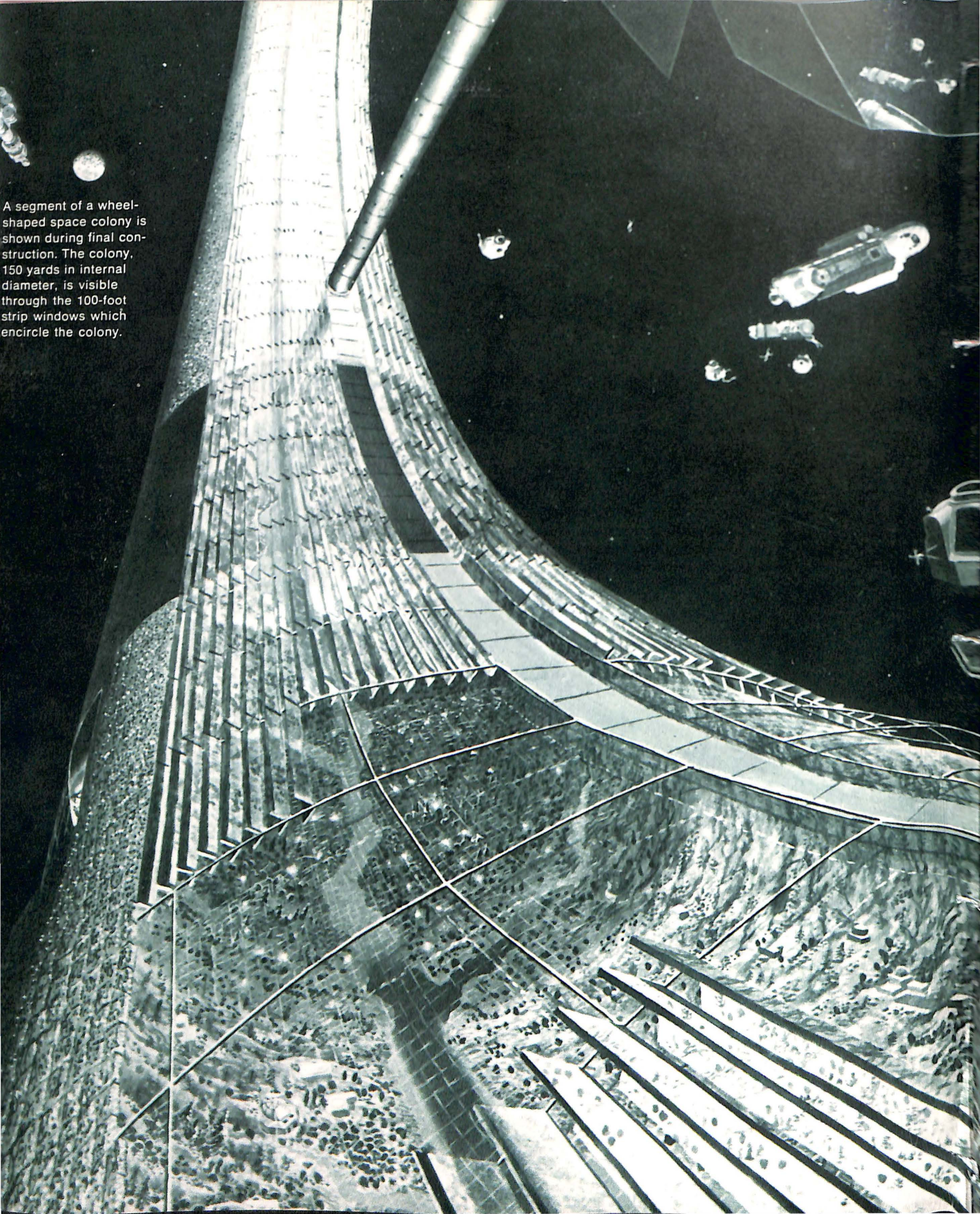
Foster understanding of the aerospace industry's capabilities to apply its techniques of systems analysis and management to solve local and national problems in social and economic fields.

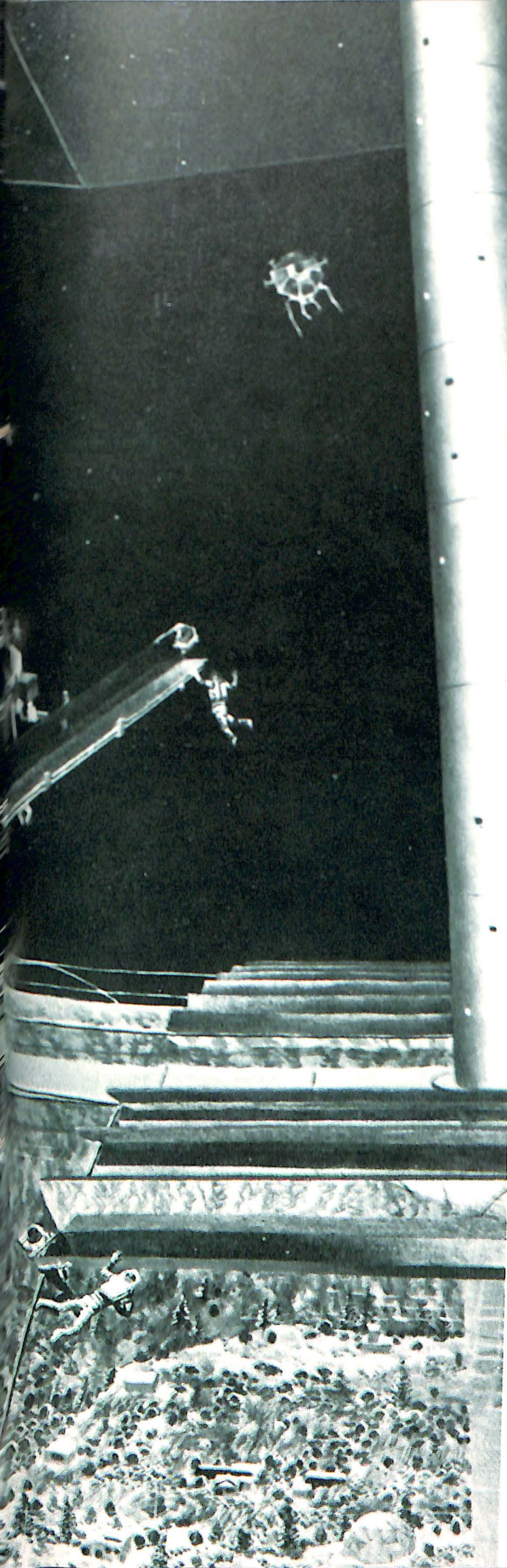
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A segment of a wheel-shaped space colony is shown during final construction. The colony, 150 yards in internal diameter, is visible through the 100-foot strip windows which encircle the colony.





SPACE COLONIES

THE NEXT FRONTIER

Dr. Gerard K. O'Neill, Professor of Physics at Princeton University, since 1969 has investigated the possibilities of research, manufacturing and human habitation in space. He works in the field of high-energy experimental particle physics. He is a graduate of Swarthmore College, and received his Ph.D. in physics from Cornell University. Dr. O'Neill is a Fellow of the American Physical Society, and a member of the American Institute of Aeronautics and Astronautics, Phi Beta Kappa, Sigma Xi, the Soaring Society of America and the Experimental Aircraft Association.



BY GERARD K. O'NEILL
Professor of Physics,
Princeton University

Within the last year a new possibility for the direction and motivation of our thrust into space has reached the stage of public discussion. We have yet to find an appropriate name for this new concept; space colonies, space manufacturing facilities, space industrialization have all been tried, but none is wholly appropriate. The definition of the topic is best made operationally:

- To establish a highly industrialized, self-maintaining human community in free space, where solar energy is available full-time.

- To construct the community almost wholly out of lunar surface materials and, later, to use the same source for materials to be processed into finished products; not to be used directly on Earth, but for use in high orbit.

- By so freeing the construction effort from launch-vehicle limitations, and by reducing the total launch requirements from the earth, to initiate the space-colonization program soon—within a time frame appropriate to the space-shuttle and to a simplified shuttle-derived lift vehicle.

The possibility of space colonization brings up a curious distinction, not often made: Some lines of research and development require nothing new in the way of physical understanding or of materials technology, but have not previously been worked on and therefore seem

strange. In contrast, there are lines of development which we accept as inevitable simply because we have been exposed to them for a very long time, even though they may still require for their realization new physical understanding or real breakthroughs in materials technology. Fusion energy research is perhaps a classical example of the second class, and space colonization seems to typify the first.

Although my own work on this topic began in 1969, originally as an academic exercise, I later found that others had considered pieces of the problem much earlier. Of these, Konstantin Tsiolkowsky, J. D. Bernal, John Stroud, Dandridge Cole, Arthur C. Clarke, G. Harry Stine and Kraft Ehrlicke should all be mentioned, but in my opinion the work of Tsiolkowsky is particularly relevant to the present developments.

The key ideas of space coloniza-

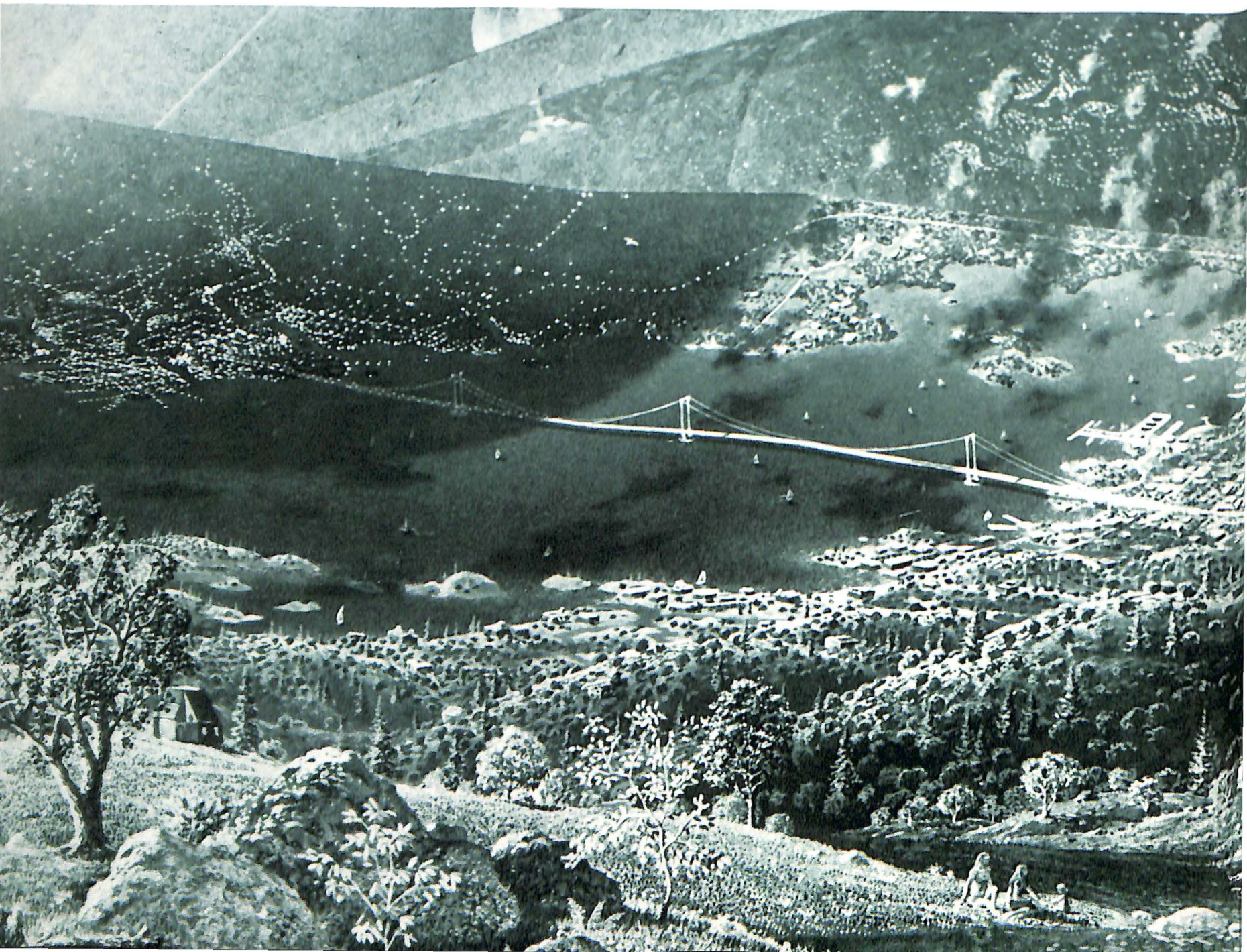
tion are, first, the utilization of solar energy in the environment where it can be used most efficiently, at the desire of the user: in free space, remote from the shadow of any planet; second, obtaining materials from the weak gravity of the moon rather than from the strong gravity of the earth.

An automatic, lunar-based electromagnetic launching device which we now study for transporting those materials is unusual from an aerospace industry viewpoint: it would operate no higher than room temperature and, in contrast to any new rocket or jet engine, would make no demands on high-strength materials technology.

In essence, it would be a recirculating linear electric motor, in which vehicles would be constrained by the phenomenon known as dynamic magnetic levitation, which involves permanent magnets flying above a conducting metal surface producing

lift with low drag. This "mass-driver" would accelerate a small vehicle to the lunar escape speed. Over a kilometer of track length, following acceleration, velocity errors would be sensed by precise laser measurements. They would be corrected by pulsed magnetic fields before the payloads were released to climb out of the moon's gravitational field. The vehicle, slowed and recirculated for another payload, would be re-used every 150 seconds, so its own capital cost would be negligible when amortized over the payloads launched. The total weight of several hundred such vehicles would be less than one ton. The mass-driver can be analyzed by Maxwell's electromagnetic theory (magnetism created by an electric charge in motion), which was well-understood a century ago.

Yet, because it is so unlike a rocket engine, it is sometimes viewed with suspicion by aerospace engi-



neers—including those who would consider acceptable the doubling of chamber pressures and the raising of temperatures by several hundred degrees in the next rocket engine to be developed.

The practicality of space colonization rests on at least two factors:

1. The factor of 20 in energy by which it is easier to transport to free space a payload from the moon than from the earth.

2. The factor of about 10 in time-averaged intensity between sunlight in free space and sunlight at the earth's surface in our midwinter.

Those two numbers suggest the first likely use of a space colony: for the manufacture of satellite solar power stations, to be relocated in geosynchronous (24-hour) orbit to supply energy to the earth through a microwave link. The energy interval between lunar orbit, where a space manufacturing facility would be lo-

cated, and geosynchronous orbit is only 1/30 as large as the interval from the earth's surface to geosynchronous.

If a space colony is to be useful, it must be large enough and attractive enough to attract talented, hardworking people as residents; it must be far more than a space-station.

It was a surprise to me to discover, six years ago, that a pressure vessel in space, containing an atmosphere, and rotating to provide the equivalent of earth-normal gravity, could be made as large as several miles in diameter, within the limits of the ordinary structural materials with which we are familiar.

The largest colonies now foreseeable would probably be formed as cylinders, alternating areas of glass and interior land areas. From those land areas a resident would see a reflected image of the ordinary disc of the sun in the sky, and the sun's image would move across the sky from dawn to dusk as it does on earth. Within civil engineering limits no greater than those under which our terrestrial bridges and buildings are built, the land area of one cylinder could be as large as 100 square miles. It would be a very long time before there would be a need to build colonies of so large a size. Even for the early small colonies, though, there would be the same options of independent control over the day-length, climate and seasons.

Agriculture for a space community would be carried out in external cylinders or rings with atmospheres, temperature, humidity and day-length chosen to match the needs of each crop being grown. Agriculture in space could be efficient and predictable, free of the extremes of crop-failure and glut which the terrestrial environment forces on our farmers.

Heavy industry at a space colony could benefit from the convenience of zero gravity. In external, non-

rotating factories, zero gravity and breathable atmospheres would permit the easy assembly, without cranes, lift trucks or other handling equipment, of very large, massive products. These could be the components of new colonies, radio and optical telescopes, large ships for the further human exploration of the solar system, and power plants to supply energy to the earth.

In the early years of this research, before the question of implementation was seriously addressed, it seemed wise to check whether an expansion into space would soon encounter "growth limits" of the sort which humankind is now reaching on earth, and which have been described for us vividly by Professor Jay Forrester of M.I.T., in studies supported by the Club of Rome.

In the long run, it seems fairly certain that the materials source for space colonies will be the asteroids rather than the moon. The asteroids have, in addition to those minerals found on the lunar surface, carbon, nitrogen and hydrogen. Typical asteroids are no more remote in energy from lunar orbit than is the earth, and no high thrusts are required to transfer materials or finished colonies from the asteroid belt. Given that source of materials, the "limits of growth" are absurdly high; the total quantity of material within only the three largest asteroids is quite enough to permit building space colonies with a total land area more than ten thousand times that of the Earth.

As Hubert Davis of NASA-Houston has aptly pointed out, the introduction of the space colony option is equivalent to releasing us from what must otherwise be a "zero-sum game" on the surface of the earth. The practical and immediate question is how to establish the first colony; once it exists and is in full production, it will serve as a beach-head in space, manufacturing additional colonies as well as other products.

During the summer of 1975 a group of about 25 people meeting at the NASA Ames Laboratory, in cooperation with Stanford University, studied the space-colony concept from two viewpoints: first, to find whether there is any essential flaw in the arguments set forth in the first paper on the topic (Physics Today, September 1974); second, if no such flaw is



This conception of a space colony features a bridge comparable in size to the San Francisco Bay Bridge to emphasize the eventual sizes of such colonies. Solar energy would supply power to the habitat while raw materials would be derived from lunar rocks or asteroids.

found, to examine in more detail the optimizations and tradeoffs which would control the cost and time-scale for an actual construction project. In that effort the group, working under a program of the American Society for Engineering Education, was aided by having access to the papers of 1974 and 1975 Princeton Conferences on this topic.

No "fatal flaw" was uncovered in the original arguments. In detail, some conclusions were reached which were not suspected at the time the study began. It is easy first to dispose of those items which were anticipated but which now have been put on a firmer basis.

First, the details of launch vehicles and deep-space tugs were established through papers by Hubert Davis and Adelbert Tischler at the 1975 Conference. Nothing more advanced than the space-shuttle main engines is required, and the assumption is made that transport from the Earth will be by the shuttle, for people, or by a simple lift vehicle with shuttle main engines, for freight. In deep space, only a chemical tug is assumed. In keeping with those assumptions, if the cost of transport to low earth orbit is taken as one unit, transport to lunar orbit is taken as four units and, to the lunar surface, eight units.

The optimum location for the first colony is not yet established at the time of writing. The L4 and L5 Lagrange-points* of the earth-moon system have been considered, as have geosynchronous orbit and high lunar orbit. Geosynchronous orbit appears to be less advantageous, mainly because it would raise the costs of materials transport from the lunar mine to the processing facility.

It is assumed automatically by most people who consider the space-colony concept that materials processing would be carried out on the moon. So far, that does not appear to be a cost-effective choice. Processing machinery carried to the moon would be saddled with a large additional amortization cost due to its transport, and it would lose the

advantages of full-time solar energy and of adjustable gravity. The absence of the zero-gravity option would alone be a grave disadvantage. As it now appears, even unselected lunar surface material is close enough to ideal in its element-concentrations that there seems not much point in processing it on the lunar surface. The unselected Apollo-11 fines, for example, are 40 percent oxygen by weight, more than 30 percent metals, and about 20 percent silicon. Baseline Colony One designs, with a total mass of 500,000 tons, require about 150,000 tons of metals, 150,000 tons of soil, and smaller amounts of glass—materials that seem to be well matched to those available on the moon. Work by the Summer Study group has substantiated earlier indications from the 1975 Princeton Conference, to the effect that the original estimates of agricultural growing-area needs were pessimistic by about a factor two; the agricultural specialists now conclude that under the ideal growing conditions of a deep-space greenhouse, a growing area of 45 square meters per person should be enough. A normal type of North American diet, with vegetables, poultry, dairy products and meat is assumed.

We take a conservative approach to electric power plant masses; although further improvements may come with time, for the purposes of cost estimation the Study Group assumed for the surface of the moon a nuclear reactor, weighing 45 tons per megawatt of power. It would be rated at about 170 megawatts, of which just under 160 would be devoted to the mass-driver. That would be sufficient for the transport of 900,000 tons/year assuming 70 percent reliability. For the deep-space applications, we assume at present a solar thermal system with a turbogenerator, as has been studied by Gordon Woodcock of Boeing. We assume, however, a performance appropriate to an early timeframe: that is, 10 tons per megawatt instead of 5.

Unexpectedly, the summer study has shown up a possible physiological limit more severe than had been anticipated. Until now, on the basis of advice from those experienced in aerospace physiology, we had assumed that rotation rates of up to three rotations per minute (rpm) would be acceptable to nearly all prospective colonists after initial ac-

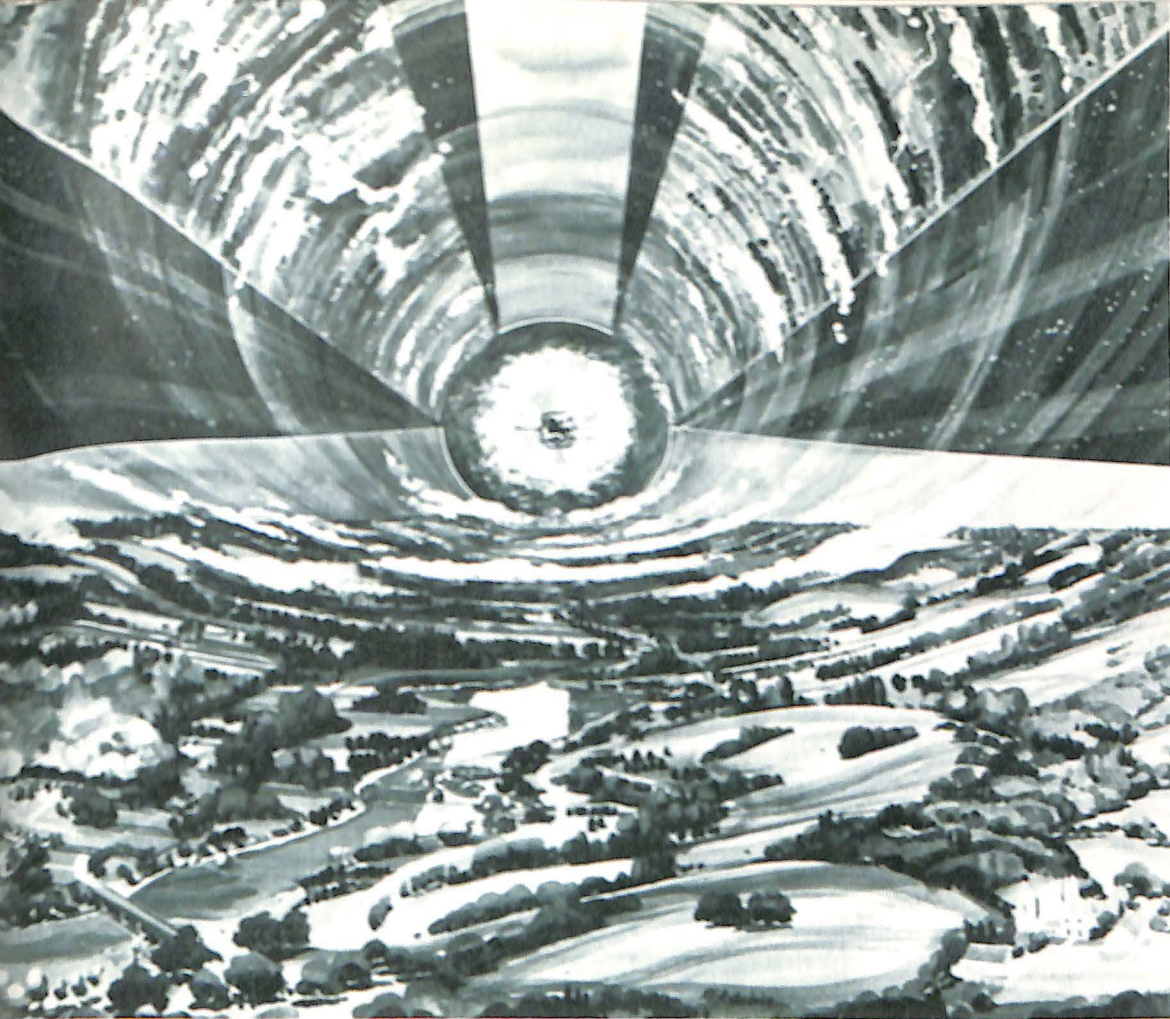


climatization. To those of us who have logged some centrifuge time, that rate seems rather slow. It seems, though, that there is enough disagreement among physiologists that contingency plans must be made. Conceivably, the rate may have to be held below 1 rpm, because of the fraction of the work force which will be commuting daily between the rotating environment and the zero-gravity assembly areas.

This possible limit prompted more attention, in the summer study, to habitat geometries than was anticipated initially. For constant gravity, if the rotation rate is cut from 3 rpm to 1 rpm, the required radial dimension of the habitat must go up from 100 meters to 900 meters. For Earth-normal gravity a rotation rate of 3 rpm translates to 100 meter radius, for which the atmospheric pressure dominates the equation for habitat total mass. At 1 rpm the radius must go to 900 meters, and there the gravity itself dominates the mass equation.

A number of geometries have been considered. The most efficient in terms of mass is probably a tethered pair of pressure vessels, but that arrangement is inconvenient for passive cosmic-ray shielding. The next most efficient may be a cable-supported band structure, and after

*In 1772 Astronomer Joseph L. Lagrange computed points in space equidistant from the Earth and moon—points of triangles 237,000 miles on a side—where a satellite or space station would remain in constant orbit above the Earth. L4 (east) and L5 (west) are the two stable positions.



A resident of a 21st Century space colony might view this vista of Earth-like landscape inside his home in space. The interior could be made to resemble the Rocky Mountains, the plains of South Dakota or the timber forests of Oregon, depending how the builders plan it to be. This conception shows a colony 19 miles long and four miles in diameter.

that a wheel. It appears that for a population of 10,000 people a total land area (residential, service, recreational and agricultural) should be about 900,000 square meters—about one-half square mile—if the density is to be as low as in attractive suburban areas of the U.S. and Southern France, so far taken as models. For 1 rpm the summer study chose a wheel geometry, as a compromise between esthetics and spin rate. Passive shielding against cosmic-rays would be possible though inconvenient with that geometry.

Until further experiments on the physiological tolerance-range are carried out, we retain an alternate design which would be more attractive esthetically and which would lend itself naturally to cosmic-ray shielding, but which would rotate at 1.95 rpm. Its circumference would be 0.87 mile, and its external agricultural areas would use the efficient cable-supported band structure.

In preparing for testimony before the Space Science and Applications Subcommittee of the House Committee on Science and Technology (July 23, 1975), I calculated, with the aid of Mark Hopkins, a number of economic scenarios for the growth of space manufacturing facilities, and for their construction of satellite solar power stations. One such calcula-

tion assumes an investment of about \$96 billion over a six-year period during the establishment of the first beachhead-colony, and an additional \$80 billion over the next decade as the initial colony builds others as well as power stations. We assume payment of 10 percent interest per year on the outstanding investment. The key factor entering the estimates is productivity; conservatively we assume that, in spite of the advantages of zero gravity and of any improvements which automation may bring, the productivity per person-year will be only about the same as it is in heavy industry on earth.

Including all processing, manufacturing and assembly, it appears that a population of 10,000 could manufacture about one new colony every two years, and could in addition build two power stations per year of 5,000 megawatts each. As in all the others which we considered, the program builds toward a steady-state population of about 160,000 people in space. In all cases, even with program costs of up to \$300 billion, the payback in dollars exceeds the total investment and interest; profits from the sale of power begin in the ninth year and grow rapidly; total payoff of the program cost, including all interest charges, occurs after about 20-25 years.

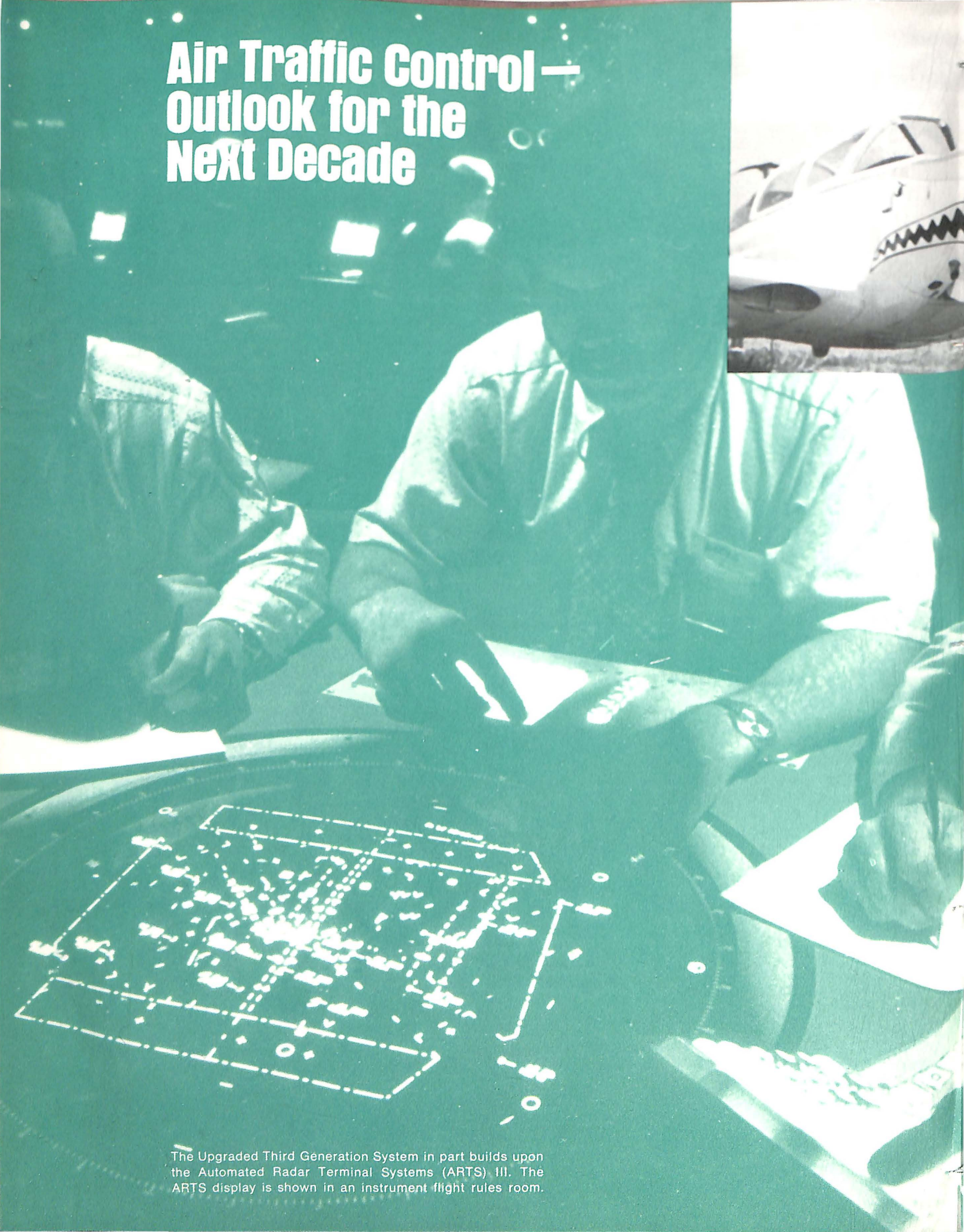
In these scenarios the amount of energy supplied to the Earth is quite sufficient to end the energy-crisis permanently. Typically, 13 years after the beginning of construction the amount of energy being supplied to the earth each year in the form of usable electricity at the busbar (the point where power enters the distribution system) exceeds the peak capacity of the Alaska pipeline (two million barrels per day) and a few years later the total electrical energy supplied to date could exceed the estimated fossil fuel capacity of the Alaskan North Slope.

For us who work in technical fields it is easy to become immersed in performance optimizations and cost-benefit analyses. Such work is necessary, though, and the practicality of a space-colonization program is becoming better established mainly because additional people are giving their talent and hard work to the research on that topic.

It seems clear, though, that the extraordinary amount of interest which the space community concept has aroused during the last year stems at least in part from an intangible payback: the beginning of hope that our near-term future may not be one of despair or resignation in an increasingly rigid, resource-limited society, but of freedom and new opportunities on a frontier which is just within our reach.

In the great days of American progress and enthusiasm, it was the private sector which spurred the drive toward industrial expansion. It remains to be seen whether industry retains the drive and imagination to take an active part in the next advance, or whether it will be content to leave both the risks and the opportunities to government. I believe that it will be more healthy for the country if industry takes an active role in exploring the new possibilities.

Air Traffic Control — Outlook for the Next Decade



The Upgraded Third Generation System in part builds upon the Automated Radar Terminal Systems (ARTS) III. The ARTS display is shown in an instrument flight rules room.



Congressman Dale Milford has a broad background in aviation. Elected to Congress in 1972, Mr. Milford, in addition to his duties as Chairman of the House Subcommittee on Aviation and Transportation Research and Development, is also a member of the Aviation Subcommittee on Public Works and Transportation which oversees the aviation regulatory agencies. He is an Army pilot, serving in World War II and Korea. Mr. Milford attended Baylor University, and became a certified professional meteorologist while he operated a flight service. He has a commercial pilot rating and has compiled more than 6,500 flying hours. Mr. Milford is shown with a plane he built, the T-35 Buckaroo.

BY CONGRESSMAN DALE MILFORD

Chairman, House Subcommittee on Aviation and Transportation Research and Development

Considerable public attention is generated by Government research and development programs, particularly those of the Department of Defense and the National Aeronautics and Space Administration. This is proper since their programs deal with the frontiers of technology, and are deeply involved in such vital concerns as our national defense posture, national prestige and economic progress.

Less known, but equally vital, are the research and development programs of the Federal Aviation Administration (FAA), which provide a key element to a prime national asset—air transportation.

The House Subcommittee on Aviation and Transportation Research and Development has, among other duties, the responsibility for recommending to the full Committee and the Congress FAA research and development programs which will keep this national asset viable. It is hoped that this outlook for air traffic control will be useful in understanding this important activity.

The FAA is charged with regulating air commerce to foster aviation safety, promoting civil aviation, developing a national system of airports, achieving efficient use of the navigable airspace, and developing and operating a common system of air traffic control and air navigation for both civilian and military aircraft.

This is a large and difficult mandate for maintaining, and even improving flying safety in today's evermore crowded skies.

The scope and extent of the FAA's current activity are reflected by the size of its workforce and the amount of its annual budget.

For a workforce of 57,600 employees to operate, maintain, and continue to improve this National Airspace System in Fiscal Year 1976,

the FAA has requested approximately \$2 billion dollars, distributed as indicated:

| Item | (in 000's) Amount |
|---------------------------------------|----------------------|
| Operation of ATC* system | 764,261 |
| Maintenance of ATC system | 388,974 |
| Installation of new equipment | 162,746 |
| Flight Standards Program | 173,582 |
| Facilities and Equipment | 250,000 |
| Research, Engineering and Development | 80,400 |
| Other | 468,237 |
| Total Appropriation | 2,288,200 |

*Air Traffic Control

The trend has been for the FAA operating costs and number of people required to operate and maintain the system to increase in almost direct proportion to the air traffic activity growth as measured by various indicators. Some of them are number of aircraft, number of air carrier flights, and number of instrument operations. In general, the air traffic activity has been increasing at the rate of 6 to 8 percent per year over the past decade. Even with the decline in economic activity and the higher fuel costs in recent years, the growth rate still exceeds 5 percent. This trend has generated the need to conduct a continuous development and modernization program concentrating on enhancements to safety, performance, and system productivity.

Safety

The current Air Traffic Control (ATC) system has an excellent flight safety record with less than two air carrier fatalities per billion passenger miles. The fact, however, that some accidents still occur, coupled with the continued growth in air traffic and in-

crease in passenger carrying capacity of air carrier aircraft, make it essential that safety improvements continue to receive the highest priority in the FAA's engineering and development program.

Performance

The ATC system currently handles about 60 million operations, generating 40 million flight hours per year (excluding military operations) in the U.S. Improved performance requires achievement of higher capacity by reducing the number and length of delays and improvement in service by extending the coverage, reliability, and continuity of the ATC system.

The capacity problem exists primarily at the higher density terminal areas, but affects airspace and airports serving these terminals. Improvement in capacity must address the problem of providing more precise control of aircraft in the airspace around the airports where the flight paths converge, and improving control on the surface where the number of runways available and the runway occupancy time of aircraft are limiting factors. These problems, of

course, intensify in bad weather.

Although there are standard approach and departure routes which can be flown by reference to navigation aids, the efficient handling of large numbers of aircraft with different performance characteristics currently is primarily dependent on the skill of air traffic controllers. The engineering and development program is developing the means to supplement these skills with new concepts and equipment that will resolve the problems and increase the system's capacity and efficiency.

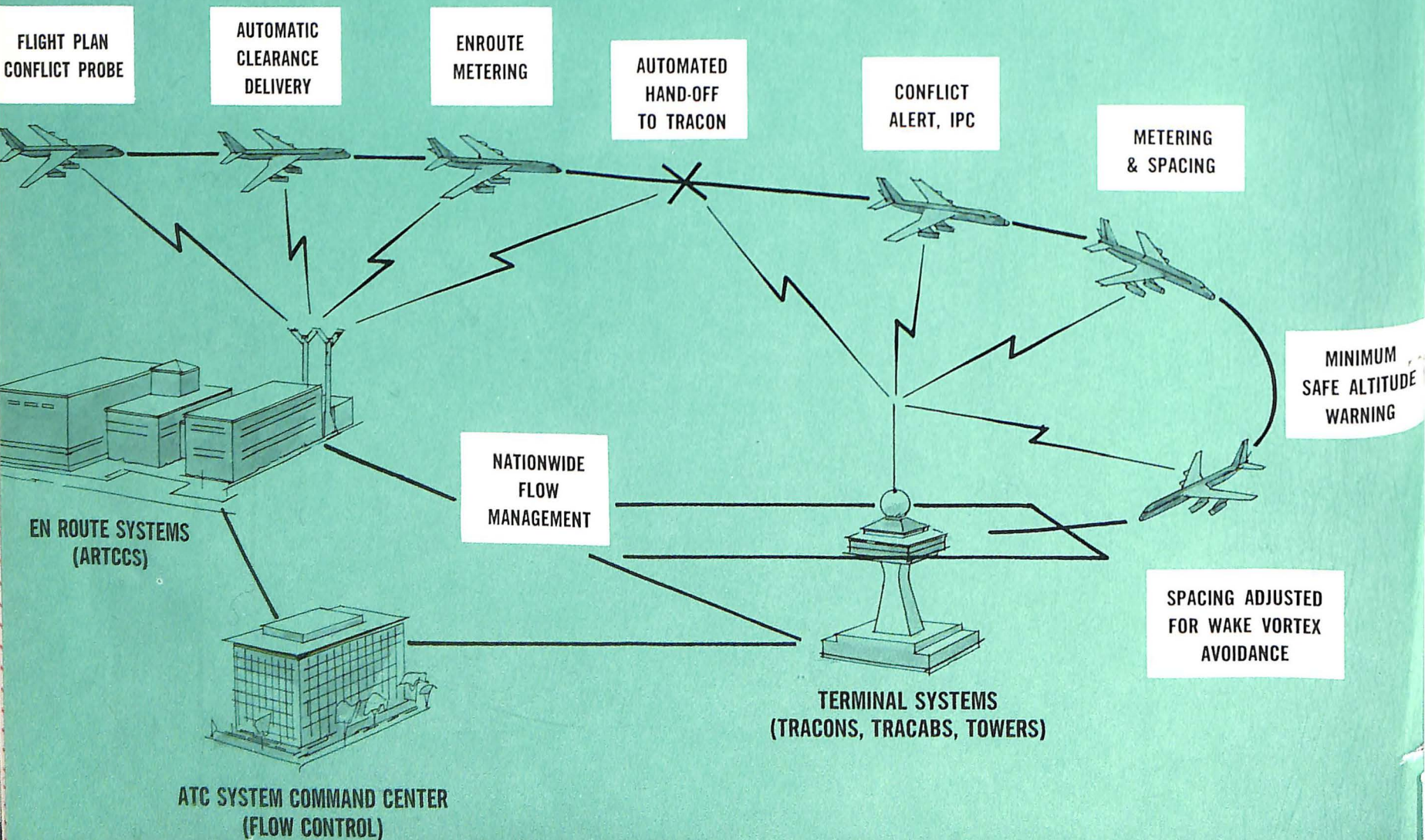
System Productivity

The third main objective is to provide increased safety and improved service in the most economical way. Achievement of the required increases will not be easy. It will require increased effectiveness on the part of controllers, flight service station specialists, and maintenance personnel and is only possible through the use of the most modern technology and implementation of higher levels of automation.

In structuring an Engineering and Development (E&D) program to

meet the objectives, there are constraints that the FAA must consider in upgrading the system. These include protection of the natural environment, conservation of energy, preservation of the greatest possible freedom of flight, and access to the airspace for all users. The accessibility to airspace is of particular significance to an ATC system that serves general aviation, the military, and air carriers. Air carriers with millions of dollars invested in each airframe can tolerate ATC avionics costs of several hundred thousand dollars per aircraft while this same ATC avionics cost would be intolerable to general aviation, largely corporate and private aircraft. Still another factor to be considered is the "user charge" concept, where users of the airspace are expected to pay a fair share of the ATC system cost based upon services rendered. Although the present taxes on aviation fuel and passenger tickets are used to fund new airports and airway development (ATC), there is no attempt to recover equitably all the ATC system operation and maintenance cost from different users. Congress is now

UPGRADED THIRD GENERATION ATC AUTOMATION FUNCTIONS



reviewing the user charge legislation.

The three main objectives of safety, performance and productivity (cost) are also not mutually exclusive or always complementary. In addition, the requirements (and/or desires) of the various users are not the same and in some cases are not completely compatible. For example, air carriers prefer positive control while general aviation normally prefers a minimum of control. Hence, the problem facing the FAA is to design and engineer an improved system which represents an acceptable compromise among the varying requirements, constraints, and diverse needs and desires of the customers while at the same time providing an economically feasible and implementable approach.

Commercial air passenger enplanements are increasing at a rate of five to six percent per year and some 15,000 new general aviation aircraft are produced each year. The corresponding expectation for all measures of air activity, including both enroute and terminal-area traffic, is a continued substantial growth in the range of 5 to 7 percent per year. This means that the demand for air traffic control services will double every 10 to 15 years. There will not, however, be a doubling of major hub airports or the number of runways on these airports (in fact, little physical growth is expected), the amount of airspace which aircraft desire to use, the number of major city-pairs between which the bulk of this traffic will travel, or the radio spectrum available for air traffic control use.

Coincidentally, 10 to 15 years is just about the length of one ATC generation or, perhaps more pertinently, it is the length of time required to develop and deploy a new or upgraded system to provide for the forecast increase in traffic. Implementation of needed Air Traffic Control improvements requires large FAA Research and Development (R&D) budgets followed by increased implementation funds. If we wish to accommodate the increased use of air travel, we must be willing to accept its increased cost. The other solution is to restrict the development of air travel. Clearly this is not acceptable.

It is not acceptable, because aviation manufacturing is one of our healthiest industries, and one on which we must depend as a major exporter—i.e., a significant portion of

the U.S. balance of trade.

The recent breakthroughs in electronic technology, leading to extraordinary reductions in the size, weight, cost and power requirements of electronic digital circuitry, has led to many new and interesting possibilities for the design of air traffic control equipments, systems and subsystems. Accordingly, a number of suggestions have been made for entirely new ATC system designs based on these new avionic and ground-based capabilities. Dispersed system architectures involving greater use of airborne avionics or major new designs including equipment integration of communications, navigation and surveillance functions have been suggested.

Despite the technical attractiveness of these new concepts and designs, they do not stand up yet to careful scrutiny and detailed analysis and realistic implementation planning. The present system must be maintained in continuous operation and the very large investment in the ground-based ATC system and user avionics cannot be discarded. Accordingly, there continues to be a preponderance of evidence that we must continue the gradual step-by-step evolution of our current system, rather than consider a revolutionary approach, as we proceed to meet the requirements of the future.

In 1969, the Department of Transportation appointed an Air Traffic Control Advisory Committee to define the future ATC development program. The Committee's report contained the concept for an improved air traffic control system, which could be achieved for the 1980s and 1990s through evolution and improvement of the present ground based system, with priority given to the greater use of automation. This concept, now referred to as the Upgraded Third Generation System (UG3RD), has been adopted by the FAA and builds on the National Air Space (NAS) Stage A and the Automated Radar Terminal System (ARTS) III, which constitute the Third Generation System. While there is not yet a commitment to implement this system, there is a commitment to perform the engineering and development activities necessary to develop and evaluate such a future system.

This Upgraded Third Generation System Concept has been transformed into a broad system design

highlighted by, but not restricted to, nine key features. Hardware and software development programs associated with these features have been initiated, with most test and evaluation activity scheduled for the 1976-1978 time period. At the conclusion of these tests, the FAA will make final system design choices and implementation decisions leading to operational capabilities in the early 1980s. A summary of the nine elements follows:

Airborne Separation Assurance

As the volume of air traffic grows, the probability of collisions rises. The E&D program is investigating several solutions to improve safety and potentially reduce the number of mid-air collisions. One is to extend the limits of controlled airspace to include airspace areas where the bulk of the non-controlled general aviation flights and fatalities occur. This alternative places a heavy penalty on these aircraft in terms of both freedom of flight and avionics requirements.

Another solution, which places a heavy avionic burden on all aircraft, is to institute a mandatory Airborne Collision Avoidance System (CAS) by which aircraft automatically exchange information with surrounding aircraft and generate collision avoidance instructions. Various CAS systems are under an expedited test program by the FAA. Still another solution is to extend the current ground-based system to provide a new separation service: Intermittent Positive Control (IPC). With IPC, the ground-based system will maintain surveillance on all aircraft—controlled as well as non-controlled flights—and will transmit advisory and collision avoidance instructions when non-controlled aircraft approach each other or pose a danger to controlled aircraft. This intermittent service would only intervene into the VFR flight regime when one aircraft's course and altitude put it into conflict with another.

Discrete Address Beacon System

The Discrete Address Beacon System (DABS) is to provide the improved surveillance and integral digital data link between the ground-based ATC system and aircraft to allow higher levels of automation to be used effectively. DABS will be an extension of and compatible with the present Air Traffic Control Radar

Beacon System (ATCRBS). Some of the major advantages of DABS over the present ATCRBS are improved detection, reliability, position accuracy; unique address code for each aircraft (discrete address), and an integral data link. The design of the DABS system is such that the present ATCRBS transponders will be useable in the DABS environment and DABS can be incrementally implemented leading to an orderly, evolutionary introduction of the new system. The basic design and breadboard verification of DABS are complete, and prototype development and testing will begin soon.

Area Navigation

Presently navigation is performed along a series of straight line courses, which extend radially from VHF Omni-directional Range/Tactical Air Navigation (VORTAC) and VOR ground stations. This constrains all routes to a series of straight line segments, which results in extra mileage being flown between many terminals and has limited the number and capacity of air routes. Area Navigation (RNAV) refers to a navigation system capability which permits navigation along direct routes to most destinations. Advanced avionic capabilities have made possible the future elimination of the restrictions imposed by radial airways. They also provide aircraft with the ability to follow predetermined altitude and time schedules in proceeding from one navigational fix to the next. Integration and utilization of RNAV in two-, three-, and four-dimensional versions is a goal of the Upgraded Third Generation System. Such utilization will provide more routes, permitting possible traffic segregation by speed classes and separation of traffic headed for metropolitan areas served by several airports according to the airport of destination. Vectoring by ground-based controllers and pilot workload will be reduced, and aircraft operating costs will be lowered through the use of more direct routes and optimum climb-out profiles. RNAV development activities are primarily concerned with the proper integration of the capability into the existing ground-based system. It is possible that by 1980 the enroute airways structure at high altitudes and in those dense terminal areas where positive control is exercised will be almost entirely based on area navigation capabilities.

The Microwave Landing System

Although the present Instrument Landing System (ILS) has provided highly useful service, it has several problems which limit its use for the UG3RD. Two of these limitations are: susceptibility to reflections from objects in the vicinity of the antenna which can preclude its use at some airports altogether, and provision of only a single approach path which does not allow the flexibility required to meet the new environmental constraints.

The new Microwave Landing System (MLS) will provide more flexible and precise approach paths with less stringent site requirements. The new MLS will make possible steeper glide paths to meet V/STOL (Vertical/Short Takeoff and Landing) requirements, will extend service to many airports, and will aid in noise abatement by providing curved approaches. Its greater precision also will make possible close-spaced parallel approaches, thus increasing the capacity of many existing airports. A three-phase MLS development program was launched by the FAA in 1971 as a joint effort by the Departments of Transportation, Defense and the National Aeronautics and Space Administration. Phase I involved six aerospace industry contractors in technique analysis and design definition. Phase II, involved four contractors in the construction and test of feasibility equipments for two of the techniques studied. Phase III resulted in the selection of two contractors who are proceeding with development of prototype equipment using the selected time-referenced scanning beam technique.

Automation

Increases in the number of aircraft to be controlled normally results in a nearly linear increase in the number of air traffic controllers. This in turn results in smaller control sectors and an increase in the amount of the controller's time which is spent in coordination activities such as the transfer of control responsibility between sectors. This process increases both pilot and controller workload.

To completely replace the man as the principle element in the control loop is very difficult and expensive, and it is probably most unwise to try. Hence, the focus of the automation program is on providing automation to check the man (controller and

pilot) through implementation of automation features such as Minimum Safe Altitude Warning, Metering and Spacing, Conflict Alert, Central Flow Control, Cockpit Warning Systems and others. The NAS Stage A and ARTS III systems represent a major step forward in the automation of air traffic control. But they are only a first step, primarily providing collection, correlation and presentation of flight plan, radar, and beacon data; the controller must then use these data in the monitoring and control processes. However, these steps represent a base to which other functions can be added. Development and testing of the new functions are now underway and some have reached the stage where they can be implemented in the field.

Airport Surface Traffic Control

Increased traffic loads, coupled with weather conditions and building obstructions which block the tower controller's view of runways and taxiways, result in traffic handling problems and delays on airports. Improvement in the control of aircraft on the airport surface requires better surveillance of the airport surroundings in all weather, better guidance information for aircraft, and improved control of all airport traffic.

To improve surveillance, the current airport surface detection radar equipment is being enhanced. Even with the improvements, its performance is limited; therefore, new ground surveillance techniques are being developed and tested, with the goal being a reliable, automatic aircraft tracking system for the airport surface.

Some of the techniques being investigated include advanced radar systems, trilateration systems based on the ATC radar beacon system, and discrete sensor detection equipment. All techniques would lead to designs for a completely automated and integrated control system. The end goal is a modular design for airport traffic control that can be readily adapted to individual airport needs.

Wake Vortex Avoidance System

Trailing wake vortices, especially those generated by large aircraft, present hazards to following aircraft during approach and landing. Presently, increased longitudinal separation is used to provide safety, but this procedure significantly reduces airport capacity. Several areas are be-



Trailing wake vortices generated by large aircraft present a hazard to following aircraft during approach and landing. Shown here is the instrumentation used to develop a wake vortex avoidance system.

ing investigated. NASA is examining methods of reducing the size and hazard of vortices by modification of the aircraft wing structure.

The FAA is developing and testing ground-based systems to detect and predict the location and movement of vortices to help pilots avoid the associated hazards. Tests conducted at Denver Stapleton, Chicago O'Hare and Kennedy airports have demonstrated that pulsed and doppler radar-like devices operating at acoustic frequencies can detect and track vortices. Development and test of these devices continues on an expedited basis. Laser detectors are also being investigated. Since these detectors provide improved knowledge of the movement and effect of vortices on aircraft, it is expected that they will form a major component in a system which would detect the presence of vortices, predict their behavior and hazard, and present this information in a suitable fashion either to tower controllers, who can "tailor" aircraft spacings accordingly, or to the automation system for automatic adjustments of approach spacing intervals by the metering and spacing function.

Flight Service Stations

A new automated Flight Service Station (FSS) system is under development. The automated system will

continue to emphasize the telephone as the primary interface between the pilot and the FSS system, but the preflight briefing messages will be largely computer generated and selectively accessed through utilization of the touch-tone or dial telephones. Flight plan processing will be automated through the use of telephone accessed recording devices.

Consideration will be given to development of interfaces for more advanced portable data terminals for pilot/system interface. The main emphasis of the system improvement program is to reduce the amount of manpower required per briefing while at the same time improve the overall quality of the service provided.

Aeronautical Satellites For Trans-Ocean Flights

Air traffic control and air carrier communications for trans-ocean flights are presently conducted over high-frequency radio circuits which are of relatively low reliability and are approaching saturation in the North Atlantic and Eastern Pacific. Except for coastal areas, there is no surveillance capability in the oceanic airspace.

Separation and control are based on pilot reports of aircraft positions as determined from on-board navigation equipment. With the future air traffic loads predicted, improved

communications and surveillance capability will be required to achieve safely the required reduction in aircraft separations. The alternative will be lengthy ground delays or the use of longer and less desirable flight paths.

Although many solutions have been considered during the last ten years, there is universal agreement that satellites in geo-stationary orbits provide the best method of relaying voice and data link messages to transoceanic aircraft and of providing surveillance information to the ATC system. A joint international AERO-SAT program to test and evaluate the application of satellites to oceanic traffic control has been consummated between the U.S., Canada, and the European Space Research Organization (ESRO). The two required satellites should be launched over the Atlantic by 1980.

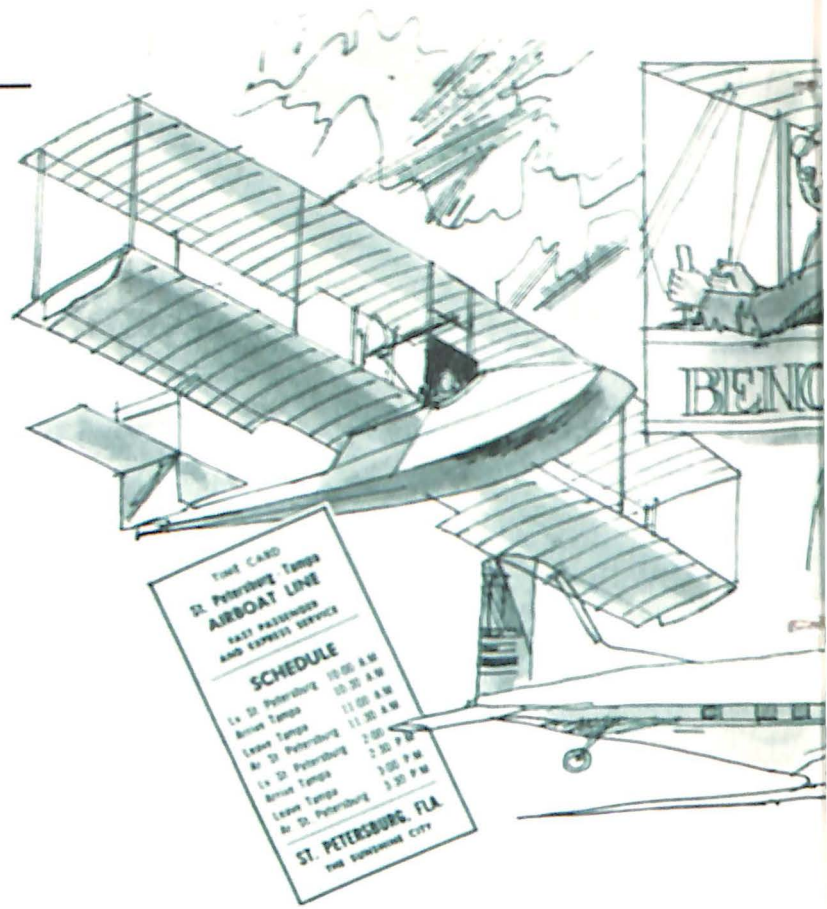
Although each of the nine features make some contribution toward improving safety, always the number one priority, most contribute to the other two objectives of improving performance with minimum costs, but many of the significant gains are only achieved by simultaneous implementation of several features. For example, the DABS surveillance system will provide the automation system with target information which is accurate and reliable enough to permit the control of aircraft safely with closer separation than is possible today.

Automation of the metering and spacing of aircraft with minimum separations being controlled by the Wake Vortex Avoidance System will permit delivery of aircraft to runways at higher rates. Use of MLS will permit this improved capability to be achieved under all weather conditions. On the surface of the airport, the ASTC will allow the controllers to clear the runways and taxiways safely and expeditiously even though they do not have visual contact with the aircraft.

In conclusion, if the nation's air traffic control system is to operate safely and effectively in the 1980s and 1990s, the major development program for the UG3RD system being actively pursued by the FAA must be completed. This system, although it still is in the engineering and development phase, contains the system improvements that will meet the challenges and needs of the future.

Air Transportation— Accomplishments, Challenges, Opportunities

BY PAUL R. IGNATIUS
President, Air Transport Association of America



It speaks well for the national mood, I think, that so many people from all walks of life and so many institutions and industries have joined in observing our country's 200th anniversary. The airline industry's opportunity to participate comes at a most appropriate time.

The U.S. airlines in 1976 will mark the 50th anniversary of regularly scheduled service. The Air Transport Association also has a birthday—its 40th—on January 1, 1976.

In the first half century of service to the growth and strength of our nation, the scheduled airlines have become the dominant form of public transportation among our cities, large and small. The Postal Service relies upon the airlines to move most of the country's first class intercity letter mail, and the airline system rapidly transports some of the world's most valuable freight.

Any meaningful response from the airline industry to its own 50th anniversary should be at least threefold:

First, let's make room for a dash of history. For the airline history has been as productive as it has been exciting, accounting for remarkable evolutions in transportation productivity, in service to the passenger and shipper, and to the Department of Defense.

Then there should be a prideful review of the present scope of the air transport system and its contribution to the country's economy.

And finally, we need to assess the seriousness of two challenges—increasing fuel prices and threats against the basic structure of the system—that must be overcome, if air transportation is to realize the opportunities for even greater service in the decades ahead.

Seaplane Service

The dash of history actually should go back more

than 50 years, to salute the first venture in scheduled airline service. It lasted for three months—from January through March in 1914—when a Benoist seaplane was operated between St. Petersburg and Tampa.

The 18-mile one-way trip was made in 23 minutes—a considerable improvement over the two hours by steamer, the six hours by car and the 12 hours via a circuitous rail route. The company, the St. Petersburg-Tampa Airboat Line, adopted as its motto "Safety First"—the forerunner of an airline priority that has never changed—and operated two scheduled round-trips a day.

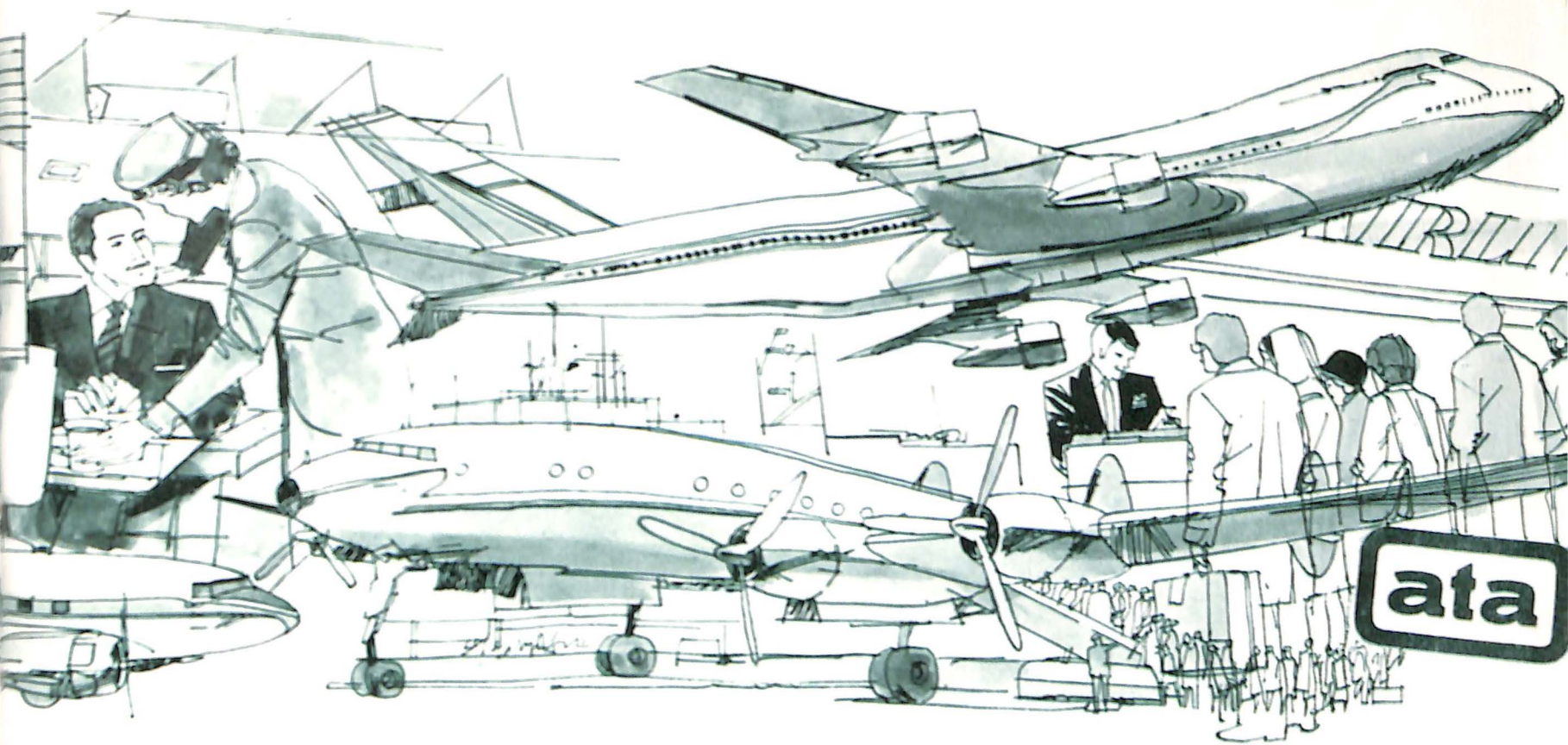
A ticket cost five dollars—usually. It was five dollars per 100 pounds of cargo and five dollars per passenger, provided the passenger didn't weigh more than 200 pounds. Above that, the charge was five cents for each additional pound.

Twelve years later, in 1926, Congress passed a landmark piece of legislation, the Air Commerce Act, from which our industry traces the beginning of scheduled air service as a continuing and increasingly important part of this country's national life.

The 1926 Act gave national impetus to the development of commercial aviation in the United States, assigning to the Department of Commerce responsibility for regulating and fostering development of a commercial airline system. As a result, airline operators now saw the prospect of profit in transporting people. Before that, the few people who did fly often sat on top of mail sacks.

Aviation writers have written volumes about the developments in commercial aviation that have occurred since passage of the Air Commerce Act of 1926. One way of compressing the highlights of this history into a few words is to take a quick look at the two evolutions that have characterized our industry: the evolutions in aircraft productivity and in improved service.

As appliers of technology, airlines and airframe and



engine manufacturers have worked together in introducing generations of new aircraft that were faster, had greater range and more capacity than the airliners they replaced.

DC-3—First Modern Airliner

The DC-3, introduced in 1936, was the first really modern airliner and the first one that could transport people at a profit. It dominated the world's air routes for more than a decade. This 21-passenger aircraft, cruising at 180 miles an hour, required 17 hours and at least three stops on a trip across the United States.

A few years after the end of World War II, aircraft such as the Douglas DC-6, the DC-7, the Boeing Strato-cruiser and the Lockheed Constellation increased airliner speed to more than 300 miles per hour and aircraft range to 3,000 miles. This made possible non-stop trans-continental flights in 10 hours. Trans-Atlantic flights were being made in about 12 hours, down from 25 hours a decade earlier.

Later in the 1950's another boost in aircraft productivity was provided by the turboprops. These aircraft formed a short but significant technological bridge between the piston-powered planes and the turbojets.

The most significant advance in airliner productivity occurred with the introduction of the commercial jets in 1958. The jets doubled airliner speed and capacity. The wide-body jets—the Boeing 747, the Lockheed L-1011 and the McDonnell Douglas DC-10—took the productivity evolution a step further.

The evolution in airline service to passengers and shippers has produced some innovations that have become part of the American way of life. Airlines pioneered the credit card, invented the flight attendant and greatly advanced the supermarket concept of travel services by providing for a rental car, hotel, and sightseeing tours for a passenger at the same time he or she reserves an airline seat.

At a cost of hundreds of millions of dollars invested in computers and other sophisticated equipment, the airline industry has produced for passengers and shippers the most advanced reservation system in all of transportation. A passenger or shipper can visit or phone the office of one airline and arrange service to any point served by that airline and most other airlines throughout the world. About 80 per cent of these reservations are made by phone—through switchboards open 24 hours a day, every day of the year.

The price tag for innovation in service and in more productive aircraft has been high. For example, the present airliner fleet of about 2,200 of the world's most modern commercial aircraft represents an investment of more than \$12 billion. But the cost of air transportation to the consumer remains one of the best buys in the economy.

Despite all the advances that have occurred in scheduled air transportation since 1948—speed more than doubled, service more comfortable and convenient—the average price of an airline ticket has increased only about 22 per cent in these 27 years. Prices generally, as reflected by the Consumer Price Index, have risen 123 per cent in these same years.

Role in National Life

Consumer value, technological advances and service innovations have given air transportation a deeply ingrained role in the fabric of national life. It is well to assess this role, in its transportation dimensions as well as in its economic and social dimensions.

- The U.S. scheduled airlines now account for almost 80 per cent of this country's intercity passenger miles of public transportation and for about 95 per cent of such travel between the U.S. and points abroad.
- Modern air service has broadened the jet set from the glamorous few of yesteryear to the people next

door. And among the more than 200 million passengers flying annually with the airlines are some of the world's most talented people in science, medicine, business and arts—people using the speed of air travel to make their talents available to more people and in more places than ever before.

- The airlines now move about eight out of every ten pieces of intercity first class mail, about 16 billion pieces annually.

- The air freight industry, increasing its volume by more than 275 per cent in the past decade alone, delivers substantial quantities of high-value goods to other industries and to retail customers, and rushes life-saving pharmaceuticals to some 3,000 hospitals and medical research facilities throughout the country.

- The airline system in this country now serves a network of 58,000 city pairs. This is the combination of city pairs between which a passenger, a letter or a freight shipment can move via scheduled air service.

- The airline industry makes many of its long-range aircraft available to support the nation's military aircraft capabilities in time of need.

- The airline industry, a substantial employer in its own right, with a work force of some 300,000, supports a much larger work force through the billions of dollars the industry invests in capital goods in the major airframe and engine manufacturing companies and among their subcontractors, large and small, throughout the country. More than 70 per cent of the commercial planes flying the air routes of the world were built in this country. First ordered by U.S. airlines, these aircraft are a most important element in the nation's export sales.

- Air transportation helps make possible a major portion of the \$60 billion tourism industry in the United States.

Serious Challenges

This brief summary of the accomplishments of scheduled air transportation points the way to further expansion in the scope of service and contributions to the national economy. But such expansion cannot be taken for granted. Indeed, continuation of the present scope and coverage of scheduled air service cannot be taken for granted—unless the industry is successful in overcoming two serious challenges.

The most immediate challenge arises from cost pressures that have combined to place the airline industry in financial difficulties. The most severe of these cost pressures comes from the soaring cost of jet fuel.

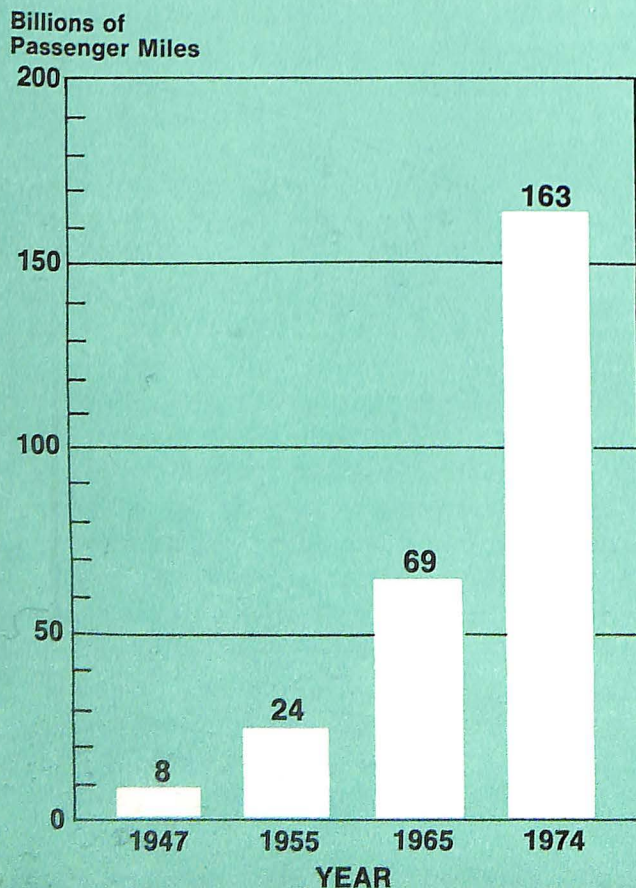
The second challenge, now in the legislative proposal stage, arises from demands for a radical restructuring of the airline industry and a dismantling of the regulatory framework that has helped produce the finest air transport system the world has ever known.

The impact of skyrocketing fuel costs on the airlines is pointed up in the fact that the price of jet fuel was running about 12 cents a gallon for this country's airlines in April, 1973, when fuel accounted for about 12 per cent of direct operating costs.

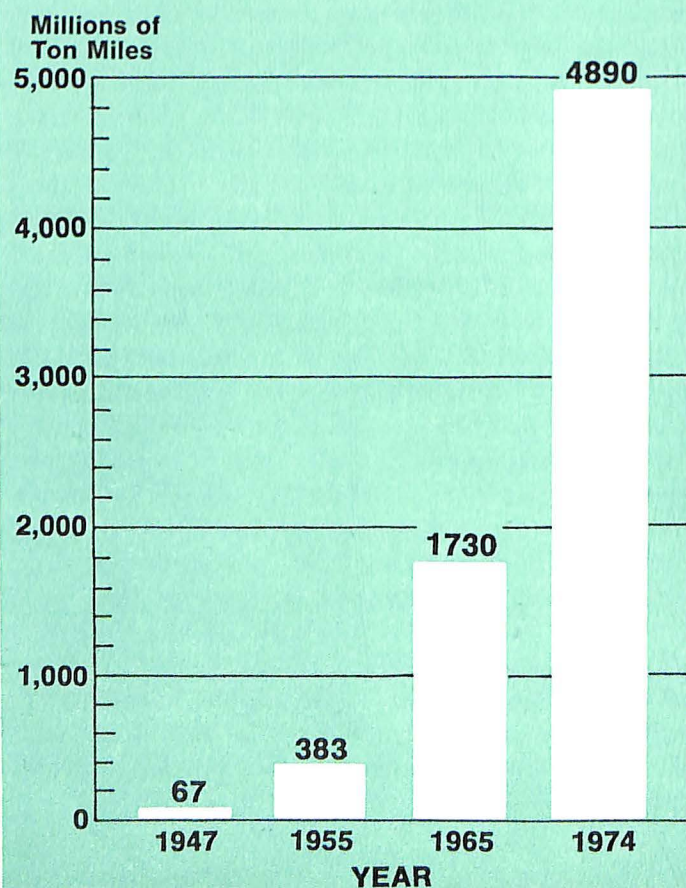
Now the U.S. airlines are paying, on average, about 29 cents per gallon, and fuel accounts for about 20 per cent of the industry's direct operating costs. Each penny increase in the price of a gallon of jet fuel increases the airline industry's annual fuel bill about \$100 million.

In 1973 the airlines launched comprehensive programs of fuel conservation, and consumed a billion gallons less fuel in 1974 than in 1973; but their fuel bill increased by more than a billion dollars. The fuel bill increases continued in 1975 at the rate of about \$1.4 million a day.

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The doubling of fuel costs in domestic service and their tripling in international service have reduced airline employment, grounded aircraft and wiped out profits for some carriers. Further escalation in the price of jet fuel could result in a further reduction of service.

Airlines could be forced to cancel or delay all or part of the billions of dollars needed for investment in new aircraft and support equipment for the last half of this decade and beyond. The investment is needed to keep providing the quietest, cleanest, most productive commercial aircraft for the world's finest public transportation system.

Deregulation Problems

If the airline industry fuel price problem has impacted the aerospace industry, the same is true of the problems deregulation would create in making it nearly impossible to determine future needs for commercial aircraft.

An uncertain and unstable airline market entry and exit environment would be far from conducive to the long and costly process of developing new aircraft. Manufacturers would find it difficult, if not impossible, to make meaningful plans. Similarly, the airlines would find it difficult, if not impossible, to find the financial resources for new aircraft because heretofore meaningful route franchises, which have provided the basic foundation for securing capital, would be severely downgraded by market entry and exit instability.

Deregulation is proposed as a magic elixir to lower the price of air transportation. No deregulation scheme yet proposed addresses itself to the key elements going into the price of air transportation—the costs of providing the service. If total deregulation occurred tomorrow:

- The price of jet fuel would not go down.
- Skilled airline employees would not work for less.
- Airport operators would not lower their landing fees.
- Nor would other suppliers of goods and services to the airlines lower their prices.

The one thing that would go down would be the widespread availability of airline service.

The most far-reaching deregulatory proposals appear to be grasping at an utopian shadow, at the risk of losing the substance—in this case the substance of the best air transport system in the world.

Fortunately, there is growing awareness in Congress and in communities throughout the nation of the need to preserve and strengthen the scheduled air transportation system. There is, of course, recognition that some changes in the regulatory process are desirable, such as streamlining procedures to combat "regulatory lag." But it is essential that no actions are taken which would degrade the air transportation system.

The first 50 years of scheduled air transportation have demonstrated the capabilities of the airline industry to accept and overcome great challenges and to embrace and fulfill ever-expanding opportunities for service to the nation.

At this birthday observance, the men and women of the airline industry, with their many partners in transportation progress, look forward to another exciting 50 years ahead, filled with new challenges and new opportunities.

AEROSPACE INDUSTRIES ASSOCIATION

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Revenue passenger miles flown by U.S. scheduled airlines jumped from 8 billion in 1947 to 163 billion in 1974, an astonishing increase of nearly 2,000 percent. (See *Air Transportation — Accomplishments, Challenges, Opportunities*, p.14).



