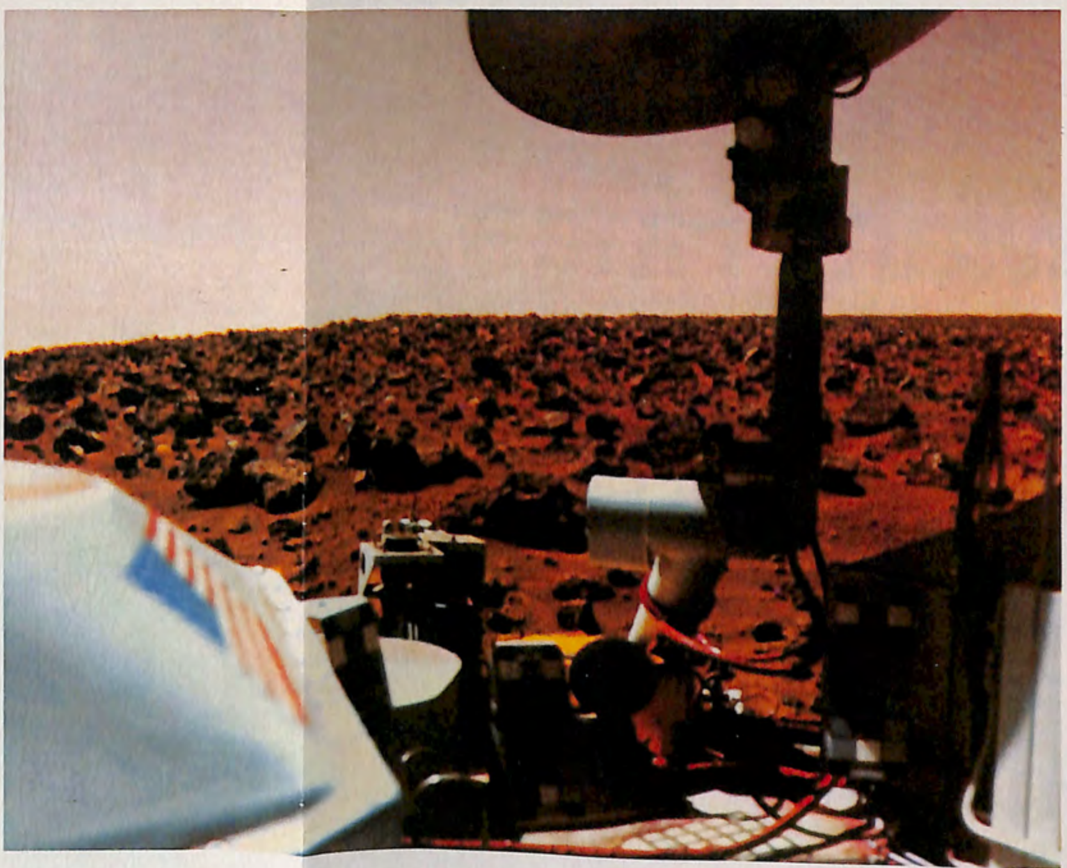
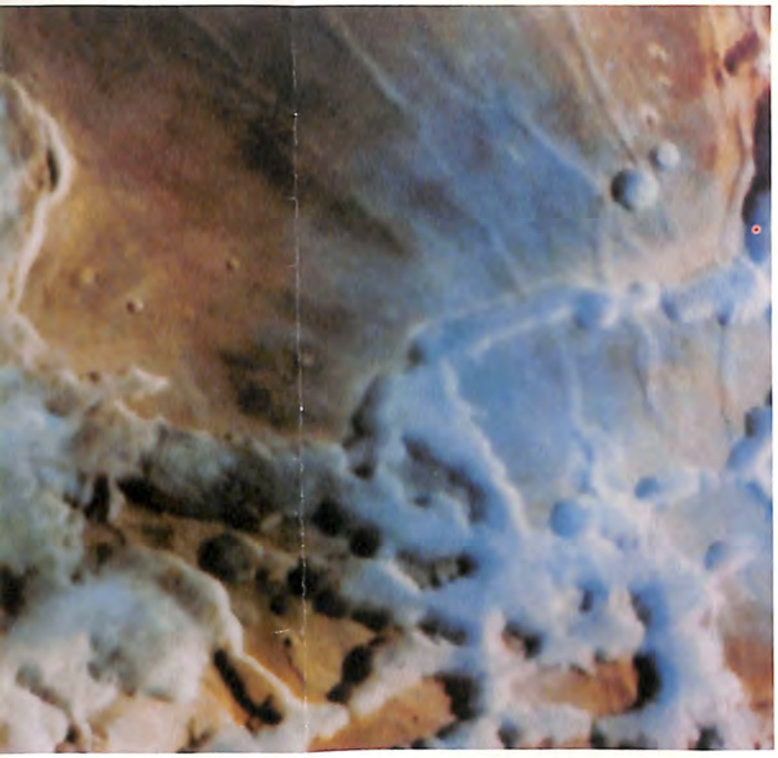


This striking photo of the Martian surface and sky was taken from lander II in November, 1976. The color calibration charts are shown in the foreground. Suspended dust particles are the cause of the salmon hue in the sky.

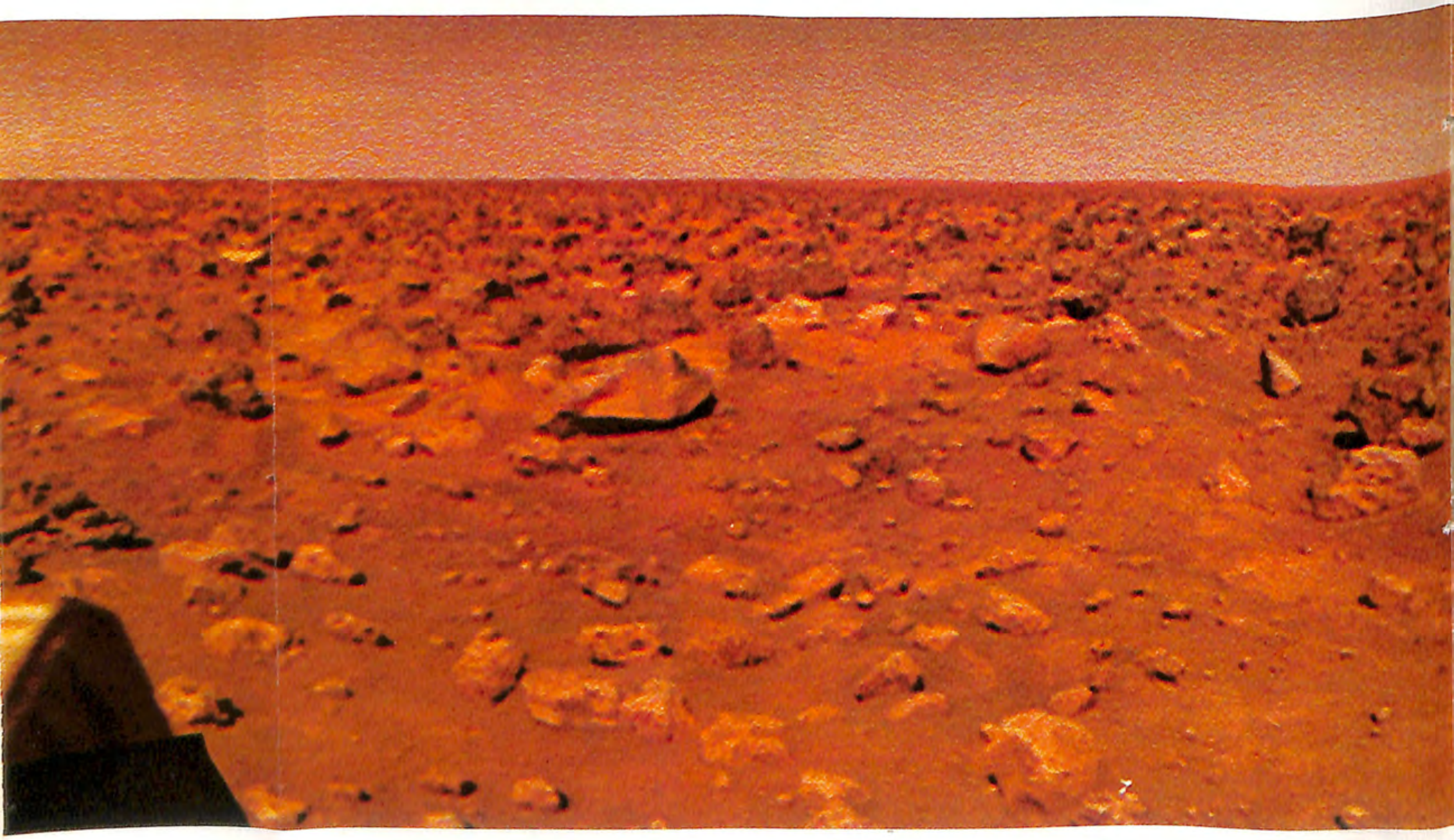
A Martian dust storm in the 1976-1977 Martian winter is shown in this photo from orbiter II. A bright dust cloud (arrow) covering 186 miles of the great Argyre Basin in the southern hemisphere of Mars is apparently moving eastward with strong winds.

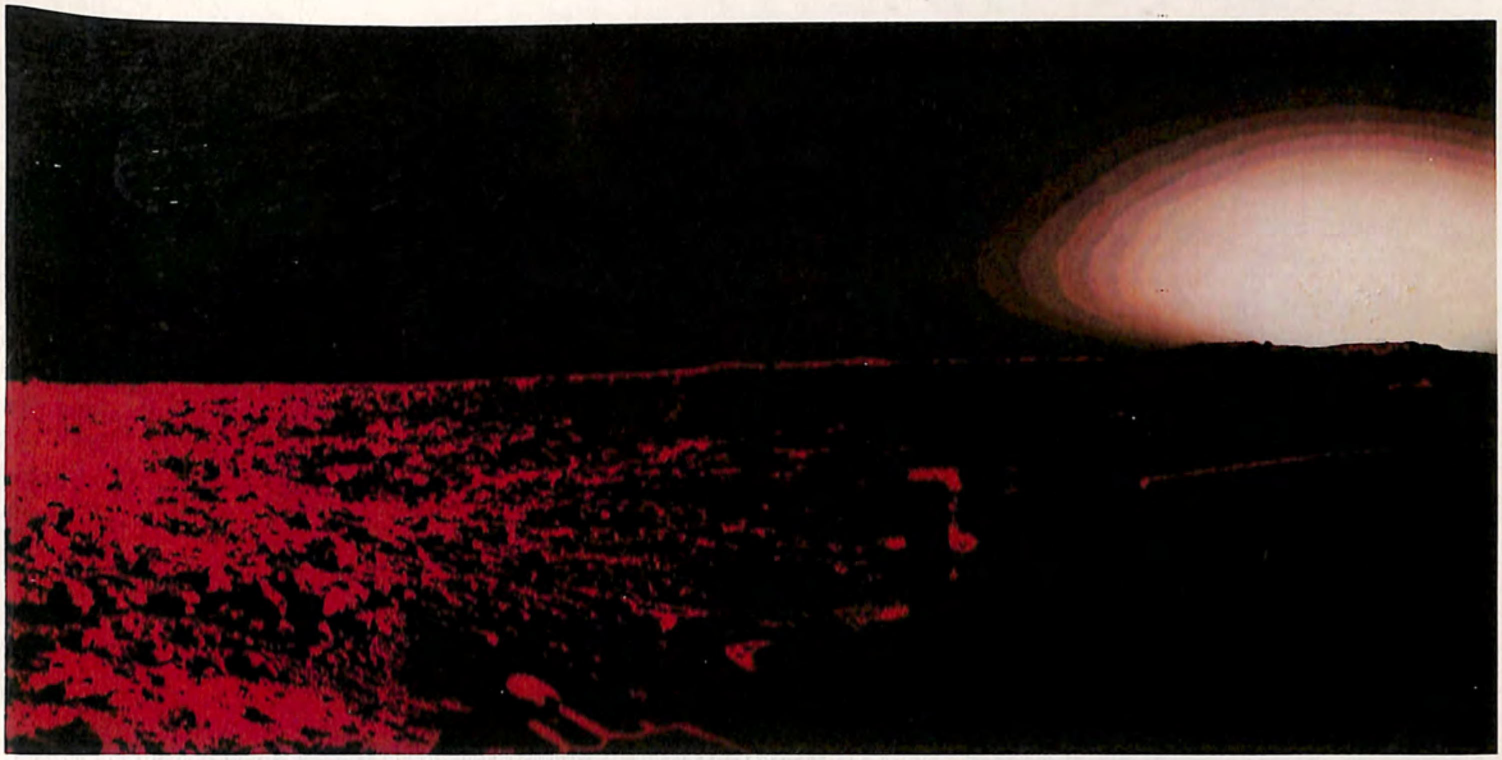
"Big Joe", its nearly 7 foot long top covered by fine red dust, stands out on the landscape 26 feet away in this view from lander I.

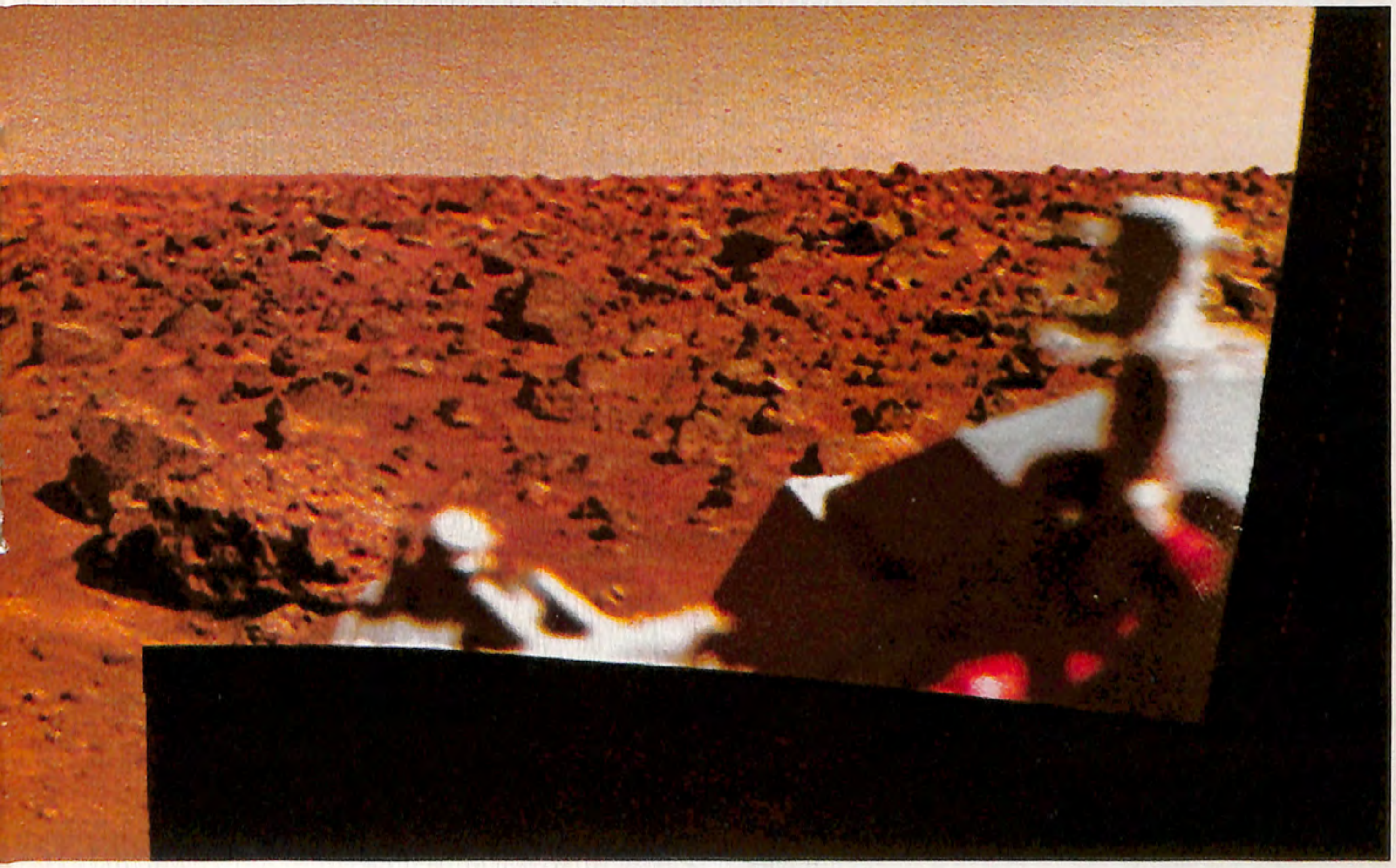


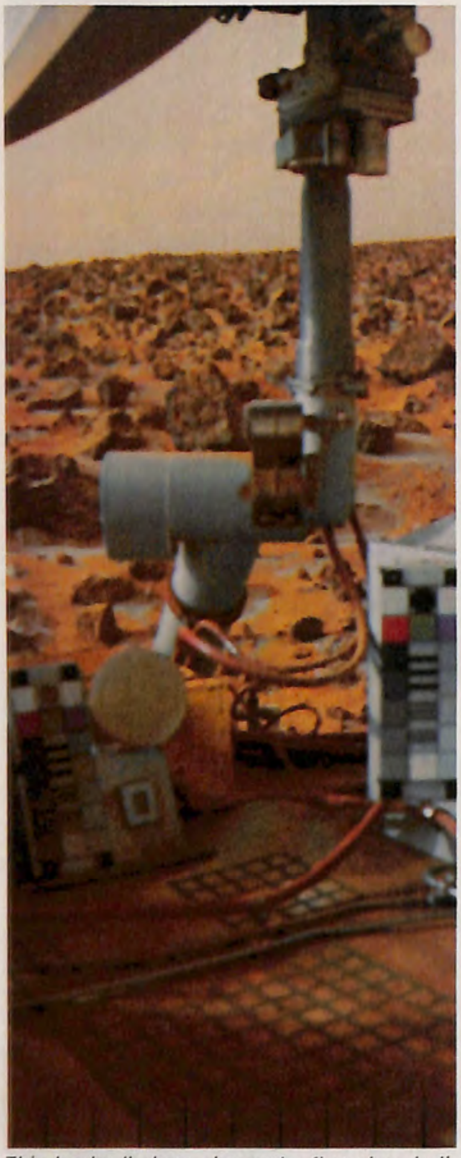
Bright clouds of water-ice can be seen in the tributary canyons as the Sun rises over Noctis Labyrinthus, a high plateau region of Mars. The area seen is about 4000 square miles. The photo was taken by orbiter I on its 40th revolution of the planet.

This dramatic sunset on Mars is captured through infrared filter of the Viking lander I's camera on August 20, 1976. The photo took six minutes to complete, providing the shading effect as sunlight strikes particles in the atmosphere. Red at left is caused by heat from surface rocks.

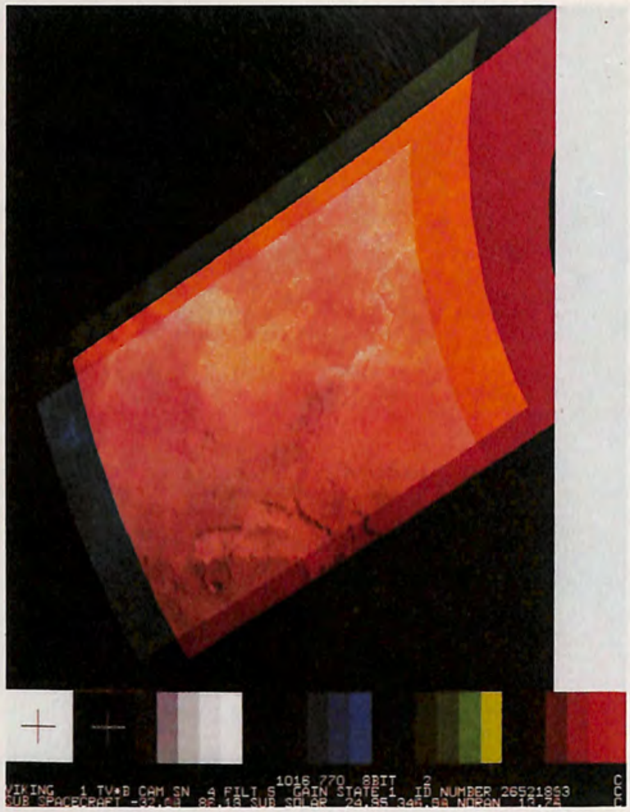




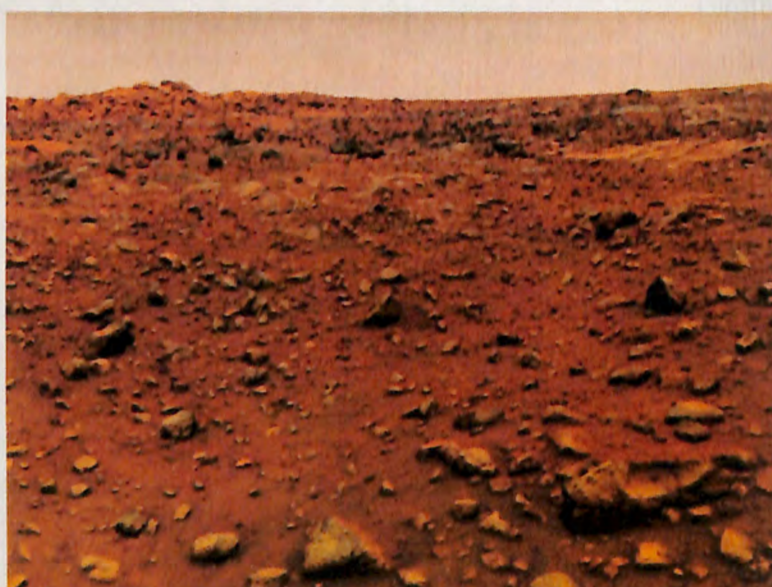




This lander II photo shows the first clear indication of frost accumulation on the Martian surface as seen by the lander cameras. This late winter photo shows the white accumulations around the bottom of rocks and scattered patches on the darker surface. Scientists say the frost is most likely carbon dioxide frost due to temperatures recorded by instruments on the orbiter.



Three separate photos were computer processed to make up this photo of Valles Marineris. They were taken by orbiter I through red, green and violet filters and used to detect color variations that may show compositional mineralogical differences.



The first color photo from Mars taken July 21, 1976, the day following lander I's successful landing on Mars, shows the orange-red surface material that covers most of the planet. Local time was noon.

tory (orbiters) and Martin Marietta Aerospace (landers), are still there. One of them—orbiter II—is now silent, turned off when its attitude-adjustment fuel was expended. The others are still reporting data and will continue to do so through next February. Collectively, the Viking spacecraft have returned tens of thousands of photographs and billions of "bits"—informational signals—of Mars data.

The Viking program is a monumental triumph of unmanned space exploration. The technological accomplishments are extraordinary. The NASA-industry Viking team had to build four of the most sophisitcated spacecraft ever launched; they had to send the robot vehicles more than 400 million miles through space to rendezvous with a moving planet; they had to separate the lander and orbiter elements of each vehicle and guide them to their planned positions; and they were able to direct the operations of all four spacecraft, even to effect repairs, over the vast distances that separated spacecraft and controllers.

Viking is an enormous success. The range of scientific information acquired is so broad it would take a volume of telephone-book size even to encapsulate it, but here are a few examples of the findings:

- No clear-cut evidence of Martian life was found at either landing site, but this does not rule out the possibility of life elsewhere on the planet. Though inconclusive, the information is valuable in planning strategy for future exploration of Mars.
- Mars has an abundance of water, nearly all of it frozen in polar ice caps or subsurface layers.
- Clouds are common and diverse, many of them containing water.
- Massive dust storms are frequent; two of global scale were reported in a single year's observation.
- The Martian atmosphere is 95 percent carbon dioxide and 2.5 percent nitrogen. Mars has more of the heavy form of nitrogen than does Earth, an important clue to Mars' evolutionary history.
- Temperatures range from 62 degrees Fahrenheit to 225 degrees below zero. Daily temperatures vary one hundred degrees or more in the summer but only about nine degrees in winter.
- Mars' weather system is considerably less complex than that of Earth.
- Only one minor Marsquake was recorded, indicating that Mars is much less internally active than Earth.
- Mars' surface material is composed of iron-rich compounds, with some sulfur and chlorine compounds.
- Mars' two moons, Phobos and Deimos, are substantially less dense than the planet itself and apparently of different composition. This supports the theory that the moons were formed elsewhere in the universe, became asteroids and were captured by Mars' gravity. Thus, they may offer important evidence of conditions existing at the time the solar system was formed.

These and hundreds of other Viking findings are immensely valuable to the scientific community, and, in the long run, to everybody. They provide a basis for comparing conditions on Mars with those on Earth and other planets. "Comparative planetology," as NASA calls it, is developing clues to the origin, history and structure of the solar system and shedding new light on the processes that govern our own planet Earth. With better understanding of these processes will come the possibility of managing them to mankind's advantage. The Viking program represents a major step in that direction.

THE VIKING TEAM

Overall management of the Viking project was the responsibility of NASA's Office of Space Science. The major portion of the management task was delegated to NASA's Langley Research Center. Jet Propulsion Laboratory handled mission control, tracking and data acquisition. Other NASA organizations involved were Ames Research Center (biology unit research and development); Lewis Research Center (launch vehicle development); and Kennedy Space Center (launch and flight operations).

Assigned to develop, build and test the major hardware elements were:

Landers: Martin Marietta Aerospace.

Orbiters: Jet Propulsion Laboratory.

Launch vehicle (Titan IIIE/Centaur): Martin Marietta Aerospace (Titan IIIE) and General Dynamics Convair Division (Centaur).

Martin Marietta's subcontractors for the Viking landers included:

Teledyne Ryan Aeronautical, Electronic and Space Systems, radar altimeter and landing radar.

Sheldahl, Inc., landing parachutes, bioshields, landing leg covers.

RCA Astro-Electronics Div., lander communications subsystem.

TRW Inc., biology and meteorology instruments.

Celesco Industries, surface sampling equipment.

Itek Corp., Optical Systems Div., lander cameras and photo reconstruction equipment.

Goodyear Aerospace Corp., Mars-landing decelerator system.

Honeywell Aerospace Div., lander guidance and control, sequencing computer; also Centaur guidance.

Bendix Aerospace Systems Div., three major lander science instruments

Rocket Research Corp., deorbit, control and landing engines.

Today there are more than 7,000 civil helicopters operating in North America alone, almost three times as many as there were only a decade ago. There are additional thousands of rotorcraft in foreign civil use and in service with the world's military forces.

As their numbers have grown, so have the uses of rotary wing aircraft. Along with such traditional jobs as short-trip transportation, pipeline patrol, crop treatment and traffic reporting, the versatile helicopter continues to broaden its work spectrum to include a great variety of new assignments, for example, off-loading cargo ships, pouring concrete in construction projects, airlifting bank checks for faster clearance and harvesting timber tracts once considered inaccessible. There has been similar expansion of helicopter employment in military service; once primarily an observation and rescue vehicle, the helicopter is now an active combat system with assignments in such areas as large-scale movement of assault troops, anti-armor and anti-personnel attack, and anti-submarine warfare.

In short, rotorcraft have come a very long way since Igor Sikorsky made the first successful helicopter flight 39 years ago. And, says a NASA Rotorcraft Task Force, there is still a lot of growth potential. It appears feasible to develop, for use about 1990 and thereafter, some very advanced rotorcraft: city-to-city transportation vehicles capable of helicopter-like vertical lift combined with the faster forward speeds of fixed-wing airplanes; big rotary-wing commercial transports carrying 100 or more passengers; and very large rotorcraft lifting as much as 150 tons of cargo.

In the interim, the task force report predicts, there will be continuing expansion of rotorcraft service. The petroleum industry, already using hundreds of helicopters to service offshore drilling rigs, is expected to spend $6 billion on helicopters and helicopter services over the next decade. Other areas where expansion of helicopter usage is indicated include commercial transportation, particularly for short trips of 20 to 250 miles; construction; logging; forest protection and management; public service operations, such as fire-fighting, rescue, disaster assistance, ambulance duty and law enforcement; and cargo transfer operations, for instance, airlifting complete containers for loading or unloading ships.

Assuming a 10 percent annual growth in overall rotorcraft operations—a conservative figure in light of recent experience—the number of active helicopters, heliports and operators could approximately triple by 1990.

Thus, the potential world market for both civil and military rotorcraft is enormous. But there is a problem for U.S. rotary-wing companies, one similar to that confronting American jetliner manufacturers: improved technological competence and aggressive pursuit of a larger market share by foreign competitors threatens U.S. leadership in rotorcraft development and production. Foreign producers are already making inroads in the rotorcraft field, says the task force report, which cites these statistics:

• Of more than 28,000 helicopters built through 1976, 84 percent were of American design and the remaining 16 percent of European design.

• A new survey estimates that the European share of the 15,000 helicopters to be produced by free world nations in 1977-83 will increase to 38 percent.

What U.S. rotorcraft builders need to meet this new challenge and maintain their long-held leadership is a major infusion of new technology to enhance the attractiveness of future American rotorcraft products. NASA has identified a number of opportunities for advanced technology development and the task force recommends that the U.S. pursue these opportunities by increasing the investment in rotorcraft research and development.

The group proposed funding levels, over the next several fiscal years, ranging from double to almost four times the current level. NASA has not approved the expanded rotorcraft program, but the recommendations are being considered in formulation of the Fiscal Year 1980 budget request, now in preparation. Congressional sanction, of course, would also be needed for increased funding. But in view of the national goal of increasing export sales and particularly high-value exports, the relatively modest sums proposed for accelerated rotorcraft R&D would seem to be a good investment. There appears to be a good chance for

ROTORCRAFT R&D:

Heavy Lift Helicopter. Artist's concept shows heavy lift helicopters of the future servicing an offshore oil rig. The drawing is based on the design of the Boeing Vertol XCH-62A, which can lift 35 tons. The huge helicopter is a candidate for further development in a proposed accelerated rotorcraft research program.

some degree of expanded rotorcraft effort.

The Rotorcraft Task Force, which included representatives of the military services and the Federal Aviation Administration as well as NASA people, outlined these areas where opportunities exist for technology/advancements to meet predicted needs for both civil and military rotorcraft:

- New rotorcraft configurations for the advanced vehicles to be operational in a decade or more.
- Greater point-to-point speed.
- Significantly improved load-lifting capability.
- Major reductions in vibration and noise.
- Advanced propulsion systems.
- Lighter, more efficient rotorcraft structures.
- Further improvement in flight control and all-weather capability through a variety of advanced technology avionic systems.

The broad program contemplated would involve, in many instances, joint participation by NASA and the Department of Defense, with industry assistance. Much of the research and development would be carried out on the ground—in wind tunnels, laboratories, propulsion test stands, rotor whirltowers and other facilities. There would also be extensive flight testing. Among current and future flight programs there are several of particular interest, because the vehicles' designs and capabilities provide indications of tomorrow's directions in rotorcraft operation. They include:

Rotor Systems Research Aircraft (RSRA). A joint NASA/Army project, the Sikorsky-built RSRA is a unique "flying wind tunnel," an aid in developing technology for increased rotorcraft speed and general performance; improved safety; and reduced vibration, noise and maintenance requirements.

The RSRA is an airborne laboratory. Instruments for measuring flight loads are built into its fuselage and the main rotor support structure contains devices for measuring the forces acting upon the rotor during flight, just as is done in a wind tunnel. But the RSRA can also perform certain tests which cannot be accomplished in wind tunnels, for example, investigating a rotor system throughout a wide range of flight maneuvers. The vehicle offers research economy by eliminating the need to build a new machine or modify an existing helicopter for flight tests of each promising new rotor concept; it provides a standardized base for evaluating many different rotor systems on the same aircraft and under the same conditions.

The RSRA has a special capability: it can be flown either as a conventional helicopter or as a compound helicopter, a winged rotorcraft which is capable of greater cruise speed although it retains the helicopter's vertical flight characteristics. This concept holds considerable promise for future short-haul transportation and it will be thoroughly explored with the RSRA, which becomes a compound helicopter by the addition of two turbofan engines and a 45-foot wing. The craft made its initial flight as a compound earlier this year.

Sikorsky has built two models of the RSRA and is currently conducting preliminary flight tests. Advanced flight testing will begin soon at NASA's Ames Research Center, Moffett Field, California.

Tilt Rotor Research Aircraft. Also a joint NASA/Army project is the XV-15 Tilt Rotor Research Aircraft, two models of which have been built by Bell Helicopter Textron to explore another method of combining the best features of the helicopter and the fixed-wing airplane. The XV-15 has large rotors like those of a helicopter for vertical take-off and landing. Once the craft is airborne, the rotors tilt forward to become propellers for cruise flight at speeds far in excess of conventional helicopter speeds.

Earlier this year, the first two XV15s completed five weeks of wind tunnel testing, including operation as a helicopter and as an airplane. The second vehicle is now starting hover tests at Bell's Arlington Flight Research Center, Texas. In a later series of flights, the angle of rotor tilt will gradually be increased until full conversion from the helicopter mode to the airplane mode is achieved; that is expected by the end of 1978. Thereafter, NASA and the Army will use the two XV-15s in a lengthy research program exploring both the civil and military potential of tilting rotor aircraft.

ABC System. The "ABC" stands for Advancing Blade Concept, a Sikorsky-developed method of combining the

TOMORROW'S POTENTIAL

Tilt-rotor Plane. Shown on its first hover flight earlier this year, Bell Helicopter Textron's XV-15 combines the best features of helicopters and fixed-wing aircraft. Its rotors operate in the horizontal plane for helicopter-like take-off, then tilt forward to become propellers for fast forward flight.

Flying Wind Tunnel. The NASA/Army/Sikorsky Rotor Systems Research Aircraft is an airborne laboratory for testing a variety of advanced rotor systems. It can be flown as a conventional helicopter or, as shown above, as a compound helicopter, a winged rotorcraft which has the higher cruise speed of an airplane although it retains the helicopter's vertical flight characteristics.

advantages of the low-speed helicopter with those of a relatively high-speed aircraft without the use of a wing. The ABC system has two counter-rotating main rotors mounted one above the other on a common shaft; it does not require the customary tail-rotor to counter torque, and therefore design eliminates the complicated "plumbing" needed to drive the tail rotor.

Under an initial Sikorsky/Army program, an ABC technology demonstrator called the XH-59A was flown extensively in the pure helicopter configuration. These tests confirmed a number of advantages inherent in the ABC system—simplicity, improved maneuverability, low noise, high hover efficiency, and the ability to maintain high helicopter speeds—about 180 miles per hour—at high altitude.

The ABC flight program is now entering a new high-speed phase, which involves the addition of two Pratt & Whitney turbojet engines mounted on the sides of the fuselage. The auxiliary engines have been installed and high speed flights are about to begin at Sikorsky's Development Flight Test Center in West Palm Beach, Florida. This advanced phase of ABC development is being jointly funded by NASA, the Army and the Navy, with the USAF providing the auxiliary jets. The Advancing Blade Concept offers promise for future vertical lift/high speed applications, such as short-haul commercial transportation and such military uses as antisubmarine warfare, vertical assault, surveillance and search/rescue.

X-wing System. A considerably different approach to combining rotorcraft and fixed-wing performance is Lockheed-California Compay's X-wing design, in which the rotor becomes a fixed wing. The systems employs a four-bladed wing, shaped like an X, which rotates for vertical lift operations, but locks in place to become a fixed wing for high-speed horizontal flight.

This concept is being evaluated in a program sponsored by the Defense Advanced Research Projects Agency (DARPA). The design offers considerable flexibility for future military aircraft, which could operate as helicopters, or as fixed-wing craft where runways were available, or as convertibles where both helicopter take-off and airplane speed were needed; it also has civil-use potential. A turbofan-powered X-wing airplane could reach speeds up to 233 miles per hour in the helicopter mode and subsonic jetliner speeds in the fixed-wing configuration.

A one-quarter scale model of an X-wing aircraft has been wind tunnel tested at the David Taylor Naval Ship Research and Development Center, Carderock, Maryland. Lockheed has also built a full-scale 25-foot-diameter X-wing and control system. The quarter-scale tests were limited to the fixed-wing mode; the full-scale system will be checked out in both the rotary and fixed-wing modes at speeds up to 200 miles per hour in the subsonic wind tunnel at NASA's Ames Research Center. Under the contemplated expanded NASA/DoD rotorcraft program, the X-wing concept would be further examined in flight tests.

Large Rotorcraft. For future civil and military applications, rotorcraft planners see a number of potential applications for large rotary-wing aircraft—meaning vehicles with passenger-carrying and load-lifting capabilities far beyond those of currently operational rotorcraft. One example is a civil transport helicopter accommodating about 100 passengers, which could be available in the late 1980s. Looking farther down the road, the Rotorcraft Task Force envisions someday transport craft handling as many as 250 passengers or 60,000 pounds of cargo; they would range as far as 800 miles with speeds from 180 to 350 knots. In the "very heavy vertical lift" category, there is potential utility for a short-haul rotorcraft capable of hauling loads up to 150 tons, many times the lifting ability of the largest helicopters in service today.

Initial work on super-size rotorcraft would focus on design studies and model tests. Eventually, NASA might build and fly an advanced technology large rotorcraft vehicle. As an interim step, NASA is considering revival of a dormant project, the Boeing Vertol XCH-62A Heavy Lift Helicopter (HLH). The Army initiated this project in the early 1970s but was forced to terminate it in 1975. The project was well along when it was cancelled; all of the flight hardware for the giant helicopter has been stored and is now available. The XCH-62A assets provide an opportunity to move into an advanced heavy lift research and development program on an "affordable" basis, taking advantage of the $180 million already spent in earlier work. It would cost only $35-40 million, spread over several years, to complete and fly the vehicle.

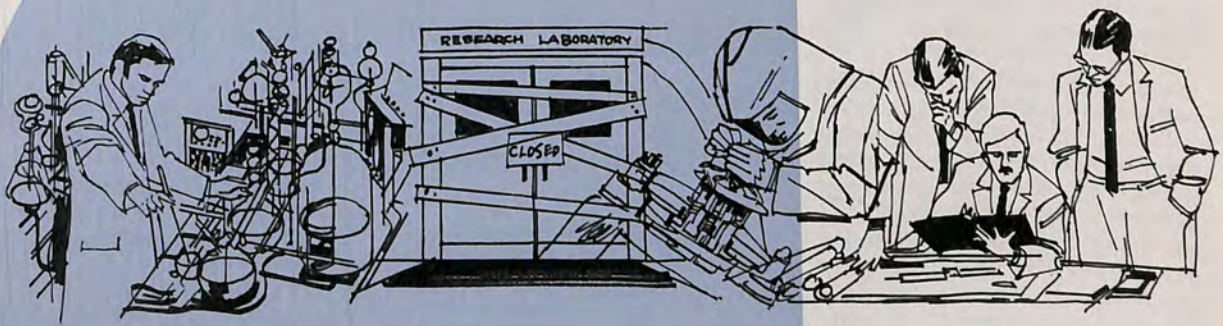
Powered by three turbine engines driving two large four-bladed rotors, the Boeing Vertol HLH is a huge craft with a design lift capability of 35 tons. It could serve as a technology-developed forerunner for future "jumbo rotorcraft" with wide military heavy lift applications. It could also pave the way for development of inter-city commercial transport rotorcraft whose high capacity—100 passengers or more—would make economically feasible this long-envisioned addition to the world's air transportation system.

X-wing Aircraft. Shown being prepared for wind tunnel testing is a one-fourth scale model of Lockheed-California Co's X-wing aircraft, designed to operate like a helicopter when its wing is rotating or to fly at high subsonic cruise speed when the wing is locked in position.

ABC System. The Sikorsky XH-59A pictured is a technology demonstrator for the company's Advancing Blade Concept, which combines the vertical lift advantages of a helicopter with the speed of a fixed-wing aircraft—but without the use of a wing. The craft is shown in helicopter configuration; in new tests just getting under way it has two auxilliary jet engines for high speed cruise flight.

TECHNOLOGY

Biting the Hand that Leads Us



Over the years many AIA companies have spoken out on issues of special importance to our nation. Some of the most thoughtful statements in recent months have been made by Gould Inc. in a series of "white papers" on the relationship of technology to national growth. Aerospace has excerpted the following article from the Gould report, "Technology and Scientific Inquiry." For the full text of this and other Gould perspectives on the importance of technology to our nation, write to Gould Inc., Dept. W9-5, 10 Gould Center, Rolling Meadows, Illinois 60008.

The 1977 Nobel Prize Ceremony resulted in an almost embarassing domination by American scientific achievement. It was acclaimed by many as yet another glowing testimonial to the long tradition of American scientific and technological superiority.

But the 1977 Nobel Prize Ceremony and the acclamations that followed are a smoke screen covering an increasingly critical problem that could dramatically affect all our lives very soon.

The prizes American scientists received in 1977 were the result of work begun in the late 1950s and early 1960s. Since then, our interest in investment in scientific inquiry and technological development have dramatically declined. We appear to have taken our tradition of technological supremacy for granted. Even placed it under suspicion. As a result, we have not made the investment in time, talent and money to make certain the technologies we will need to solve tomorrow's critical problems will be available and not mere dreams.

Unless we somehow renew our commitment to science and technology, we won't be invited to the Novel Prize Ceremonies in the 1980s. But even more important, we will have to suffer the consequences of our inaction.

Technology has significantly improved the quality of our lives over the past 200 years. Where did it really come from?

If you made a list of the major scientific developments over the past 200 years, your list, no doubt, would include the computer, the electric light bulb, the transistor, the internal combustion engine, television, the laser, atomic fission, radar, penicillin, the airplane and space science.

When you examine the specifics of the development of these technologies, it becomes apparent that our image of technological supremacy is more illusion than fact, and that we need to better understand where we are now, how we got there, and where we should be going. Consider:

1. Most of the discoveries listed above were initially the result of work people did, or began, in other countries. American scientists principally applied basic research from abroad, refined it, or extended it.
2. The majority of the technological extensions listed above evolved from work done on American college or university campuses. From minds trained on American soil and sup-

ported by American business.

3. Most of the recent advances in science and technology have resulted from a national emphasis on and reward for scientific achievement that reached a peak in the 1950s and 1960s—*not* from work done in the 1970s.

It may look to us like a lot is going on. But our new pocket calculators and business machines, computers, video games, microwave ovens, digital watches, fuel-injected automobiles, supersonic aircraft, space satellites, and telecommunications systems are really the result of the application and extension of 10- to 15-year-old science.

For the past 10 years, the public and government have viewed "new science" as a luxury we can't afford. Thus, investment in and support of scientific inquiry have been extremely conservative.

Technological progress, however, is still the cornerstone of our social system. But it requires gifted people, not "tinkers." Today's scientists, and tomorrow's, will need extensive training if they are to develop the scientific solutions we need to solve the critical problems now, and in the future. Where will that training come from? Our colleges and universities, of course. But that may not be possible.

Our colleges and universities are no longer able to provide the facilities, programs, and professors that tomorrow's scientists will need.

The well is running dry. For the past 10 years, The Council for Financial Aid to Education has warned business and the public that America's colleges and universities are in serious financial trouble.

Government funding and support, expressed in constant 1967 dollars, has declined by more than 20% since that year. Funds for equipment and facilities have been cut by more than 50% since 1967. Grants have been eliminated. University scientists are hampered by instability in federal funding and by red tape in the administration of contracts. Long-term projects designed to evolve the solutions to tomorrow's problems have been abandoned and replaced by fewer short-term projects aimed at providing stopgap solutions to more immediate problems. And financial stringency has limited the career opportunities of young scientists and threatens to drive them to other, less productive environments.

There is a reason. Our political system naturally poses pressures to satisfy the majority and spread its resources over a large number of claimants. If there is too little money to satisfy all claims, the needs of institutions of special quality—such as research-oriented schools—are readily dismissed as elitist and unnecessary.

As a result, the underlying foundation of American science—our colleges and universities—is today inadequate to support and direct the progress of future technological growth.

Significantly reduced R&D investment by American business is the other half of the problem.

In 1976, industry spent $38 billion for R&D. Measured in deflated dollars, this represents a 5% drop from 1968. As a percentage of our GNP, R&D spending has averaged 2.4% in the 1970s thus far, as compared to 2.9% in the 1960s, a reduction of over 17%. In contrast, Japan has steadily accelerated investment in R&D by 74% since 1950. And West Germany has increased R&D investment by 40% since 1968.

The federal budget reveals a major reason for the dwindling dollars. In 1965, 12.6¢ of every dollar spent by the government went for R&D. By 1975, this share had dropped to 5.7¢. Industry R&D spending has barely held even with inflation.

No wonder the list of technological achievements is getting shorter.

Basic research, applied research, or development? Where should our money be?

R&D involves three kinds of efforts. "Basic research," where new knowledge is sought. "Applied research," which works toward practical application of existing knowledge. And "development," where new products emerge.

Financially, "basic research" has suffered the most—dropping about 10% from 1968. Because industry and the public have demanded more emphasis on short-term application R&D that will provide quick results rather than invest in more expensive, long-term inquiry that could solve many of the world's health, energy, food, population, and economic problems.

"Applied research" also suffers from lack of funding. Up to now, this area has been responsible for our technological reputation. But now industry must direct much of its R&D effort and funds toward creating products that comply with new federal regulations—such as pollution control, worker safety, and product safety—and divert funding from other, less immediate projects. As a result, there isn't enough left over to pay for the kind of widespread effort that has been largely responsible for our rapid technological growth over the past century.

"Development" is what we now have most. That's why the public thinks we're still technologically superior and moving ahead. But development can only occur as the final step. We must invest first in basic and applied research. Only then can development evolve the answers to our critical problems.

All too often, we overlook the facts behind our tradition and embrace the illusions.

Fact #1: Up to 1880, our technology was imported.

Up to 1850, we were basically an agricultural country that imported both the equipment and technology to help us grow.

Between 1850 and 1880, America changed from an agricultural economy to an economy increasingly dependent upon the technology that would create whole industries and complex products.

The first stage of technological progress involved laying the railroad tracks, stringing the telegraph and telephone lines, and digging the coal, copper, and steel that industry needed. And during this period the older arts of cotton manufacturing, iron casting, and forging shared popular attention.

The technologies and research needed were brought, or bought, from abroad. For we had little time to spend in the labs. And we didn't have the labs to spend the time in.

Fact #2: From 1880 to 1940, technology evolved by shrewd guessing.

As the need for increased scientific inquiry and research grew in response to the demands of the industrial revolution, so too did the environment for technological growth.

Our basic science was still imported. But American scientists began to work toward extending and applying the principles imported from abroad.

Yet our country was not led by scientific management. Instead, popular opinion and shrewd guessing directed technological growth. The probabilities of good fortune and success were exceedingly high—witness the work of Edison, Rockefeller, Ford, Carnegie—but it was still guessing. Guessing, characterized by scientific insight that brilliantly applied the ideas and theories of others to evolve such technological achievements as the automobile, the telephone, electric lamps, agricultural machinery, the radio, motion pictures, medical machines, the airplane, and sophisticated photography.

But it is one thing to provide an environment for the application of science—as we did up to 1940—and quite another thing to provide the continuing environment that will stimulate basic scientific inquiry that will ultimately lead to the development of significant new technologies. *That* we haven't done.

Fact #3: After 1940, technological development was more a smorgasbord approach to scientific achievement than a disciplined attack on a specific problem.

The Depression of the 1930s, followed by the traumatic world war of the early 1940s, made us abundantly aware of our scientific inadequacies. We could no longer depend on science from abroad to act as the catalyst for our technological progress. And we needed immediate answers to extremely complex problems. Answers that only scientists could provide.

As a result, American scientists on college campuses, in the laboratories of industry, and in the military were encouraged to do one thing. Expand the scope of scientific inquiry.

The results of this emphasis on scientific achievement were remarkable. Colleges and universities filled classes with young people intent on scientific careers, built new facilities, added complex new courses, and brought in expert faculties. Scientists, both young and old, produced a vast collection of new ideas and discoveries. And science was considered by the general public to be the ultimate panacea.

It was hoped that this "smorgasbord" of scientific results would bring solutions to our most pressing immediate and long-range problems. In fact, to some degree it did. For the '50s produced the development of the transistor, the entire semiconductor industry, the development of nuclear science and discovery of nuclear fission silicones and modern polymerchemistry, the first commercial computer, the refinement of radar, microwave communications, masers and lasers.

Fact #4: Sputniks did less than we think.

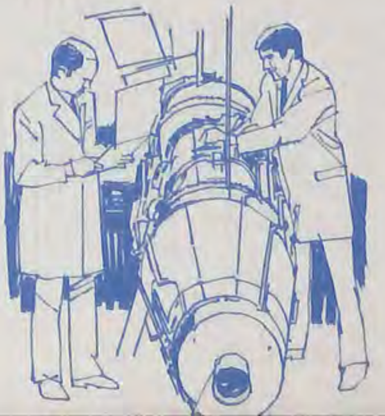
It is fashionable to date the increase in emphasis on applied science and technology back to the Russian launching of Sputnik. But it is also a mistake to attribute more to Sputnik than is actually there.

Basically, the launching of Sputnik did two things: (1) Russia threw down the gauntlet and challenged American science to maintain its reputation for technological superiority, and (2) more importantly, Sputnik proved "it could be done" if science were properly applied to the accomplishment of an important mission—and if funds were available.

Fortunately, we responded to the challenge of Sputnik. President Kennedy promised that we would have a man on the moon by 1970 and provided the stimulus and funding to do the job. By 1969, man walked on the moon.

But the emphasis on the close association between scientific inquiry and technological development in the late '50s and '60s wasn't due only to the challenge of Sputnik.

The recessions of 1958 and 1963 dramatically decreased unrestricted scientific inquiry and unlimited funding of basic research. Thus, government and business were forced by sheer economics to abandon the smorgasbord approach and emphasize the application of scientific inquiry toward the solution of a few specific problems.



Fact #5: In the mid-1960s, people expected more from technology than technology was prepared to give.

In the mid-1960s the achievements of American scientists were proclaimed throughout the world's media.

Our space program was nearing completion; we would win the space race. The challenge of space exploration that had so dominated public attention for 10 years had been met. But the price tag bothered people.

Then our attention turned to Vietnam. This was the war that technology would win—almost by remote control—in perhaps a week's time. All we had to do was apply our tremendously superior technology and the situation would no longer exist.

The harsh facts of war quickly exploded our illusions. And our exaltation of science as panacea diminished dramatically. As well, scientific and technological development outpaced social acceptance. People were exposed to complex new ideas and revolutionary new products daily. Ideas that forced them to change job status, economic levels, and lifestyles—changes most weren't prepared to make.

Technology had let us down.

And, due to previous recessions and military research spending, the faucet of research funding that had flowed so freely 10 years before was turned off—and wasn't turned on again.

Ultimately, our nation rebelled against technology. For technology didn't provide a ready solution to our deep social problems. It didn't have immediate answers to war and social disruption. All it did was promote change and cost a lot of money.

As a result, emphasis on scientific inquiry decreased drastically and was placed under strict control. Government and business withdrew their commitments to technological growth—and their funding. And colleges and universities with dwindling funds were faced with large bills to pay. Business became conservative, content to develop or refine products based on old science. And young people turned away from science to such humanities-oriented programs as law, journalism and teaching.

Perhaps we expected too much from technology. For neither science nor technology is capable of solving all our problems. Certainly not our social and political problems.

But in our desire to blame technology for our problems, we let the pendulum swing too far in the reverse direction.

Fact #6: Now we are at the crossroads.

During the past 10 years of decreasing emphasis on, and investment in, scientific inquiry and technological development, three major things have happened:

1. Foreign competitors have crept up, quietly. We are in the process of being beaten in the world market. Countries like West Germany and Japan have invested heavily in support of scientific inquiry and technological development. And the results are beginning to pour into our country and challenge our own competitive products.
2. There are a number of serious problems we must resolve immediately. Problems that a continuing commitment to technological progress might have prevented or solved. The energy crisis and its related problems. Productivity in the steel industry. The demand for more fuel-efficient, automobiles. The need for alternate sources of energy. The need for cost-efficient pollution control. And the need for more electronics research to counteract foreign imports.
3. We seem to have lost our scientific spirit. Government, business, and the general public now appear skeptical of the contributions of technology. And the spirit of scientific inquiry that was the hallmark of the "golden age of science in the 50s and 60s" has been all but forgotten.

Perhaps this is why government and industry are unable to provide the leadership and encouragement required for the investment of the same kind of talent, time and funds they applied to winning the race to the moon to the discovery of short- and long-term solutions to the energy crisis. Had we done so, technology might well have helped prevent the problem.

Fact #7: Technological development doesn't take as long as you may think.

One way people have of ignoring the problem is to suggest that technological development takes a long time. It does. But certainly not as long as we may think.

The time technological development takes actually is directly related to the ability of a society to accept it.

But in an environment where technology is suspect and funding lacking, technology will take a long time to evolve. And that is basically where we stand today.

What we need is not so much a return to the "golden age of science of the '50s and '60s," but the beginning of an era where government both directly and indirectly supports and encourages scientific inquiry, rather than exercises control over it.

Universities can press the case for support of research more stringently than in the past.

Up to now, this task has been largely left to individual scientists, who have worked effectively with their counterparts in the National Science Foundation and HEW. But scientists cannot fully appreciate the needs of universities as a whole. They have little contact with members of Congress or with other key officials in government. And they find it difficult to attract support from representatives of business and other sectors who have a stake in a vigorous science development program.

What can be done? University organizations—especially the Association of American University Professors—must make a sustained effort to develop an effective policy for the financial support of research. And they need to create an effective forum in Congress and in the Executive Branch where they can discuss this policy not only at budget time, but also on a more informal, long-term basis.

Above all, a much more forceful case must be made by university officials for the importance of research universities to the nation's technology welfare. There is a need for a "national research commitment," including federal support to universities and colleges as a "critical national resource," to combat nations who have a more substantial commitment to R&D. A sound continuing commitment would sustain a vigorous research effort in all basic fields of knowledge, as opposed to using universities as vehicles to attack only immediate problems.

Government holds the key to the future.

Government hasn't totally ignored the problem. But government hasn't been totally responsive to the immediacy of the problem, either.

To effect the changes needed to encourage technological growth in the future, government needs to change its attitude from a desire to control technological growth to a spirit of mutual cooperation and encouragement to all spheres of scientific endeavor.

The 10.9% increase in federal funding of research proposed for 1979 is a step in the right direction. But a small step nonetheless.

Recently, *U.S. News & World Report* updated their 1976 survey of public opinion on the ability of 25 institutions and groups to get things done, and on their honesty, integrity, and dependability.

Science and technology, a new addition to the list, was rated highest in *both* performance and dependability, while "politicians" and "the federal bureaucracy" rated *lowest.*

No wonder funding lags behind desire.

Perhaps government can learn a lesson from our foreign competitors. In Japan, for instance, government encourages industry and research laboratories to work together. And provides a good deal of the funds to support scientific inquiry.

Our government can do the same thing. By supporting scientific inquiry and creating a positive environment for technological growth.

By increasing federal research funding to colleges and universities, and to private industry.

By developing programs that would provide tax incentives to industries that increase their investment in R&D.

By providing incentives to people or businesses who come up with solutions to our most pressing problems.

By speaking out in favor of the spirit of inquiry.

By educating the public about the true role of science and technology and its relevance to our future.

There's one thing we all can do.

Give technology a chance to solve our problems.

First, we must all recognize what technology can do. And what it cannot do.

Then we must direct technology to meet specific challenges the future brings. And support scientific inquiry as enthusiastically as we did in the late '50s and early '60s.

As it has in the past, technology will provide the solutions.

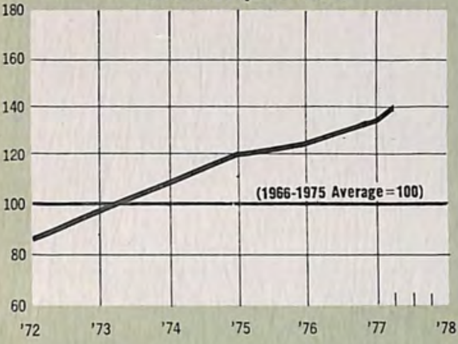
We have a great tradition of technology that must be preserved and encouraged. Its enemies must be overcome even if they happen to be "us."

Science and technology can solve many problems. If they don't, what else will?

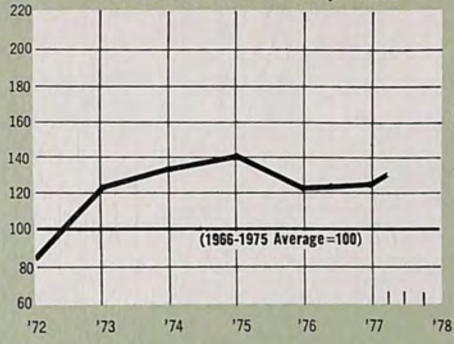
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

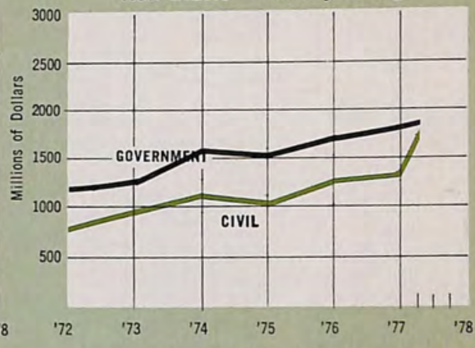


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average



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

ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD†	LATEST PERIOD 1st QTR. 1978
AEROSPACE SALES: TOTAL	Billion $	Annually	26.6	30.6	32.9	33.9
	Billion $	Quarterly	6.4	7.6	8.8	8.5
AEROSPACE SALES: TOTAL	*Billion $*	*Annually*	*27.3*	*22.1*	*22.8*	*23.1*
(In Constant Dollars, 1972=100)	*Billion $*	*Quarterly*	*6.9*	*5.1*	*6.1*	*5.8*
DEPARTMENT OF DEFENSE						
Aerospace obligations: TOTAL	Million $	Quarterly	3,792	3,539	4,058	3,125
Aircraft Procurement	Million $	Quarterly	2,361	2,687	3,152	2,638
Missiles Procurement	Million $	Quarterly	1,431	852	906	487
Aerospace outlays: TOTAL	Million $	Quarterly	3,411	2,264	2,055	2,045
Aircraft Procurement	Million $	Quarterly	2,031	1,497	1,602	1,672
Missiles Procurement	Million $	Quarterly	1,380	767	453	373
Aerospace Military Prime Contract Awards: TOTAL	Million $	Quarterly	3,327	4,124	5,010	N/A
Aircraft	Million $	Quarterly	2,109	2,691	3,458	N/A
Missiles & Space	Million $	Quarterly	1,218	1,433	1,552	N/A
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	816	1,001	874
Expenditures	Million $	Quarterly	789	724	824	776
BACKLOG (Major Aero Mfrs.) TOTAL	Billion $	Quarterly	28.6	38.7	44.3	46.8
U.S. Government	Billion $	Quarterly	15.9	23.3	25.4	25.8
Nongovernment	Billion $	Quarterly	12.7	15.4	18.9	21.0
EXPORTS						
Total (Including military)	Million $	Quarterly	1,038	1,641(r)	1,256(r)	1,830
New Commercial Transports	Million $	Quarterly	345	368	636	316
PROFITS						
Aerospace — Based on Sales	Percent	Quarterly	2.7	4.0	4.1	4.2
All Manufacturing — Based on Sales	Percent	Quarterly	4.8	5.0	5.3	4.7
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	885	894	922
Aircraft	Thousands	End of Quarter	650	485	477	497
Missiles & Space	Thousands	End of Quarter	114	83	81	81
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	6.74	7.23	7.31

* 1966-1975 average is computed by dividing total year data by 4 to yield quarterly averages.
† Preceding period refers to quarter preceding latest period shown.
r Revised to reflect changes in Schedule B.
N/A Not Available.

Source: Aerospace Industries Association

AEROSPACE INDUSTRIES ASSOCIATION
1725 De Sales St., N.W., Washington, D. C. 20036

AIA

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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
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General Dynamics Corporation
General Electric Company
General Motors Corporation
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OFFICIAL PUBLICATION OF THE AEROSPACE INDUSTRIES ASSOCIATION • WINTER 1978

AEROSPACE REVIEW AND FORECAST 1978/79

Notable views of notable people on aerospace matters...

aerospace perspectives

Larry Kitchen, *President of Lockheed Corp., addressing the National Management Association in Atlanta, Ga.:*

"One of my associates opines that we are lucky the airplane was invented back in 1903 and developed over the following years. In overstating his belief, he says we would probably be stopped from developing the aircraft in today's climate. The environmentalists would object to the noise. The consumerists would want them all recalled before they got out the factory door. The pacifists would complain that they could be used to carry troops. Preservationists would be afraid they would fly into City Hall. And 10 government study groups would prove that they definitely cause cancer."

Senator Strom Thurmond (South Carolina), *speaking at an Aerospace Industries Association meeting in Charleston, S.C.:*

"Armaments do not cause wars, people cause wars. U.S. sales of arms is not something inherently nefarious or destabilizing, but a means to strengthen our own defense hand and that of our allies in an increasingly dangerous world.

"In 1977, weapon sales produced a $7 billion net balance of trade factor for our country. While arms sales cannot be justified on this basis, the balance of payment dividend reveals one of the favorable aspects of U.S. arms sales when consistent with our national policy."

Secor D. Browne, *Washington-based aviation consultant, in a speech before the Airport Operators Council International in New York, N.Y.:*

"Month after month, the biggest (international) exchange earner—after agriculture—is air transport aircraft, engines and components. Looking at our self-inflicted wounds, I think our industry is impaled on a three-pronged fork.

"The first prong is human rights. I don't propose to comment on the United States' moral rectitude versus that of the rest of the world. But I find it rather inconsistent that we can't ship transport aircraft to Libya because they harbor terrorists, although we bought $450 million dollars worth of oil from them last year, and we can't ship ambulance planes to Argentina because they shoot terrorists. . .

"The second prong (is) the financing of research and development. . . In Boeing's 767/757 programs, the company will have to risk somewhere between 100 and 200 percent of its total net assets, whereas the press recently reported that the Airbus consortium had made a preliminary allotment of some $850 million dollars of taxpayers' funds to the development of the A310 model of the Airbus. This is not a situation where our government is putting on anything like an equal basis in the competitive marketplace. . . ."

Langhorne Bond, *Administrator, Federal Aviation Administration, at the Sikorsky S-76 certification ceremony, Bridgeport, Conn.:*

"I doubt very much that the development and exploitation of energy resources in remote and offshore areas could have reached the degree of success and intensity that it has without the operational flexibility of the modern helicopter. The requirement for this form of priority transportation in congested metropolitan areas, in law enforcement, emergency medical airlift , and in disaster relief has increased immensely. It is continuing to do so.

"It has been my conviction that the FAA, due perhaps to an historical 'fixed-wing' fixation, has not properly addressed the needs of the aviation frontier where Igor Sikorsky pioneered more than 40 years ago.

"I can assure you this is no longer the case. In September, I approved establishment of the Helicopter Operations Development Plan. During the next five years, it will thoroughly modernize and streamline all agency standards, procedures and regulatory activities dealing with the rotorwing segment of air transportation. This action is aimed squarely at expediting the safe and economical integration of the helicopter into all-weather operations of the National Airspace System—a capability which hitherto has prevented the full exploitation of this magnificently unique form of air transportation."

Paul Thayer, *Chairman and Chief Executive Officer, The LTV Corp., at the annual meeting of the American Astronautical Society, Houston, Tex.:*

"Based on what has gone before, perhaps it is not too optimistic to say that by the middle of the 21st century, oil wells, refineries and coal mines will be relics of the past . . . replaced by solar power systems in space. Placed in orbit by the Shuttle, giant solar power stations will collect, store and return to Earth by microwave abundant supplies of pollution-free energy from the sun.

"Impractical? Maybe not. If you say to me: 'How much will it cost?' I would answer: 'How much is it worth?' How much is it worth to have an endless supply of energy for ourselves and our descendants? How much is it worth to be free of the threat of economic blackmail? How much is it worth not to be dependent upon foreign sources for the fuel to heat our homes and power our factories? Certainly, with the price tag for the Alaskan pipeline totaling serveral billion dollars, the economics of solar power may soon begin to make sense."

Salvatore A. Conigliaro, *President, Sperry Division of Sperry Rand Corp., commenting on a study advocating modification of the Triad concept of defense with attendant reductions in research and development funding:*

"The security currently provided by U.S. defense forces is the direct result of expenditures made as long as 20 years ago. Continued technological superiority, not just strength in numbers, is essential to maintaining national security at the most reasonable cost over the long term.

"A major cut in research and development would jeopardize long-range U.S. defense. Research programs can take 10 years or longer to advance to development and production stages. If the United States winds down its support of R&D during the next decade, then by the 1990s the Soviets will surely have the technology to countermeasure our most sophisticated weapons systems. We could become vulnerable. I think even the staunchest critics of defense policy would regard this as an unacceptable price to pay for reduced military spending."

A I A

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Associate Editor, Aerospace Magazine

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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.

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SOLAR POWER

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

With the debut of the Space Shuttle next year, the U.S. space program will enter a new era in which emphasis, according to official pronouncements, will be on developing space systems designed to produce direct Earth benefit.

Of all the planned and proposed space applications, none has greater benefit potential than the Solar Power Satelite. This concept envisions enormous orbiting platforms, several miles long, collecting energy from the sun and converting it to Earth-use electricity. A single satellite could continuously beam to Earth more than four times the power producible by the largest nuclear power plant; a network of orbiting power stations could supply a significant portion of the nation's electrical power needs. The Solar Power Satellite is not an immediate answer to our energy problems; it would take, at a conservative estimate, 15 years to put a prototype in orbit and additional years to build an operational system. But the potential of the system is so great it merits our most serious consideration.

Although the solar power system is still in study status, it has already encountered opposition from anti-technologists. Some express concern about the environmental considerations of beaming microwave energy to Earth; others question whether space-derived power can be cost-effective; still others, citing horrendous and dubious estimates of development costs, object to the monetary outlays development would require.

The answer to these objections is simply, "Let's find out." Let's find out by testing hardware, not by endless rounds of inconclusive study and debate.

Unquestionably, the solar power system is technologically demanding and its development would be a high-challenge program of Apollo-like proportions. But many of the best minds in the aerospace community feel that the development is feasible, that the system will be cost-effective, and that the environmental problems are more inaginary than real.

Proponents of the system are not suggesting that the nation commit itself to an operational system, or even full-scale development of a prototype, without essential preliminaries. We should proceed, as a first step, with a technology development and demonstration program, producing experimental hardware to get answers as to whether the system is practicable, what it will cost, and how the cost of space-generated electricity will compare with other energy alternatives.

We should check out the hardware not only in ground laboratories, but in orbit, utilizing the capabilities of the Space Shuttle. Such a technology demonstration program can be accomplished on an affordable basis, with funding spread over several years. If it produces positive answers, *then* we could proceed with full-scale development, with confidence that whatever the costs they would be more than justified by the social and economic gains the system would bring.

We have spent 20 years building an extraordinary space capability which promises huge dividends in direct Earth benefit—but only if we have the national will to pursue them. We cannot fail to take advantage of the beneficial opportunities space will afford without forfeiting our responsibilities to future generations.

AEROSPACE REVIEW AND FORECAST 1978/79

The year 1978 was characterized by substantial improvement in the aerospace industry's sales, earnings, backlog, export performance and contribution to the U.S. balance of trade.

Here are the highlights:

• Sales, at $37.3 billion, were up almost $5 billion over the preceding year; the major gain was in commercial sales. The sales figure represents a new statistical high but, of course, the nation's continuing high inflation rate has a distorting effect on sales data. Nonetheless, the industry's sales in 1978 amount to an increase of about 15 percent above the previous year, a gain well in excess of the inflation rate.

To get a more realistic yardstick of performance measurement, it is the industry's practice to compare current-year figures with those of 1968—the *real* peak year—by converting to constant, or inflation-adjusted, dollars. On that basis, 1978 sales were some $8.7 billion below those of the peak year.

• Industry profits as a percentage of sales climbed half a percentage point to 4.7 percent, still below—as in previous years, the profit rate manufacturing industries—5.3 percent in 1978.

• Aerospace exports reached an all-time high of $9.3 billion, an increase of $1.8 billion over 1977. At a time when export sales are more important than ever to the U.S. economy, the aerospace industry recorded an international trade surplus of nearly $8.4 billion. Aerospace led all U.S. manufacturing industries in contribution to the nation's balance of trade.

• The industry's backlog at year-end 1978 is estimated at $51.4 billion, a sharp increase over 1977's $44.3 billion. The increase is attributable, for the most part, to a surge of new orders for commercial transports during the year.

While the year witnessed several favorable actions on the part of the government which could have important bearing on the aerospace industry's posture in future years, the industry still has a full plate of concerns about issues important to its future. On the favorable side during 1978, was President Carter's announcement of an export stimulation plan, backed by his personal commitment to a higher priority for export sales. Among its provisions was a proposed increase in the lending authority of the Export-Import Bank, a helpful step in improving American competitiveness in the international arena, and a Presidential directive that government agencies weigh more carefully the impact on U.S. trade and jobs of administrative and regulatory actions—human rights considerations, for example, which have blocked many U.S. sales abroad.

Another encouraging note was the increase in government-sponsored basic research and development funding for the current fiscal year. The level of R&D funding is a vital factor in the aerospace industry's international competitiveness and its overall capability for technological advancement. While most industrialized nations of the world have steadily increased R&D expenditures over the past 15 years, the U.S. outlay curve has been declining over that time span. The current R&D budget arrests the downhill trend, particularly in basic research, where the U.S. trails far behind competing nations. It provides a substantial *real* funding increase for basic research—above the rate of inflation—and a moderate increase in defense research outlays, the government R&D area of greatest impact on aerospace industry activity. Additionally, there are indications that the Administration's request for fiscal year 1980 appropriations—to be presented to Congress next month—will call for at least equivalent levels of R&D outlays.

In a similar vein, the Administration launched a study of factors affecting the lagging U.S. industrial innovation process. It will address such matters as requisite levels of R&D funding and impediments to innovation that stem from the often conflicting policies of individual government agencies. The study is to be completed next spring. Whether it will spawn positive actions to halt the general decline in U.S. technological innovation and productivity remains to be seen. But the fact that the study was initiated is in itself encouraging since it represents long-overdue government recognition of a major problem, the solution of which is vital to U.S. industry and to the nation's economy.

In the latter part of the year, the Congress passed a tax bill which included corporate and capital gains tax reductions, together with a 10 percent investment tax credit for plant and equipment. This measure offers some help in a major problem area confronting all U.S. industry—capital formation, which is obviously a matter of particular concern to high technology industries, such as the aerospace industry.

Although the industry is still concerned about many government-generated problem areas, these 1978 actions hint at an improved climate for aerospace business operations in coming years. They suggest easement of some of the barriers to effective aerospace industry operations, but others remain. For example, the President's export policy statement is a heartening first step toward improving

American industry's posture in international trade, but the industry has yet to see any real signs that the policy will be effectively translated into concrete actions by the government agencies involved.

There are also inequities in international aircraft sales competition, inequities stemming from the fact that foreign competitors have stronger backing from their governments than do American manufacturers. This makes it possible for the foreign manufacturer to offer potential customers more attractive deals than are available from U.S. companies. A draft agreement has been completed which would remove many of the unfair advantages foreign firms enjoy over their American counterparts. But the agreement must be approved by both U.S. and foreign governments, which is not certain, and the resulting treaty, if approved, must still be effectively implemented.

There are a number of other matters of special concern to the aerospace industry:

- A plan for greater European involvement in development and production of NATO equipment could, if not handled with great sophistication, have adverse impact on the aerospace industry's competitive standing, market access and technological posture.
- An Administration initiative to control export of "strategically critical" technology is a move which the aerospace industry supports in principle, but is a highly complex matter which in practice could result in restrictions on some exports which are not strategically critical.
- The Administration's call for phase-out or modification of the Domestic International Sales Corporation (DISC) program would, if implemented, eliminate a valuable aid to export promotion.
- Capital formation remains a problem and demands further government measures to improve the industry's financial strength; a particular need is government recognition of the necessity for depreciation policies appropriate to the risks involved in high technology operations.

Forecast

From all indications, the coming year will witness another strong sales performance on the part of the aerospace industry.

Aerospace Industries Association projects another dramatic rise in commercial sales—an increase of more than \$4 billion over the current year's level. Slight gains are predicted for sales to the Department of Defense and the National Aeronautics and Space Administration. Non-aerospace sales, which have risen every year since 1971, are expected to do so again.

Overall, AIA predicts total sales at almost \$43 billion. This would mean an increase of roughly \$5.6 billion over 1978. In terms of constant dollars, however, sales would remain well below those of 1968, the peak year. Industry employment, which climbed appreciably this year, is estimated at more than one million by the end of 1979; that would mark the first time since 1970 that the aerospace labor force has topped the million level.

Projecting further down the road is difficult. With orders already on the books for deliveries into 1983, and substantially more expected, sales of commercial transports are expected to remain strong at least through the mid-eighties. Sales to DoD, NASA and other government agencies are less susceptible to accurate prediction. DoD's announced plans for production of aircraft and missiles, together with new developments in both areas, indicate a high order of aerospace industry activity. Similarly, NASA's contemplated buildup to an annual payload launch rate roughly double the current year's augurs a high level of space equipment fabrication. In both cases, however, the governing factor is the extent to which these plans will be backed by annual funding. In the final analysis, the state of the national economy will largely dictate the levels at which these programs are funded. Given improvement in the economy, the outlook for the aerospace industry is better than it has been since the start of this decade.

BACKLOG

The aerospace industry's backlog is estimated at \$51.4 billion as of the end of 1978. This represents an increase of more than \$7 billion over year-end 1977. The major component of increase is in sales to customers other than the U.S. government; in the "other customers" category," the gain is approximately \$5.8 billion. Government orders boosted the backlog by \$1.3 billion over the 1977 figures. Aircraft, including engines and parts, make up about 54 percent of the total backlog.

BACKLOG OF MAJOR AEROSPACE COMPANIES

Calendar Years 1968-1978

(Millions of Dollars)

Year	GRAND TOTAL	Total U.S. Government	Total Other Customers	Aircraft, Engines & Parts		Missiles & Space Including Propulsion	Other Aerospace		Other Non-Aerospace	
				U.S. Gov't.	Other		U.S. Gov't.	Other	U.S. Gov't.	Other
1968	\$30,749	\$16,343	\$14,406	\$ 8,150	\$12,409	\$5,083	\$1,851	\$ 983	\$1,576	\$ 697
1969	28,297	14,298	13,999	7,089	12,099	4,338	2,001	880	1,163	727
1970	24,705	12,882	11,823	5,913	9,800	4,522	1,986	805	827	852
1971	24,579	13,997	10,582	6,221	8,059	4,780	2,232	1,042	1,314	931
1972	26,922	15,322	11,600	7,027	8,605	5,272	2,018	972	1,816	1,212
1973	29,661	16,695	12,966	7,815	8,550	5,670	1,819	1,078	2,242	2,487
1974	35,516	20,889	14,627	9,789	9,602	6,643	1,926	1,665	2,997	2,894
1975	35,038	22,168	12,870	10,751	8,141	6,415	1,983	2,088	3,340	2,320
1976	39,702	24,141	15,561	11,950	8,929	6,286	2,046	3,496	4,248	4,747
1977										
1st qtr	38,668	23,260	15,408	11,321	8,483	6,000	2,099	3,555	4,243	2,967
2nd qtr	39,548	23,080	16,468	11,629	9,713	5,041	2,434	3,547	4,297	2,887
3rd qtr	39,546	22,291	17,255	10,815	10,867	5,112	2,509	3,495	4,150	2,598
4th qtr	44,301	25,365	18,936	12,182	12,362	5,981	2,974	3,421	4,534	2,847
1978										
1st qtr	46,796	25,843	20,953	11,937	13,585	6,163	3,144	3,792	5,058	3,117
2nd qtr[e]	51,000	28,600	22,400	13,700	14,600	6,700	3,500	4,600	4,700	3,200
3rd qtr[e]	51,200	26,900	24,300	12,400	15,700	6,400	3,700	5,200	4,400	3,400
4th qtr[e]	51,400	26,700	24,700	12,200	15,800	6,400	3,700	5,200	4,400	3,400

Source: Bureau of the Census, Current Industrial Reports, MQ-37D.
[e] Estimate

SALES BY CUSTOMER

Aerospace industry sales in 1978 totaled $37.3 billion, up $5 billion over the previous year. Inflation accounted for part, but by no means all of the gain; the percentage of increase was well above the rate of inflation. In terms of inflation-adjusted constant dollars, the 1978 sales figure is $8.7 billion below the sales volume of 1968, the industry's peak year.

Sales to the Department of Defense, at $16.3 billion, remained the largest single component of the sales total. The largest gain, however, was recorded in commercial sales, which climbed $2.3 billion to an all-time high of $11.3 billion.

Industry estimates for 1979 indicate another increase in total sales. Further gains in commercial and non-aerospace activity, coupled with slight increases in DoD and NASA sales, are expected to boost total sales to almost $43 billion.

AEROSPACE INDUSTRIES SALES BY CUSTOMER
Calendar Years 1968-1979
(Millions of Dollars)

Year	GRAND TOTAL	Aerospace Products and Services				Non-Aerospace **		
		Total	DoD	NASA	Commercial Sales *	Total	U.S. Government	Other Customers
Current Dollars								
1968	$28,977	$26,428	$16,573	$ 3,938	$ 5,917	$ 2,549	$ 1,568	$ 981
1969	26,149	23,450	15,771	3,337	4,342	2,699	1,633	1,066
1970	24,904	22,260	14,643	2,974	4,643	2,644	1,465	1,179
1971	22,154	19,631	12,584	2,745	4,302	2,523	1,372	1,151
1972	22,818	20,172	13,295	2,608	4,269	2,646	1,546	1,100
1973	24,809	21,466	12,886	2,394	6,186	3,343	1,925	1,418
1974	26,400	22,333	12,650	2,527	7,156	4,067	2,060	2,007
1975r	28,373	23,581	13,127	2,727	7,727	4,792	2,496	2,296
1976r	30,118	24,748	13,402	2,815	8,531	5,370	2,744	2,626
1977r	32,294	26,262	14,389	2,880	8,993	6,032	3,469	2,563
1978p	37,270	30,603	16,273	3,021	11,309	6,667	3,500	3,167
1979e	42,900	35,397	16,359	3,263	15,775	7,503	3,930	3,573
Constant Dollars (1968 = 100)r								
1968	28,977	26,428	16,573	3,938	5,917	2,549	1,568	981
1969	24,899	22,329	15,017	3,177	4,135	2,570	1,555	1,015
1970	22,509	20,119	13,235	2,688	4,196	2,390	1,324	1,066
1971	19,052	16,882	10,822	2,361	3,699	2,170	1,180	990
1972	18,842	16,657	10,978	2,154	3,525	2,185	1,277	908
1973	19,362	16,754	10,057	1,869	4,828	2,608	1,502	1,106
1974	18,788	15,894	9,003	1,798	5,093	2,894	1,466	1,428
1975	18,421	15,310	8,523	1,770	5,017	3,111	1,620	1,491
1976	18,575	15,263	8,266	1,736	5,261	3,312	1,692	1,620
1977	18,830	15,313	9,390	1,679	5,244	3,517	2,023	1,494
1978	20,246	16,624	8,840	1,641	6,143	3,622	1,901	1,721
1979	21,732	17,931	8,287	1,653	7,991	3,801	1,991	1,810

Source: Department of Defense: FAD Reports for each year; The Budget of the United States Government.
NASA: NASA reports to AIA, The Budget of the United States Government.
Non-Government and Non-Aerospace: AIA estimates based on latest Department of Commerce information and company reports.
e Estimate
p Preliminary
r Revised
* Includes some aerospace exports.
** Includes non-aircraft, non-space vehicle and non-missile products and services, and basic research.

PROFITS

Aerospace industry profits, measured as a percentage of sales, increased from 4.2 percent in 1977 to 4.7 percent in 1978. As in previous years, profits remained well below the average for all U.S. manufacturing corporations when computed as a percentage of sales. A preliminary estimate of the industry's 1978 net profit after taxes is $1.7 billion, up approximately $300 million over 1977.

NET PROFIT AFTER TAXES
Calendar Years 1968-1978

Year	AEROSPACE INDUSTRIES				ALL MANUFACTURING CORPORATIONS		
	Millions of Dollars	As a Percent of			As a Percent of		
		Sales	Assets	Equity	Sales	Assets	Equity
1968	$ 857	3.2%	4.4%	14.2%	5.1%	6.6%	12.1%
1969	804	3.0	3.5	10.6	4.8	6.1	11.5
1970	501	2.0	2.2	6.8	4.0	4.9	9.3
1971	423	1.8	2.0	5.8	4.1	5.1	9.7
1972	609	2.4	2.7	8.6	4.4	5.5	11.1
1973	855	2.9	2.4	10.3	4.7	6.5	12.8
1974	861	2.9	3.7	10.4	5.5	8.0	14.9
1975	927	3.0	3.8	11.0	4.6	6.2	11.6
1976	1,094	3.5	4.7	12.8	5.3	7.5	14.0
1977	1,427	4.2	5.7	14.9	5.3	7.6	14.2
1978p	1,732	4.7	5.9	15.6	5.3	7.3	14.5

Source: Federal Trade Commission
p Preliminary

SALES BY PRODUCT

Aircraft manufacturing continued in 1978 to be the major area of industry sales, with sales of military aircraft constituting the principal dollar volume element. Aircraft sales, military and civil, amounted to almost $21 billion, or better than 56 percent of total aerospace sales. Military aircraft sales, at $13.1 billion, were up $2.3 billion, while civil aircraft increased by $1.2 billion to a total of $7.8 billion.

In other areas of industry activity, sales of non-aerospace products increased for the seventh straight year to a total of $6.7 billion. Missile sales climbed by some $600 million and sales of space equipment by more than $200 million.

For 1979, AIA projects a major increase—more than $3 billion—in commercial aircraft sales, and lesser but substantial increases in all other major product lines.

AEROSPACE INDUSTRIES SALES BY PRODUCT
Calendar Year 1968-1979
(Millions of Dollars)

Year	GRAND TOTAL	Aircraft			Missiles	Space	Non-Aerospace
		Total	Military	Civil			
Current Dollars							
1968	$28,977	$16,578	$11,088	$5,490	$ 4,719	$ 5,131	$ 2,549
1969	26,149	14,097	10,007	4,090	5,058	4,295	2,699
1970	24,904	13,293	9,156	4,137	5,379	3,588	2,644
1971	22,154	11,442	8,032	3,410	5,018	3,171	2,523
1972	22,818	11,866	8,050	3,816	5,217	3,089	2,646
1973	24,809	13,338	7,937	5,401	5,177	2,951	3,343
1974	26,400	14,050	8,105	5,945	5,187	3,096	4,067
1975[r]	28,373	15,227	8,736	6,491	5,126	3,228	4,792
1976[r]	30,118	16,426	9,953	6,473	4,936	3,386	5,370
1977[r]	32,294	17,388	10,845	6,543	5,452	3,422	6,032
1978[p]	37,270	20,911	13,151	7,760	6,047	3,645	6,667
1979[e]	42,900	24,798	13,973	10,825	6,552	4,047	7,503
Constant Dollars (1968 = 100)[r]							
1968	28,977	16,578	11,088	5,490	4,719	5,131	2,549
1969	24,899	13,423	9,529	3,894	4,816	4,090	2,570
1970	22,509	12,015	8,276	3,739	4,861	3,243	2,390
1971	19,052	9,840	6,907	2,933	4,315	2,727	2,170
1972	18,842	9,798	6,647	3,151	4,308	2,551	2,185
1973	19,362	10,409	6,194	4,215	4,040	2,303	2,608
1974	18,788	9,999	5,768	4,231	3,692	2,203	2,894
1975	18,421	9,886	5,672	4,214	3,328	2,096	3,111
1976	18,575	10,131	6,139	3,992	3,044	2,088	3,312
1977	18,830	10,139	6,324	3,815	3,179	1,995	3,517
1978	20,246	11,359	7,144	4,215	3,285	1,980	3,622
1979	21,732	12,562	7,078	5,484	3,319	2,050	3,801

Source: Department of Defense: FAD Reports for each year; The Budget of the United States Government.
NASA: NASA reports to AIA, The Budget of the United States Government.
Other Government Agencies: The Budget of the United States Government.
Non-Government and Non-Aerospace: AIA estimates based on latest Department of Commerce information and company reports.
e Estimate
p Preliminary
r Revised

EMPLOYMENT

Spurred by increases in several categories of activity, particularly in production of civil transports, aerospace employment climbed sharply in 1978. The labor force grew to 999,000 employees, an increase of 105,000, or more than 11.7 percent, over the 894,000 employees on the rolls at the beginning of the year. The increase was about equally compounded of production workers and other employees.

AIA estimates a further increase in 1979. By the end of next year, it is expected that employment will top the million mark for the first time since 1970.

AEROSPACE EMPLOYMENT AND PAYROLL
Calendar Years 1968-1979

Year	EMPLOYMENT AS OF DECEMBER (In Thousands)			ANNUAL PAYROLL (Millions of Dollars)		
	TOTAL	Production Workers	All Other	TOTAL	Production Workers	All Other
1968	1,403	738	665	$14,397	$ 6,582	$ 7,815
1969	1,295	658	637	14,649	6,401	8,248
1970	1,069	528	541	12,275	5,322	6,953
1971	924	448	476	10,480	4,409	6,071
1972	944	473	471	11,197	4,565	6,632
1973	962	474	478	12,257	5,114	7,143
1974	973	483	490	13,250	5,454	7,796
1975	925	444	481	14,561	5,822	8,739
1976	898	420	478	14,908	5,766	9,142
1977	894	410	484	15,948	6,173	9,775
1978[p]	999	467	532	19,230	7,527	11,703
1979[e]	1,024	480	544	20,844	8,157	12,687

Source: Employment: Aerospace Industriea Association.
Payroll: Bureau of Labor Statistics, estimates by AIA.
e Estimates
p Preliminary

AEROSPACE EXPORTS AND IMPORTS WITH BALANCE OF TRADE

Calendar Years 1973-1978

(Millions of Dollars)

	1973	1974	1975	1976ʳ	1977ʳ	1977	1978
AEROSPACE BALANCE OF TRADE	$4,360	$6,350	$7,045	$7,267	$6,850	$6,720	$8,364
Aerospace Exports	$5,142	$7,095	$7,792	$7,843	$7,581	$7,451*	$9,259
Aerospace Imports	782	745	747	576	731	731	895

EXPORTS OF AEROSPACE PRODUCTS

	1973	1974	1975	1976ʳ	1977ʳ	1977*	1978ᵖ
GRAND TOTAL	$5,142	$7,095	$7,792	$7,843	$7,581	$7,450	$9,259
TOTAL CIVILIAN	$3,788	$5,276	$5,324	$5,677	$5,049	$4,956	$5,284
Complete Aircraft, Total	2,315	3,366	3,203	3,211	2,747	2,747	3,139
Transports	1,664	2,655	2,397	2,468	1,936	1,936	2,175
General Aviation	206	297	312	362	389	389	504
Rotary Wing	83	110	105	113	105	105	163
Other, Including Used	362	304	389	268	317	317	297
Engines, Total	175	229	231	254	233	233	278
Jet and Gas Turbine	145	195	186	213	196	196	234
Internal Combustion	30	34	45	41	37	37	44
Parts, Accessories and Equipment, Including Spares, Total	1,298	1,681	1,890	2,212	2,069	1,976	1,867
TOTAL MILITARY	1,354	1,819	2,468	2,166	2,532	2,494	3,975
Complete Aircraft, Total	791	1,101	1,306	967	1,186	1,186	2,268
Transports	131	190	235	151	317	317	116
Rotary Wing	38	50	123	102	84	84	42
Fighters and Bombers	588	845	905	513	686	686	1,986
Trainers	12	6	5	2	13	99	124
Other, Including Used	22	10	38	199	86		
Engines, Total	46	49	94	71	76	76	53
Jet and Gas Turbine	36	36	83	58	64	64	48
Internal Combustion	7	11	2	8	7	7	1
Missile Turbine	3	2	9	5	5	5	4
Parts, Accessories and Equipment, Including Spares, Total	415	513	771	649	832	794	1,166
Rockets, Guided Missiles and Parts, Total	102	156	297	479	438	438	488

* Effective 1978, the Department of Commerce has revised the "Schedule B" commodity classification codes used to classify exports. Exports for 1977 have been restated to provide a point of comparison for the 1978 data.

EXPORTS

The aerospace industry's performance in export sales reached an all-time high in 1978, as did the industry's contribution to the nation's balance of trade. Exports totaled nearly $9.3 billion, up from $7.5 billion in 1977. Aerospace imports increased by $164 million to a total of $895 million. Thus, the aerospace balance of trade was nearly $8.4 billion, which compares with $6.7 billion in the previous year.

In 1978, deliveries of civil aircraft, particularly commercial transports, constituted the major component of the export total. Civil aircraft sales amounted to $5.3 billion, compared with slightly less than $5 billion in 1977. Military exports totaled just under $4 billion; this represents a substantial increase—$1.5 billion—over the 1977 figure.

TRANSPORT AIRCRAFT ORDERS
December 31, 1972 - September 30, 1978

	AIRCRAFT ON ORDER						
	Dec. 31, 1972	Dec. 31, 1973	Dec. 31, 1974	Dec. 31, 1975	Dec. 31, 1976	Dec. 31, 1977	Sept. 30, 1978
TOTALS (Domestic & Foreign)							
No. of Aircraft on Order	534	573	564	381	326	466	537
Value (Millions of Dollars)	$7,090	$7,252	$7,587	$6,369	$5,070	$8,913	$11,619
Company & Model							
Boeing	162	180	210	130	155	242	286
B-707	16	21	14	9	5	4	2
B-727	108	104	121	60	106	157	124
B-737	13	36	46	29	22	6	93
B-747	25	19	29	32	22	45	67
Lockheed	199*	179*	178*	134*	97*	62	35
L-1011	159	142	112	81	70	61*	30
L-100-30 (Hercules)	—	—	15	12	1	—	—
C-130 (Hercules)	40	37	51	41	27	1	5
McDonnell Douglas*	173	214	176	117	74	162	216
DC-9	19	83	91	65	47	101	127
DC-10	154	131	85	52	27	61	89
TOTAL FOREIGN ORDERS							
No. of Aircraft on Order	267	378	356	258	163	233	284
Percent of Total Order	50.0%	66.0%	63.1%	67.7%	50.0%	50.0%	52.9%
Value (Millions of Dollars)	$3,452	$4,634	$5,293	$4,622	$3,113	$5,544	$7,349
Company & Model							
Boeing	85	122	112	82	50	95	129
B-707	16	21	14	9	5	4	2
B-727	40	50	41	20	13	35	40
B-737	13	34	32	28	12	16	63
B-747	16	17	25	25	20	40	52
Lockheed	82*	86*	117*	87*	59*	28	16
L-1011	42	54	55	36	32	27*	11
L-100-30 (Hercules)	—	—	11	10	1	—	—
C-130 (Hercules)	40	32	51	41	26	1	5
McDonnell Dougles*	100	170	127	89	54	105	139
DC-9	10	78	58	40	30	63	79
DC-10	90	92	69	49	24	42	60

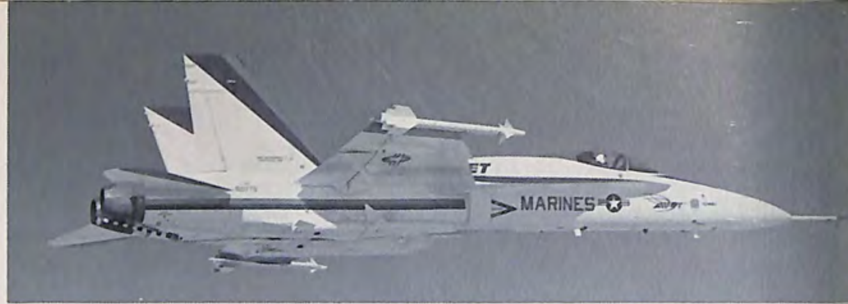
Source: Company Reports to AIA.
* Includes options.

TRANSPORT ORDERS

The industry's backlog of orders for commercial transport aircraft climbed significantly in 1978, as improving financial health of the world's airlines triggered a surge of orders for both existing production aircraft and new, advanced technology developments initiated during the year. The number of aircraft on order rose from 466 at the end of last year to 537 as of September 30, 1978, the latest date for which information is available. The dollar value of planes on order increased from $8.9 billion to $11.6 billion.

Civil Aircraft Shipments

During 1978, the industry shipped 235 commercial transport aircraft valued t $4.1 billion; this compares with 1977 figures of 185 transport worth $2.9 billion. Helicopter shipments totaled 890 units in 1978, approximately the same as 1977's 884; dollar volume, however, increased from $316 million in 1977 to $400 million in 1978. Overall shipments of civil aircraft, including more than 18,000 general aviation planes, numbered 19,125, up more than 1,100 units from the previous year. Dollar value in 1978 was $6.3 billion, up $1.5 billion. For 1979, AIA estimates total shipments of 19,505 planes, including 375 transports and 950 helicopters; dollar value is expected to increase to $8.8 billion.



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AEROSPACE HIGHLIGHTS

Steps to upgrade the U.S. long-range missile force, first flights of new military aircraft, improvement of the Earth resources satellite system, developmental progress on the Space Shuttle and development starts on new U.S. commercial transports—these were among the highlights of the aerospace year 1978.

6

By JAMES J. HAGGERTY

The Department of Defense program to update the long-range missile force passed a major milestone in 1978 with the Navy's phase-out of the Polaris first generation sea-launched ballistic missile in favor of the more advanced Poseidon. In October, the Navy announced that 31 ballistic missile submarines were equipped with Poseidon weapons, which carry multiple warheads.

Plans were under way for fitting some submarines with the still more advanced Trident 1 missile, which has a range of 4,000 miles, compared with 2,500 for Poseidon. Trident 1 moved a step closer to operational status in 1978; continuing the flight test program initiated in 1977, the Navy and prime contractor Lockheed Missiles and Space Company conducted seven more successful flights during the year. These were land-pad launches from Cape Canaveral, Florida. Several additional land-pad firings were planned for 1979, along with the first Trident launch from a submarine; the latter test was scheduled for the spring of 1979. Initial operational service of Trident 1 was targeted for next October.

Late in the year, DoD approved plans for full-scale development of a "common missile" to meet the requirements for both land-based and sea-launched, possibly also air-launched, advanced strategic weapons. The program would merge development of the Trident 2, the fourth generation submarine-launched ballistic missile, and the mobile land-based ICBM known as MX. The two developments would be separately funded under a fiscal year 1979 supplemental appropriation request to be presented to Congress in January. However, no decision was reached as to the "basing mode" of the land-based strategic weapon—how it should be deployed for least vulnerability to an enemy first strike. That determination was expected to take another year.

DoD cruise missile development advanced with further flight testing of the General Dynamics AGM-109, air-launched version of the Tomahawk, and the Boeing AGM-86 Air Launched Cruise Missile. Sub-launched and ground-launched versions of the Tomahawk were also tested. DoD announced a cruise missile development schedule: production decision in the ALCM competition will be made early in 1980 and first production weapons will be available in 1981; the Ground Launched Cruise Missile will also go into production in 1980 and it is targeted for initial operational status in 1982; the Sea Launched Cruise Missile is not scheduled for production, but it will continue in research and development status.

The year 1978 saw these other major missile developments:

• The Army/Raytheon Patriot surface-to-air missile advanced another step in its development program by successfully intercepting drone aircraft despite use of countermeasures designed to thwart intercept.

• The Army/Martin Marietta Pershing II battlefield nuclear missile successfully completed a series of development flights. Decision as to whether Pershing II would proceed to engineering development leading to operational use was expected about year-end 1978.

• The Navy/RCA Aegis shipboard air defense system, using a General Dynamics Standard 2 missile, conducted intercepts of supersonic targets at speeds up to Mach 4 and altitudes of 100,000 feet.

• The Army/Rockwell International Hellfire, a helicopter-launched anti-tank weapon, was fired for the first time in the guided mode; earlier tests were unguided. Hellfire was scheduled for first firings with a live warhead, and first helicopter launches, in mid-1979.

• The Army's Roland, a European missile being developed for U.S. use by Hughes Aircraft Company and Boeing Aerospace Company, underwent initial firing tests and scored successful hits against drone targets. Decision as to whether the missile would go into full-scale production was expected early in 1979.

In DoD aircraft development, a milestone event was the first flight of the Navy's F-18A Hornet strike fighter. The F-18A took to the air on November 18 at the St. Louis plant of prime contractor McDonnell Douglas Corporation; Northrop Corporation is principal subcontractor.

Also at St. Louis, the McDonnell Douglas AV-8B Advanced Harrier, new version of the British-designed vertical take-off and landing fighter for Navy and Marine Corps use, made its initial flight on November 9. The AV-8B offers almost double the range and payload of its predecessor, the in-service AV-8A.

Among other military aircraft developments:

• DoD's two high-performance air superiority fighters, the Navy/Grumman F-14 Tomcat and the USAF/McDonnell Douglas F-15 Eagle, continued in production.

• In August, the first production model of the General Dynamics F-16 USAF/NATO fighter was delivered to the Air Force. Current orders call for almost 2,000 F-16s.

• A new and advanced version of the Lockheed U-2 reconnaissance plane, called the TR-1, went into development for the Air Force. It was expected to go into limited production under fiscal year 1980 funding.

• The first production model of the Army/Sikorsky UH-60A Black Hawk helicopter, designed to airlift an infantry squad for tactical assaults and related combat missions, was delivered October 31.

• Development was essentially completed on the USAF/Boeing E-3A Sentry Airborne Warning and Control System (AWACS) and the first operational airplane was to go into continental air defense service on January 1, 1979.

/1978

DEFENSE

1. Flight testing of the Navy's Trident 1 continued in 1978 with a series of launches from land pads at Cape Canaveral; first launch from a submarine was scheduled for spring 1979.
2. The Navy/Marine Corps F-18A Hornet strike fighter made its first flight in November.
3. The Army's Pershing II battlefield missile successfully completed a series of development test flights.
4. In August, the Air Force took delivery of the first production model of the F-16 fighter; production plans called for almost 2,000 F-16s.
5. The Navy/Marine Corps AV-8B Advanced Harrier, a new VTOL fighter, took to the air for the first time in November.
6. First production model of the UH-60A Black Hawk tactical assault helicopter was delivered to the Army in October.
7. The Air Force started development of the TR-1, a tactical version of the U-2R high-altitude strategic reconnaissance aircraft pictured.

SPACE

The National Aeronautics and Space Administration's quasi-operational Landsat system, whose repetitive observation of Earth resources is producing large-scale direct benefit, underwent a major change in 1978 with the retirement of an older satellite and the launch of a much-improved replacement.

The original Landsat 1, which had been orbiting since 1972, was turned off on January 6. Two months later—on March 5—NASA successfully launched Landsat 3, an advanced version of the General Electric-built satellite family which has substantially greater data collecting capability than its predecessors. The system now consists of two active satellites, Landsat 3 and the four-year-old Landsat 2. Together they cover virtually every spot on Earth every nine days, relaying to Earth a stream of digital data which is converted to photo-like images that offer great potential for improved management of Earth's resources.

A similar type of Earth-monitoring satellite, the Lockheed-built Seasat 1, was launched June 26. An ocean survey satellite, Seasat was designed to explore the potential of a future operational system for such uses as ship routing, storm and iceberg avoidance, guiding fishing fleets to most productive waters, and warning of threatening coastal disasters. Seasat was only partially successful. After 99 days of operation, it suddenly stopped transmitting. The data sent during the active period was sufficient to meet some of the scientific objectives of the mission, and NASA hoped it might suffice for a limited evaluation of an operational system's potential.

An important step in NASA's planetary research program was the dual launch of Pioneer Venus spacecraft which are making an extensive reconnaissance of the neighbor planet (for additional details see page 16).

NASA science teams were also actively monitoring the progress of earlier-launched interplanetary spacecraft. Voyagers 1 and 2, launched in the late summer of 1977, were enroute to close encounters with the superplanet Jupiter. Voyager 1 will make its closest approach next March and Voyager 2 will rendezvous with Jupiter in July. Pioneer 11, which left Earth in 1973, will begin a close-up investigation of Saturn in September, 1979.

Among NASA's other major launches in 1978 were these:

January 26: The International Ultraviolet Explorer, a joint NASA/European Space Agency/United Kingdom satellite which carries telescopes to study ultraviolet emissions from stars and other deep space sources.

August 12: ISEE-3, third of the International Sun-Earth Explorers, which are investigating solar winds, sunspots, solar flares and other solar phenomena which influence Earth conditions.

October 13: Tiros N, built by RCA Corp., a polar-orbiting experimental weather satellite for the National Oceanic and Atmospheric Administration.

October 24: Nimbus 7, built by GE Space Division, a research satellite designed to test sensors for oceanographic and meteorological monitoring.

November 13: HEAO-2, second of the High Energy Astronomy Observatories, which are mapping celestrial x-ray sources. Principal contractor is TRW Inc.

NASA's 1978 plan called for launches of 25 spacecraft, nine more than in the previous year. As was the case in 1977, most of the launches were "reimbursables" whose launch costs were paid back to NASA by payload sponsors. NASA's "customers" in 1978 included the European Space Agency, the United Kingdom, Canada, Japan, Comsat Corporation, the North Atlantic Treaty Organization, the U.S. Navy and the National Oceanic and Atmospheric Administration.

The NASA/Rockwell International Space Shuttle, which is also a Department of Defense project, headed the list of major systems in development status during 1978. The Space Shuttle Main Engine, the primary pacing factor in maintaining the development schedule, was successfully test fired as a single unit a number of times; full duration testing of the complete three-engine propulsion system was planned for early 1979. Three successful ground firings of the Shuttle's solid rocket boosters were accomplished. All elements of the Shuttle—the two solid boosters, the Shuttle Orbiter and its external main tank—were mated together for the first time

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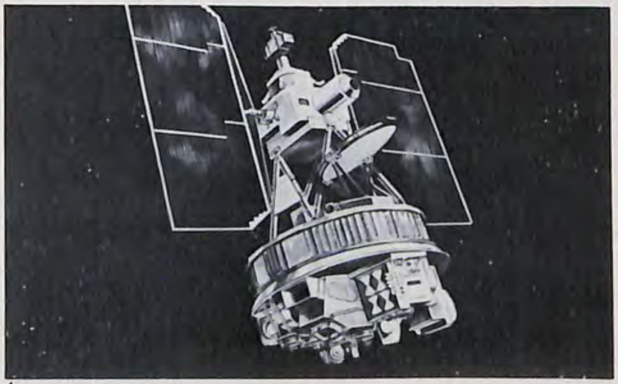
1. NASA's Landsat 3, shown undergoing pre-launch testing, was sent into orbit in March.
2. At NASA's Marshall Space Flight Center, the Space Shuttle completed a series of vibration tests to verify the structural integrity of the mated system—the Orbiter (shown being lowered into the vibration facility), the solid rocket boosters and the external fuel tank. First orbital flight of the Shuttle was scheduled for September 1979.
3. Artist's conception shows HEAO-2, second of the High Energy Astronomical Observatories, in orbit. The spacecraft was successfully launched in November.
4. Nimbus 7, an oceanographic/meteorological research satellite, was launched into polar orbit in October.
5. In development status during 1978 was Galileo, a combined orbiter/probe spacecraft designed for an extensive survey of Jupiter, beginning with a Shuttle-launch in 1982. The artist's drawing shows the main spacecraft as it releases the disc-shaped probe, which will descend through Jupiter's atmosphere.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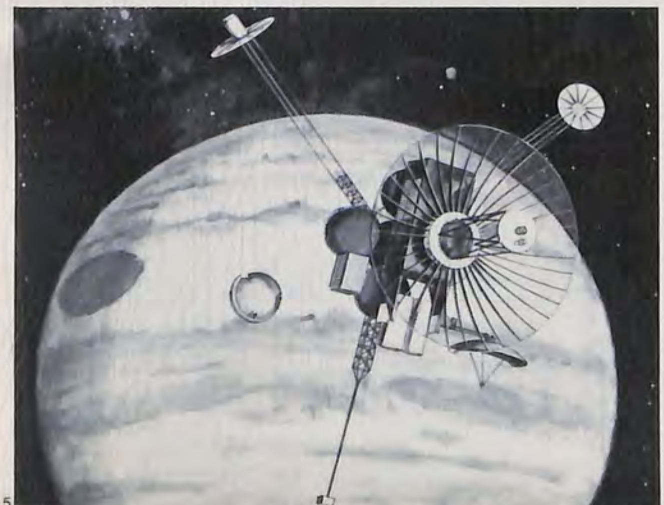
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and put through a series of vibration tests to verify that the Shuttle's structure will perform as predicted. On the basis of testing progress, NASA announced a revised Shuttle development schedule which set a target date of September 28, 1979 for the first manned orbital flight of the Shuttle system.

Other major NASA programs in development status included:

• Galileo, a dual unit spacecraft consisting of an orbiter and a planetary probe, to be launched in 1982 for an extensive survey of Jupiter. Jet Propulsion Laboratory is system integrator.

• Landsat D, the fourth and most advanced of the Landsat Earth resources monitoring satellites, to be launched in 1981. GE Space Division is prime contractor.

• Space Telescope, an advanced astronomical system which will permit observations far deeper into space than has ever before been possible.

• Spacelab, a habitable space laboratory for human-directed experiments in orbit, which fits into the cargo bay of the Shuttle Orbiter. First Spacelab flight is targeted for 1980. The laboratory is being developed by the European Space Agency.

In military space operations, the Department of Defense launched a new, long-duration reconnaissance satellite in June; details were withheld. On February 9, DoD launched the first spacecraft in the Navy/TRW Fleet Satellite Communications system; a second satellite was scheduled for launch late in 1978. The system will provide ship-to-shore, ship-to-ship and ship-to-aircraft links.

Other than the Space Shuttle, DoD's principal space development activity in 1978 focused on the NavStar Global Positioning System. Being developed by Rockwell International and McDonnell Douglas Corp. under Air Force cognizance, NavStar is a global system of satellites and ground equipment designed to provide precise positioning and other information for more effective operation of ships, aircraft, artillery and armored forces. The first three prototype spacecraft were launched in 1978 and a fourth was scheduled for year-end launch. These spacecraft are part of an eight-satellite interim system designed to prove the concept and provide information helpful to development of an advanced operational system. The fully-operational network was planned for service use in the mid-1980s.

Development starts on new, advanced technology U.S. jetliners highlighted civil aviation activity in 1978. Boeing Commercial Airplane Company launched development of two new airplanes: the 767, a widebody twinjet intended for the 200-seat, medium capacity market, and the 757, a standard body twinjet of lower seating capacity. Lockheed Aircraft Corp. announced plans for an advanced, flexible-range version of its L-1011 TriStar called the Dash 400. These aircraft, along with the earlier-launched McDonnell Douglas DC-9 Super 80, are the initial members of a new U.S. generation of commercial transports which will begin airline service in the early-1980s.

Improving financial health of the world's airlines brought a surge of orders for both new generation and existing commercial transports. With several billion dollars worth of new orders, U.S. transport builders far outdistanced their European counterparts in the 1978 round of international jetliner sales competition.

The nation's scheduled airlines set new traffic and earnings records in 1978. Passenger traffic rose about 17 percent above the previous record

CIVIL AVIATION

year of 1977. U.S. airlines boarded some 280 million passengers in 1978 and accounted for more than 80 per cent of all public intercity passenger miles. The Air Transport Association predicted that air traffic could reach 300 million passengers in 1979.

ATA estimated that 1978 earnings may exceed one billion dollars on total revenues of more than $22 billion, adding that airline earnings must remain at the 1978 level or better for near-future years to meet capital investment needs. ATA stated a need for a level of five percent on sales in coming years to finance an estimated $60 billion in expenditures for new equipment in the decade of the 1980's. The association predicted 1979 revenues would reach $25 billion.

At year-end, the U.S. scheduled airline fleet was expected to number 2,300 aircraft. Together with supporting facilities and ground equipment, this represents an investment of about $21 billion, with a replacement cost of several times that figure. Industry employment, after a dip in recent years, expanded to more than 310,000. Average total compensation per employee was about $28,000, one of

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the highest averages of all U.S. industries.

As in previous years, NASA's civil aviation research program focused on methods of reducing aircraft fuel consumption. This effort involved not only the obvious measure of improving propulsion efficiency, but also research on aerodynamic shapes, lighter aircraft structures and computerized flight control systems, all of which influence fuel consumption. In a related program, NASA continued its "clean and quiet" research designed to improve the environmental characteristics of current and future aircraft. Two major projects in this area were the Quiet, Clean Short-haul Experimental Engine, under development by General Electric Co., and the Quiet, Clean General Aviation Turbofan, two models of which were being developed for NASA by Avco Lycoming and The Garrett Corp.'s AiResearch Manufacturing Co.

A major "clean and quiet" project reached flight status in 1978 when the Boeing-built Quiet Short-haul Research Aircraft (QSRA) made its initial flight on July 6. After further company testing, the airplane was delivered to NASA's Ames Research Center in August for a two-year test program. The QSRA is designed to develop technology for future, extremely quiet transport aircraft and to demonstrate the "propulsive lift" concept which will enable tomorrow's short-haul transports to operate from very short runways.

In other flight test activity, NASA was co-sponsor with the military services on three rotorcraft research vehicles. Flight tests continued on the Sikorsky S-72 Rotor Systems Research Aircraft (RSRA), which operates either as a conventional helicopter or as a compound helicopter, a winged rotorcraft capable of greater cruise speed although it retains the helicopter's vertical lift characteristics. Bell Helicopter Textron's XV-15 Tilt Rotor Research Aircraft completed wind tunnel and hover tests and late in the year was being readied for conversion tests, in which the craft's large rotors tilt forward after vertical take-off to become propellers for cruise flight. The third NASA/military project was the Sikorsky XH-59A ABC (Advancing Blade Concept) vehicle, which can be flown as a pure helicopter or as a relatively high speed wingless aircraft powered by two auxiliary Pratt & Whitney turbojet engines. The high speed phase of the flight test program got under way in 1978.

In the commercial helicopter field, Sikorsky's S-76 12-passenger twin-turbine helicopter received its Federal Aviation Administration type certificate on November 21; first deliveries were made in December. Flight test continued on Bell Helicopter Textron's 6-10 passenger twin turbine transport, the Bell 222. The company expected certification in 1979 and first deliveries in October 1979.

The Federal Aviation Administration reported that U.S. civil aviation reached new peaks of air traffic activity during fiscal year 1978. FAA's air route traffic control centers handled 27.9 million aircraft operating under instrument flight rules, exceeding the fiscal year 1977 count by 7.5 percent.

The American Microwave Landing System (MLS) program reached a significant milestone in April 1978 when it was selected as the international standard by the World Wide All Weather Operations Panel of the International Civil Aviation Organization. The American MLS, which employs a Time Reference Scanning Beam technique, has been under development by FAA since 1971; the contractor team is headed by The Bendix Corp. and Texas Instruments. When in place, this system will overcome many of the shortcomings of the present Instrument Landing System by making possible the precise, flexible, and reliable landing guidance required for an upgraded air traffic control system. During 1978, FAA completed testing and evaluation of two MLS prototypes—the Basic (Narrow Aperture) System and the Small Community System. A Basic (Wide Aperture) System was to be delivered to FAA in 1979.

FAA also made progress in other areas in its program to enhance the capabilities of the National Airspace System. During 1978, the agency accepted delivery of two engineering models of the Discrete Address Beacon System (DABS), a major component of FAA's planned upgraded air traffic control system. Under the existing Air Traffic Control Radar Beacon System, an airborne transponder signals an aircraft's identity and altitude in response to an FAA ground radar interrogation. This system has a major shortcoming, an inability to separate transponder replies from aircraft flying in close proximity to one another. DABS overcomes this difficulty by being highly selective in its interrogation. In addition, DABS will provide a data link that will enable air traffic control computers on the ground to warn pilots whenever their aircraft are following courses that are potentially in conflict. The first operational DABS models are expected to be procured in the early 1980's; the radar beacon system will be phased out gradually over a 10-year period.

1. Representative of a family of new U.S. advanced technology jetliners is the Boeing 767, development of which was started in July.
2. U.S. scheduled airlines set new traffic records in 1978.
3. NASA's Quiet Short-haul Research Aircraft made its initial flight in July and was delivered a month later to Ames Research Center for a two-year test program.
4. The newest U.S. commercial helicopter, the 12-passenger twin-turbine S-76 received its Federal Aviation Administration type certificate in November and initial deliveries began in December.

America's future depends on the continuing flow of high technology to solve the problems that face our complex society. But, what if that flow trickles to a halt? No one knows the answer and few Americans believe our well of technological innovation will ever run dry. The nation's industrial leaders, however, are greatly concerned about the current slowdown of innovation. In recent weeks, two chief executives of AIA companies headquartered in different parts of the country sounded similar warnings about declining innovation in speeches given at opposite ends of the country. *Aerospace* magazine believes its readers will find the two speeches to be compelling statements on the need to accelerate research and development across a wide spectrum of scientific frontiers. Excerpts of the two speeches are published to help our readers understand this national problem.

U.S. I

WILLIAM M. AGEE

WILLIAM M. AGEE, *Chairman, President and Chief Executive Officer, The Bendix Corporation, in an address before the Los Angeles Rotary Club:*

Is it ignorance of how to proceed or apathy about the value of technology that has caused the rate of innovation to slow down so dramatically in this country? Are these the factors that explain why research and development—once the strongest weapon in our economic arsenal—now seems to have slipped in importance? And there is no question . . . that we are slipping badly. The evidence is not subtle.

Item: At one time, U.S. companies spent two-thirds of the world's total outlay for research and development. Recently, our share has been one-third, a decline of 50 percent.

Item: In 1968, more than 300 new high-technology companies went into business. In 1976, there were none.

Item: Federal spending on R&D has declined from 3 percent of Gross National Product in 1963 to 2.2 percent today.

Item: The amount of basic research that industry pays for was 38 percent of the national total in 1956. In 1976, the comparable figure had dropped to 16 percent.

I could go on citing statistics about the worrisome decline in research and development, for there are plenty more where these came from. But perhaps I can . . . explain *why* such statistics should bother us at all.

The reason, oversimplified only a bit, is that technological innovation is where the action is in this economy. It is the likeliest producer of growth, of productivity, and of new jobs. According to the Department of Commerce, technological innovation was responsible for 45 percent of this nation's economic growth between 1929 and 1969. And between 1957 and 1973, high technology businesses produced jobs 88 percent faster than other companies, and their productivity grew 38 percent faster . . .

Let me try to answer my own question about whether we're dealing with ignorance or apathy. I think we can rule out ignorance almost immediately. There is no doubt in my mind that we have just as many inventive people around today as we did in the 19th century and the first half of the 20th century. That period of 150 years was characterized by explosive innovation. I don't think we've lost our national imagination, and I cannot believe that the species of person who is urgent about inventing something and taking it to market—whether from a corporate laboratory or a workshop in the garage—has gone the way of the passenger pigeon.

But maybe there *is* something to say about apathy. And

ROY A. ANDERSON

ROY A. ANDERSON, *Chairman of the Board and Chief Executive Officer, Lockheed Corporation, in a address before the Wings Club, New York City:*

Here are some broad conclusions that seem to be universally recognized and acknowledged:

• Technology has played a vital role in the growth and development of the United States. It has raised us to levels of material wealth and opened avenues to personal fulfillment never before known in all of history. It has been a driving force behind many of our achievements in the past and has been a key factor in our world leadership role.

• Continued support of technological innovation is critical—not only to the future of commercial aircraft, not only to the future of national security, but to the economic future of our nation and even the world.

• Innovation in new products and services is vital to the process by which an economy grows and renews itself.

• Technological innovation is an important element in the balance of trade.

• Technology and productivity are closely related. Cost reductions and efficiency gains come primarily through inventions and innovations in methods for production and distribution.

Now, where does the U.S. stand today in the support of technological innovation? The key point seems to be that today our inventive thrust seems to be diminishing and our technological lead threatened. The evidence has been piling up in recent years. Here are a few examples.

• Today the rate of increase in U.S. productivity is below that of any of the other major industrial countries. In fact, the first half of 1978 has seen an actual decline.

• Total U.S. research and development spending dropped from 3% of the Gross National Product in 1963 to 2.2% in 1977. We no longer lead other countries in this expenditure rate. In terms of constant dollars, there has been no change during that period.

• Basic research in industry has been declining since 1966, when, in 1972 dollars, it peaked at $800 million. In 1977, it declined to $550 million in 1972 dollars.

• For the first time, the Japanese are challenging U.S. supremacy in the development and production of advanced semiconductors.

• Students enrolled for advanced degrees in science and engineering have dropped 10% over the last decade. And we may be exporting our future—well over half the science and engineering students in some of our top universities are now foreigners.

• And now a final example—a quote from Defense Secretary Harold Brown in a statement to the House Armed Services Committee in February of this year: "The fiscal year 1979 Department of Defense budget request . . . reflects our growing conviction that we must reverse the erosion of the technical and development lead the U.S.

NOVATION DECLINES

maybe the kind of apathy I have in mind is a consequence of the fact that we've built the mightiest economy in the history of this planet—and now are wondering *if it was all worthwhile.* When a citizen has a full stomach and a nice home and all the other things that the American standard of living has produced, it's time for complaints of a higher order . . .

From a psychological point of view, the American businessman is in no mood to finance research and development into risky, untried ideas. The impact of governmental action is one reason, but only one. For instance, Wall Street places a premium on steady upward growth in earnings, quarter by quarter. So, for that matter, do the incentive programs within corporations. Those twin pressures do not encourage futuristic, risky thinking about where the company should be five years from now, or what its product mix should be. What they encourage instead is capital spending that will wring as much productivity as possible out of existing processes. They encourage fine-tuning the business in the present, not growing the business dramatically in the future.

In addition, business has to remember the go-go days of the early sixties, when some stocks of new, small high-technology companies were, almost literally, selling at 15 times last year's deficit. In the ebullience of those days, technology was temporarily fashionable and, when the sorting out began, a lot of money managers got hurt.

The great truth is that people don't like change, and businessmen are people, too. And it is certain that if we managed to get a technological surge going in this country, there would be great change. Companies would spring into life, and others would die. Jobs would appear in one part of the country, and jobs would vanish in other parts of the country. There would be some turbulence.

But two things seem clear to me about that. One is that the net national effect of a boom in research and development and new technology would be strongly favorable to our economic well-being, for the reasons I cited earlier. The other is that *we don't have another viable choice.* In the world economy, and in the realm of our balance of payments, we are facing the most formidable competition we have ever faced. Take, for example, the industrial colossus called Japan. If there is any doubt in you minds that a committee system works, this enterprising country should settle the question. Within a basic structure of capitalism, business and government walk hand-in-hand for the national well-being. The Japanese have done a splendid national job of identifying the businesses they are good at. Then they plan. They have meetings and committees and they take their time in planning stages. But when they move, they move like lightning, and all together. The result is a truly formidable competitive force . . .

I am optimist enough to think that we can find our way through a very thorny thicket. It does not have to be that America gets written off as a *mature* economy, which is generally understood to mean *flagging.* I don't think it's oversimplifying to say that we are looking at a straight business proposition. And my conclusion is that the cost of failing to act on innovation is too much to pay, and the revenue from wise action is too exciting.

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has had over the Soviet Union. During the past year debate has shifted from whether or not our quality lead has eroded to how bad is the erosion and what corrective actions must be taken."

I admit this is a selective list that may be unduly frightening when taken out of context. Still, there is enough evidence around to cause genuine concern about the loss of our innovative thrust and the support and direction of research—particularly basic research.

The apparent threat comes at a critical time because never has our economy needed more help from our technology that it does today. Let me amplify that a bit. Technology is a major factor in increasing productivity and so helps to lessen the rate of inflation—it is thought to be directly responsible for at least 40% of productivity growth and perhaps as much as 70%.

We do, of course, count heavily on technology to help solve many current problems in such fields as developing new energy sources, cleaning up the environment, and countering the Soviet Union. We also count on it—or should count on it—to help solve our serious balance of trade problem.

Apart from agriculture, high techology products like aircraft, computers, chemicals, and machinery stand virtually alone in making favorable contributions to our balance of trade—and I would remind you that even agriculture in our nation should perhaps be classified as a high-technology operation. Aerospace last year generated export sales of $7.6 billion. The net favorable contribution to the trade balance was $6.85 billion, making aerospace the nation's leading net export industry. The simple truth is that industries that are technologically intensive have a favorable trade balance, and industries that are not do not. It would be fatal to our efforts to restore a favorable trade balance if we allowed to falter those industries that are most able to help. It would be tragic to see aircraft go the way of shipbuilding, or electronics the way of steel—victims of technological decline in the face of foreign competition.

The logical question is why this apparently diminished thrust in technological innovation?

Some claim many of the really big leaps in technological innovation came as a result of past government space and military problems. Among significant examples are cited such developments as communication and weather satellites; nuclear power plants; and today's commercial airliners, emerging from aircraft and engine technology that was accelerated years ago to meet military requirements . . .

But the real answers to the problem of stimulating technological innovation lie in the health of the economy and business as a whole. I strongly believe the main answer lies in stimulating capital formation—stimulating investment—in incentives to invest and invent. Technological innovation does not come quickly and it does not come cheap. It usually involves high risk and it requires financial nurturing over many years before it brings results. To support it, private industry must have the resources—it must be profitable and it must be able to attract venture capital.

Much has been said about how to stimulate capital formation—to stimulate investment. Let me mention three positive steps that could be taken in our tax structure:

First, significantly lower or defer the current capital gains tax . . .

Second, eliminate the taxation of dividends . . .

Third, give consideration to some form of partial tax credit for independent research and development expenditures . . .

PIONEER VENUS— Unde

Artist's conception shows the various units of the Pioneer Venus spacecraft team. At left is Pioneer Venus 1, which will orbit Venus for a year and send daily weather reports. At right is the Pioneer Venus "bus" and four instrumented probes, designed to parachute through the Venusian atmosphere and return data as they descend.

standing Earth's Weather

NASA's planetary exploration missions are always interesting to the layman in broad outline but usually obscure as regards the scientific objectives and what they mean to Earthlings. Generally, NASA is exploring the other planets to learn more about Earth, but the Earth-benefit aspects are rarely apparent to the non-scientist.

This year's planetary mission—to neighbor planet Venus—is different in that its goals are more readily understandable. A primary aim of the Pioneer Venus mission is to learn more about the phenomena which cause Earth's weather. Through greater understanding of weather influences, scientists are building an informational base which may—sometime well in the future—permit man to change the weather to his advantage.

But why, one might ask, should we go 30 million miles to Venus to learn about Earth weather?

The answer is that it is difficult to study Earth weather from Earth itself or from near-Earth orbit. Earth has a very complex "weather machine." Our weather and climate are influenced by a number of factors, for example, cloud cover that is constantly changing; the presence of large bodies of water and the continual intermixing of land and ocean air masses; the tilt of Earth's axis; and our planet's rapid rotation, once every 24 hours.

Venus, on the other hand, has a very simple weather machine. It has a basic atmosphere, no oceans, virtually no axial tilt and it rotates slowly, once every 243 Earth days. It is easier to study the variables which cause changing conditions on Venus. So Venus affords an ideal laboratory for study of what NASA calls "comparative planetary meteorology," which means relating phenomena on one planet to conditions on another. By amassing detailed information on Venus' atmosphere and its weather-changing influences, scientists may be able to understand better, through the comparative process, how Earth's more complex weather system works, which variables cause what weather formations and how.

The tools for this research are two separate spacecraft, Pioneer Venus 1 and 2, both built by Hughes Aircraft Co. for NASA's Ames Research Center, Pioneer Venus program manager. Launched last May, Pioneer Venus 1 went into orbit around Venus on December 4. Using infrared equipment to penetrate Venus' cloud cover, it is making weather maps of the planet's atmosphere, studying upper atmosphere temperatures, pressures and water vapor content, measuring reflected sunlight and the effects of solar winds, and investigating a great variety of other phenomena. Pioneer Venus 1 will also send back a continual stream of photos, both black and white and color.

Pioneer Venus 2 left Earth as a single spacecraft, but in the latter part of November, when it was several million miles from Venus, it separated into five different spacecraft: four instrumented probes and the basic spacecraft, or "bus." All five were to descend by parachute through Venus' atmosphere, reporting data for an hour en route to the surface—for example, data on temperatures at various levels, which are estimated to reach 900 degrees at the surface; pressures, believed to be almost 100 times as great as Earth's; atmospheric composition, wind forces and many other elements of the planet's weather system. This information, acquired from widely separated points in both the daytime and nighttime hemispheres of Venus, will complement the broader "big picture" data obtained by the orbiting Pioneer Venus 1. The latter spacecraft will send daily Venusian weather reports back to Earth for a year.

The Pioneer Venus mission is expected to supply important information applicable to Earth weather research because Venus is Earth's closest neighbor in the solar system, and, though vastly different in some respects, it is similar in others. Pioneer Venus data will be correlated with studies of other planetary weather machines, for example, Mars' cloudless atmosphere, Jupiter's rapidly-spinning atmosphere and the massive storm systems of both Jupiter and Saturn. From comparative meteorology studies, scientists hope to add new volumes to the still-rudimentary knowledge of the factors that determine Earth's complex environment and lay the foundation for realizing an age-old ambition: "doing something about the weather."

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LANDSAT—Earth Monitor

By JAMES J. HAGGERTY

Notable views of notable people on aerospace matters...

aerospace perspectives

Among the witnesses at the space policy hearings before the Senate Subcommittee on Science, Technology and Space were Senator Harrison H. Schmitt (New Mexico); Dr. Philip Handler, president of the National Academy of Sciences; and former NASA Administrator Dr. James C. Fletcher. The following comments are excerpted from their statements.

Senator Schmitt: "What is needed is the development and implementation of a (space) policy for the *future,* not the past. If indeed the lessons of history are to have any meaning in the area of space activities, we must be aware that the U.S. is at the forefront in space today because of the vision and leadership that was displayed by President John Kennedy, the Congresses and America of the 1960s. If we are tepid in our response to the challenge of space today, we will find that others have displaced the U.S. in technological dominance in the future, and the torch of leadership will have been passed to other countries."

Dr. Handler: "One of the greatest difficulties in optimizing the space program is the task of achieving *early* acceptance of—and commitment to—new initiatives, thereby assuring adequate long-term planning, developing the necessary scientific and technological support base, and keeping the scientific and technological support teams together and fully employed so that our overall capability is not eroded. If this is not done, these resources of scientists and facilities will turn their attention elsewhere and subsequently proposed new starts would become ever more difficult and expensive . . . In this sense, I strongly support the requirement for an annual presentation of a rolling five-year (space) plan, with some consideration of a 10-year outlook."

Dr. Fletcher: "I was exceedingly disturbed to learn that the operational fleet of Space Shuttles had been reduced from five to four. I have always felt that the number five was marginal to begin with. It was arrived at by attempting to project specific space missions out to 1990 and integrating them into a so-called 'mission model.' I'm afraid the mission-model became overly sacred in NASA's and the Office of Management and Budget's thinking, even though most of us realized that the real missions for such a radically new device like the Shuttle could not be forecast that accurately in advance.

"The late George Brown, former Chairman of the Joint Chiefs of Staff, strongly urged me at the start of the program to figure on at least seven, since we were both convinced that, once the Shuttle began to fly routinely, the military would want to pursue many new missions not now in its current five-year plan but designed specifically to take advantage of the Shuttle's capabilities. This will happen in the civilian program as well. I sincerely hope we have not foreclosed that option in our current four-Shuttle plan."

Secretary of Defense Harold Brown, *writing in the Department of Defense publication* COMMAND:

"There can be no effective defense of Europe that does not involve the U.S. and any viable long-run defense of the U.S. would be doubtful unless Europe, too, remains free. Separately we could not match the military and geopolitical power of the Warsaw Pact. But together we can do at least that well, if we are willing to work at it . . .

"We in the Defense Department do not have all the answers to how best improve armaments collaboration in the common interest. But we do know that it is a military impreratve if NATO is to achieve and maintain credible deterrence and defense in the 1980s at a cost which free societies can afford."

Dr. William P. Sommers, *president of the technology and management group of Booz-Allen & Hamilton, Inc., Bethesda, Maryland, writing in* NATION'S BUSINESS:

"The management of technology in the past 10 years has become increasingly risky and complex both in the United States and abroad.

"Some firms now consider long-range to mean five or even three years, instead of the seven-year time span that has been commonly used in the past. This represents a major change in the way top management perceives the future. Managers attribute this shift in planning strategy to the increased uncertainty of market, regulatory and economic conditions . . .

"Unexpected higher rates of inflation, reduced profitability, rapid rises in energy costs, shifting policies and government regulations all have had a profound influence on U.S. firms' willingness to invest in future technological opportunities . . .

"Government regulations . . . are fostering a type of competition which is not market related. Instead of innovating to compete with other firms and meet consumers' needs, a significant portion of investment dollars is going to meet regulatory requirements. The result: management is wasting valuable resources that might otherwise be invested to expand business volume and develop new products and processes."

Senator Howard W. Cannon (Nevada), *speaking before the Aero Club in Washington, D.C.:*

"Retrofit of two and three engine aircraft is not the answer to anyone's noise problem; it will cost the airline passenger, not the airlines but the passenger, well over $200 million dollars; it will increase fuel consumption and decrease productivity at a time when we can afford neither; and it will, I believe, create serious problems when 1983 rolls around and people around airports like National and LaGuardia feel they have been hoaxed . . ."

A I A

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COVER

The spacecraft on the cover is NASA's Landsat D, fourth and most advanced member of the Earth survey satellite family built by General Electric Company's Space Division. Landsat D will be delivered to orbit by the Space Shuttle in 1981.

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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SUPPORT FOR TECHNOLOGY

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

The aerospace industry's business is developing and applying technology, principally high technology. Its leaders are firmly convinced that advancing technology offers the greatest promise—in some cases the *only* hope—for solution of the pressing problems confronting the world's peoples today. In recent years, the industry has been concerned about a tide of anti-technological opinion and an apparent lack of understanding by many Americans of technology's value and importance to modern society.

But perhaps the anti-technology view is not as widely held as its highly vocal advocates would have us believe. That is the encouraging conclusion of a survey of American opinion conducted for Union Carbide Corporation by Cambridge Reports, Inc., briefly summarized here:

"A trend that has become increasingly apparent is one that some have labeled 'voluntary simplicity'—a desire to return to a simpler lifestyle. Implicit in this drive for the simpler life is the need to dispense with many of the trappings of science and technology. Symptomatic of the trend are increasing concern about environmental hazards, the boom in natural and health food sales, and 'sit-ins' and protest rallies over issues such as nuclear power plants, strip mining, and noise and pollution from airports.

"Attitudinal research in this area, however, shows that most people clearly do not wish to return to pre-industrial conditions. Indeed, increasingly the majority of Americans are looking to technology to provide the answers to the problems earlier technology itself has caused, as well as the other, yet unsolved problems of mankind . . .

"The people who do favor a slowdown in a scientific and technological development are clearly in the minority; they are more likely to be younger people, the less-educated and people with lower incomes. The great bulk of the people acknowledge the personal and economic benefits of advanced technology and are in favor of increased investment in scientific and technological research by both the private and the public sector. They especially support technological growth if it furnishes direct benefits to them, such as increased employment, or would directly address problems immediately concerning them . . .

"Americans are proud of the technological leadership of the United States and are loath to see other countries outstripping them. Regardless of the increasing skepticism many people have toward 'growth' in general, most Americans are still growth-oriented and only a minority of the people want the United States to cut back its efforts in the areas of scientific and technological research and development."

American technology is lagging in some areas, but American industry has the competence to regain lost ground and to sustain its position in those areas of science and technology where the U.S. is still pre-eminent. To do so, it needs the understanding and support of the American people. Thus, the Cambridge report is good news to those who share the aerospace industry's belief that scientific and technological advancement is vital to the future of the nation.

SPACE POLICY AND THE INTERNATIONAL ECONOMIC CHALLENGE

By SENATOR ADLAI E. STEVENSON
Chairman, Subcommittee on Science, Technology and Space,
Senate Committee on Commerce, Science and Transportation

The United States today faces decisions that could be as fateful to the country's future in space as those in the early 1960's. Then we were competing with the Soviet Union for national prestige. Now we are striving for economic and political security in an unstable and interdependent world.

The sinking dollar, the collapse of the international monetary system and a U.S. trade deficit of $30 billion signify the weakness of the United States in a fiercely competitive global marketplace. The U.S. cannot compete effectively with cheap labor or abundant raw materials or by controlling the world's capital—all that is past. Our future economic survival requires a firm commitment to basic research, technological innovation, and commercializing and marketing technology.

A healthy civilian space program helps sustain this country's scientific and technological base. While there are those who would disagree, government support for technology, both as a purchaser and developer of technology, has been and remains essential to the Nation's competitiveness in the world marketplace.

New Opportunities and Challenges

The prospect of conducting frequent trips to Earth orbit with the Space Shuttle also opens up the space environment to a range of cultural, scientific, and economic activities on Earth and in space that are not feasible with more expensive and less adaptable expendable rockets. We must not restrict our vision by relying excessively on cost/benefit ratios and zero-based budgets. We need to recapture an earlier spirit—a willingness to run risks, try new ideas, compete, test the unknown and excel. The new era in space—made possible by the Space Shuttle—should be characterized by "routine utility," using the space environment on a regular basis to bring economically productive services to people on Earth.

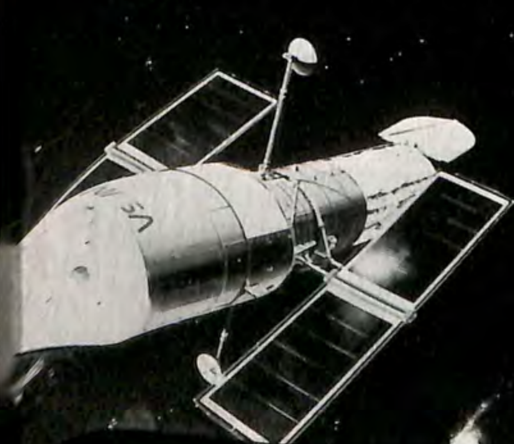
The potential for using the space environment to serve human needs is greater than ever. Remote-sensing satellites can provide vital information for climate and weather research, environmental and pollution monitoring, crop forecasting, plant disease control, drought and flood control, mineral and natural resources exploration and management, land use planning, geodesy, mapping, earthquake research and prediction, and search and rescue capabilities. The possibility of generating electric power in space and space manufacturing must be explored actively. Advanced communications satellites will open up new services to commercial and public users, including educational and medical applications. Advances such as electronic mail and wrist radios are within reach. We stand on the verge of mankind's most promising era of scientific exploration. Within the next decade, we can unravel many of the mysteries of the origin and evolution of our solar system and the universe.

Beyond the economic and scientific benefits and public services afforded by space exploration and development is an expanded view of mankind's place in the universe. Norman Cousins, editor of *Saturday Review*, discussed this aspect of the space program last year before the Subcommittee on Science, Technology, and Space. He noted that "the case for space exploration has to do with our philosophy as a people and as a nation—how we see life; and finally whether we attach any importance to our uniqueness as members of the human species."

We must also recognize that other nations are challenging the United States' lead in space technology forged during the 1960's. The Soviet Union has given priority to manned space activities. Last year's record

The Space Shuttle heralds a new era of space activity characterized by "routine utility," using the space environment on a regular basis to bring economically productive services to people on Earth.

Among goals of the Space Policy Act of 1979 is continued U.S. leadership in space science, typified by the Space Telescope, which will permit observations far deeper into space than has ever before been possible.



breaking missions to near Earth orbit are a prelude to longer and more extensive efforts. Much larger rockets will permit construction of elaborate space facilities by the Soviet Union; a permanently occupied station is only a matter of time. The European Space Agency is developing its own expendable launch vehicle, the Ariane, which will compete with the Space Shuttle for commercial business. France is developing a remote-sensing satellite comparable to the U.S. Landsat. Japan, Germany, and France are making rapid strides in satellite communications systems.

These developments involve more than national pride and prestige. Fundamental changes have taken place in the structure of the world economy. Developing countries are providing an increasing share of the world's manufactured goods at terms the industrialized countries find difficult to match. To survive economically in these conditions, we must recognize the need to replace uneconomic low technology and low productivity enterprises with high technology and high productivity manufacturing. These are the opportunities and the challenges presented to the nation.

The choice is ours. We can blindly try to preserve the past through protectionist trade policies and government subsidies of failing industries. Or we can move to build a U.S. economic structure that is attuned to the realities of today's interdependent world. The space program can contribute to our technological and economic health. We must make sure that it does.

Space Policy Legislation

It is the purpose of current space policy issuances and legislative proposals to achieve this objective. Near the close of the 95th Congress, I introduced the "Space Policy Act of 1979," S. 3530, and reintroduced the bill, with clarifying changes, on January 29, 1979, as S. 244.

Last October, President Carter issued a directive covering U.S. efforts in space for the next decade. The

Administration's civil space policy recognized the changing nature of U.S. activities in space, a tenet on which the Space Policy Act is based.

The Administration's civil space policy also recognized the need to maintain U.S. leadership in space and the importance of continuing research and development to achieve this objective. NASA was given specific authority to resume research and development in communications satellites following a six-year hiatus in such activity. Such an effort is essential if

Techniques being developed for the erection of large structures in space open up such possibilities as in-space manufacturing and generation of electric power from orbiting platforms.

the U.S. is to respond to vigorous competition from abroad in communications satellite technology. The policy also commits the United States to maintaining a position of leadership in space science and planetary exploration.

President Carter's directive was too limited. The opportunities and challenges in space were recognized. The need for the United States to maintain its position of leadership was acknowledged. Yet the directive was silent on the programmatic goals in space applications and space science that can give meaning to these words. The Space Policy Act of 1979 identifies these goals and establishes a procedure to bring increased purpose and direction to annual funding decisions. Among these goals in space applications are:

- design and construction in space of a first generation of large structures;
- research and development leading to the design and testing of prototype systems for electric power generation if technological, environmental, and economic programs can be resolved satisfactorily;
- resumption of communications R&D research;
- design and testing of space-based manufacturing technologies;
- establishment of an operational system for remote-sensing of the Earth's resources and environment.

In space science, the bill sets goals to maintain U.S. leadership in planetary and lunar exploration, the study of dynamic relationships between the Sun and Earth, the understanding of astrophysical phenomena, and the study of life sciences as related to human performance in space and the evolution and distribution of life in the universe.

The President is directed to prepare a five-year plan that spells out annual funding levels to achieve these goals. He is to update the plan annually, and he has authority to propose revisions. The existing authorization and appropriations process would be unchanged.

There is no inherent contradiction in setting longer-term goals and maintaining a constrained budget in any given fiscal year. To the contrary, a clear sense of direction is essential in making wise decisions about annual expenditures. The space budget today is essentially based upon ad hoc decisions often forced by short-run objectives of the Office of Management and Budget. It makes far greater sense to establish basic programmatic objectives and tailor annual budget outlays to fiscal realities. The "Space Policy Act of 1979" is designed to provide such a procedure.

Private Sector Participation

This legislation does not intend that the Federal government should do it all. To the contrary, the new era in space should increasingly be pursued by business and industry, using private capital, and offering services and benefits on the open market. The private sector is now the dominant force in satellite communications. The next area ready for substantial non-government participation is the processing of remotely-sensed data and information. Private companies have been exploring ways to lease or purchase one of the Space Shuttle Orbiters for commercial use. As technologies mature, new opportunities will be opened for greater financial participation by the private sector, and I anticipate fully that the potential economic returns from space-based services will generate increasing private entrepreneurial activity.

It is too early to know what kinds of arrangements will prove to be desirable. I only note that a major consideration in developing greater non-governmental participation will be the government's commitment to maintain United States' leadership in space science and technology. Passage of the space policy legislation would be a major step toward establishing the climate in which mutually beneficial public-private sector relationships could be developed.

In this period of constrained Federal funds, it is necessary to face squarely the budgetary impact of a revitalized U.S. space program. Testimony before the Subcommittee on Science, Technology, and Space indicates the feasibility of initiating such a program at the level of recent NASA budgets, adjusted for inflation. Funds which have been used to develop the Space Shuttle, in the range of $750 million to $1 billion annually, can be gradually shifted to other space activities as the Shuttle development program concludes. As new technologies mature, some additional Federal funding may be required, but under the terms of the Space Policy Act these will be subject to the scrutiny of Congress through the normal authorization and appropriations process. The five year planning process specified in the bill provides a mechanism to hold total expenditures in any fiscal year to acceptable levels. In any event, the goals contained in the Space Policy Act will not require a return to expenditure levels of the Apollo program.

A New Era in Space

In summary, a commitment and a firm sense of direction by the federal government is needed to initiate the new era in space. With the launching of the Space Shuttle approximately one year away, we are at a watershed. Decisions during the next year or so will more than likely set the course of our space activities for the rest of this century. A balanced and reasonable program, as contemplated by the legislation, will insure this nation's leadership in developing the space environment for the benefit of people in this country and around the world, and in expanding the national research and technology base. This, in turn, will help the United States meet competitive conditions in today's world.

Finally, those of us who recognize the cultural and economic potential of the space program have a responsibility to communicate this vision to the people. We have not done this well in recent years. Many people, while supportive of space exploration, are unfamiliar with the new prospects within reach. They are not aware that the Space Shuttle makes possible the routine utilization of the space environment for mankind's benefit on Earth. We need to inform those outside the scientific and technical communities about the potential of space and what that means to the nation. This includes many of my colleagues in the Congress. We need to generate a resurgence of public support that will help the United States fulfill its opportunities in space and the potentials of space for well-being on Earth. Unless we do this, the development and exploration of space may well remain the uncertain enterprise it is today.

1979 SPACE POLICY ACT TESTIMONY

Aerospace Industries Association expressed its support of the Space Policy Act of 1979 in the following statement by AIA president Karl G. Harr, Jr., submitted to the Subcommittee on Science, Technology and Space of the Senate Committee on Commerce, Science and Transportation.

During this somewhat uncertain, but promising, hiatus between the excitement of the Apollo moon missions and the opportunities for regular space operations represented by the Space Shuttle, the initiative by Senator Adlai Stevenson heralds a much needed rededication to space exploration and utilization.

We agree with Senator Stevenson that, to become a long term economic reality, space must become an extension of commercial and cultural pursuits on earth. Capitalizing on space's unique properties of overview, zero-gravity, hard vacuum, unlimited energy supplies, and potential for disposal of waste materials, American industry, in cooperation with the United States government, has an unprecedented opportunity to fulfill the potential of a vast new resource. With the help of Congress, we may be able to do so intelligently and efficiently. In calling upon the Administration to set bold new goals, within realistic budget limits, the Space Policy Act of 1979 takes a significant step toward exploitation of space resources.

We are fully in accord with the bill's five major developmental goals—1) design and construction of first generation large space structures; 2) R&D leading toward prototype testing of systems for electric power generation; 3) resumption of communications research; 4) design and testing of space manufacturing technologies; and 5) establishment of an operational system for remote-sensing of Earth resources and environment.

In particular, AIA supports pursuit of the second objective, R&D leading toward prototype testing systems for electrical power generation. We believe that harnessing solar energy from space, via the Solar Power Satellite, as now envisioned, or by some alternative method which might later prove technologically preferable, is probably feasible and, at very least, is deserving of careful study. We are pleased to see this option included in the bill's list of objectives.

With respect to the bill in general, we would suggest that in addition to being required to set out a five-year plan within one year of enactment, the President might also be required to adopt a longer term plan, perhaps twenty years in duration, with intermediate milestones setting forth the anticipated time of completion of the major stages of Shuttle and follow-on vehicle operation and capabilities, as well as progress in the five areas of development. We believe such planning to be useful in terms of firming priorities. It also would provide a reasonable basis for measuring progress toward given goals and defining shorter term (five-year) programmatic targets, allowing both government and industry to plan and budget effectively . . . In addition, we would suggest that the scientific, as opposed to the applications, side could also benefit from long range planning.

With or without carefully drawn goals, however, all future steps in exploration and utilization of space are obviously extremely risky. Industry has been disturbed of late to detect a trend toward requiring industry to bear more and more financial risk in space operations. Exploration and use of space, not to mention the valuable technological knowledge and skills which evolve from such inquiries, are a vital national resource and thus are rightfully deserving of governmental support. In our view, it is the proper role of government to underwrite, in a yet to be determined manner, some of the colossal costs of risky technological ventures. This was done during the early stages of satellite development and during the Apollo program. Now, however, the balance seems to be shifting toward industry—we believe, prematurely.

Therefore, while we welcome inclusion in S. 244 of the phrase, "the United States will encourage the development of space capabilities and systems by the private sector to provide economic benefits to, and to enhance the technological position of, the United States," we feel that the nature of government/industry coopation should be further clarified legislatively.

It would be our view, moreover, that governmental policy toward technological development of all sorts lacks coherence. Many federal policies discourage innovation and risk-taking. Policies governing proprietary data, taxes, patents, regulation and recoupment of independent research and development all tend to blunt rather than sharpen the United States' technological edge. As a result, U.S. technological leadership has slipped worldwide and will slip further unless positive steps are taken.

We suggest that the Space Policy Act of 1979 might be an appropriate vehicle for further defining the responsibilities and obligations of both the government and the industry partner in their cooperative reach into space. At very least, it should be stipulated that industry's financial role will be a reasonable and carefully negotiated one. Where advances are clearly in the national rather than corporate interest, the government should be expected to underwrite costs.

In a broader sense, we would like to see the Space Policy Act become part of a carefully conceived and articulated national R&D policy, with commensurate increases in R&D funding from the Congress. An important part of such a policy, also applicable to the extended space program contemplated here, would be various tax changes to increase capital formation. Changes in depreciation rates and in the tax credit for plant and equipment are needed to keep pace with inflation. While such tax changes would obviously go beyond the purposes of the Space Policy Act itself, we feel it should be recognized that all innovation and risk-taking on the part of industry, in space and on the ground, will be affected by the tax laws in coming years.

Orchestration of such changes will require clear vision and a strong desire to return the United States to a position of undisputed technological leadership. Everyone in industry and, we believe, many in government as well, want to see this happen. For that reason, efforts such as Senator Stevenson's, to examine and plot a course in an area as diverse, technologically challenging and visionary as America's future in space are particularly heartening and will receive our complete and active support.

LANDSAT
Earth Mnitor

By JAMES J. HAGGERTY

Of all the spacecraft yet developed, the one with the greatest potential for Earth benefit is NASA's Landsat, the Earth-watching "sky eye" which reports continuously on the changing face of the planet.

Technically still an experimental system, Landsat is already providing large-scale time and money savings in a broad variety of applications. A fully-operational worldwide system, a goal for future years, promises immense economic benefits, probably amounting to billions of dollars annually. But even more important than monetary gain is Landsat's capability for helping solve some of mankind's most pressing problems, by furnishing volumes of information for more effective management of Earth's far from limitless resources.

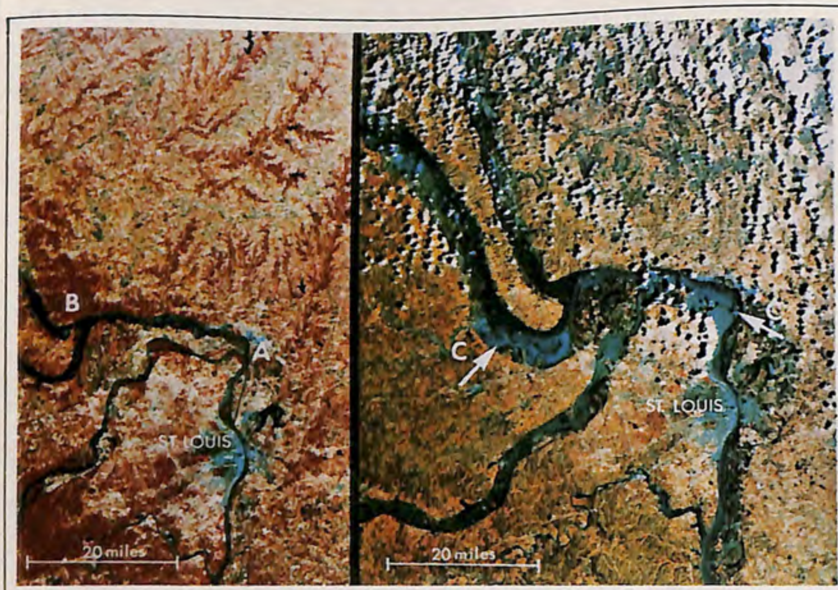
Landsat has special applicability in agriculture. It can, for example, provide early warning of crop infestation, allowing prompt measures to prevent the spread of disease, thereby enlarging the food supply available to a rapidly-growing world population. Similarly, it can identify—for corrective action—locations of poisonous weeds which kill thousands of cattle yearly. Landsat is also a useful tool for inventorying crops on a global basis. This capability is important in estimating crop yield and planning distribution, or in planning for international trade, because satellite surveys indicate which nations can expect crop surpluses and which will experience shortfalls.

Agriculture is only the beginning of Landsat's exceptional utility. The versatile satellite system has demonstrated its value in locating new oil and mineral resources; charting sources of fresh water; monitoring air and water pollutants; studying floods to lessen their devastation; inventorying the various ways in which land is being used; delineating urban growth patterns; improving the accuracy of maps; plotting changes in ecology resulting from forest fires, earthquakes or strip mining—the list goes on and on. A recent survey by the White House-directed Natural Resource and Environmental Task Force identified 79 ways in which Landsat is being used, and new applications are being found regularly.

Nearly all of the 50 states have some degree of Landsat involvement and eight of them have set up their own operational capabilities for extracting useful information from Landsat data and putting it to work in resource management. Several foreign nations are planning to follow suit, the most recent convert being the People's Republic of China.

Landsat is called a remote sensing satellite, meaning that its instruments sense information from a distance. The distance is about 560 miles, the altitude at which the satellite orbits Earth. Last year NASA retired the original Landsat 1 and replaced it with a much-improved Landsat 3; the system now consists of Landsat 3 and the four-year-old Landsat 2. Together they cover virtually every spot on Earth

1. CARTOGRAPHY
Landsat's use as a mapping tool is exemplified by this mosaic, made up of 569 Landsat images. Landsat views are extremely precise in cartographic detail and they show large-scale surface features which cannot be determined by ground survey or aerial photography. Satellite mapping is also considerably less expensive than alternative means. While the U.S. is well mapped, many areas of the world still are not and Landsat is continually discovering mapping errors.



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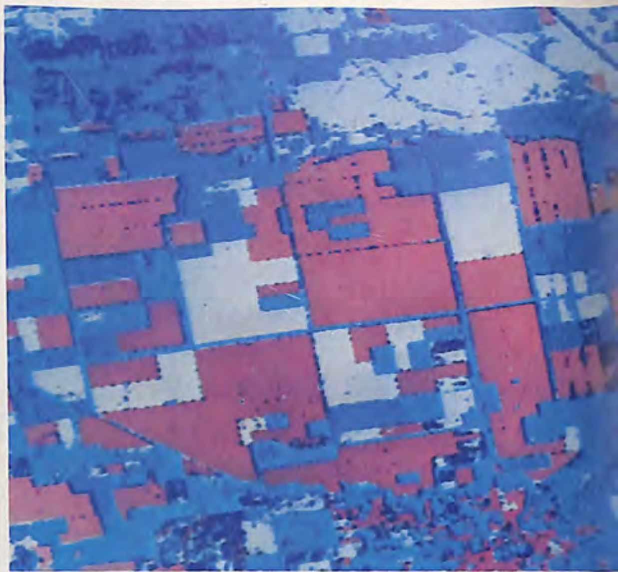

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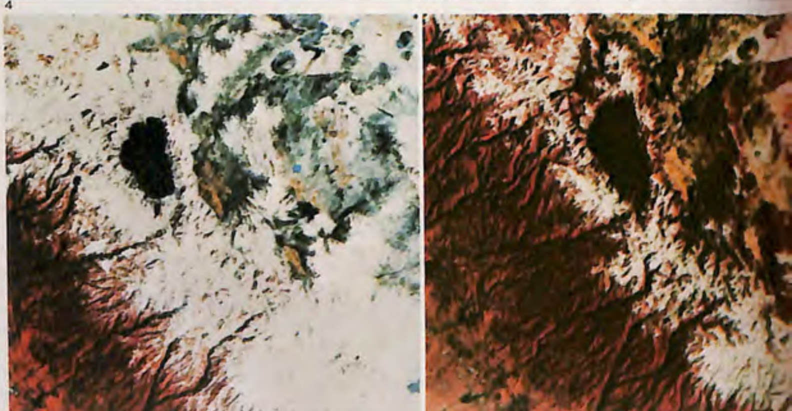

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2. FLOOD CONTROL
These Landsat images of the Mississippi show Landsat's utility in flood assessment. At left the river is at normal level; at right it is in flood. Comparison reveals the extent of flooding and identifies flood-prone areas for planning purposes.

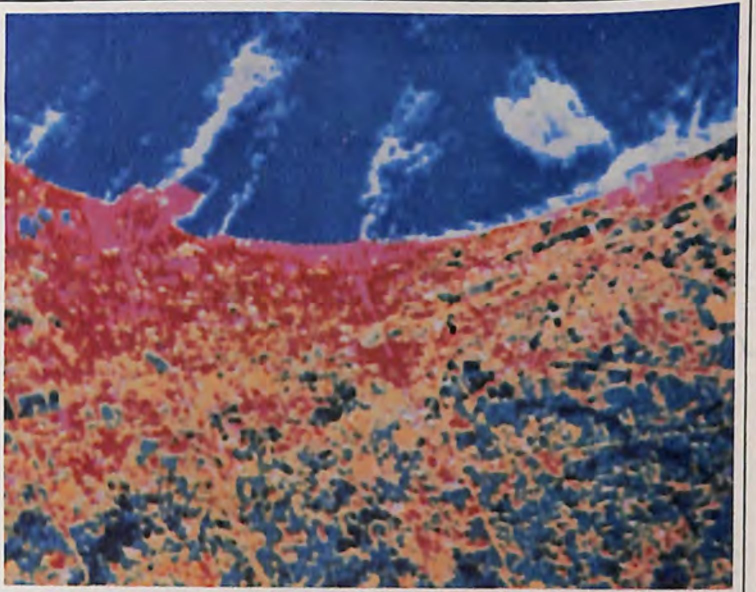
3. AGRICULTURAL INVENTORY
Landsat's broadest utility to date has been in making crop inventories, which can be accomplished by satellite in a fraction of the time required by other means. The illustration is a crop map of California's San Joaquin Valley developed from Landsat data. Each crop—for example, cotton, wheat and safflower—shows up in a different color; fallow ground is shown in blue. Pictures like these provide a basis for predicting crop yield. An important Landsat capability is early detection of crop blight, which allows prompt corrective measures to prevent the spread of disease.

4. LAND USE MAPPING
State and local planners need land use information such as the nature of urban change and various types of land cover—cultivated areas, forests, water sources, etc. This Landsat-generated land use map covers part of New England, showing the amounts of land in urban use (yellow) and in agriculture, woodland and marshland (different shades of green). The Landsat map was produced at a cost of about one dollar per square mile, compared with an estimated $10 per square mile for high-altitude aerial photography.

5. WATER RUNOFF
In areas which depend on melted snow for their water supplies, predictions of snowmelt runoff are important for planning purposes. Landsat imagery, backed by surface data, enables analysts to estimate the volume of water which will result from spring melt runoff. These images show winter snowpack for two different years in an area of the Sierra Nevada mountains. At left is a normal snowpack. The image at right, taken in February 1977, showed sharply reduced snow cover and indicated a spring water shortage—which, in fact, occurred.

6. **URBAN PLANNING**
The illustration is a Landsat image of the Gary/Hammond industrial complex in Indiana, specially color-coded to provide information useful in urban planning. Light red indicates commercial/industrial areas; dark red, older residential housing; yellow, newer housing; dark green, vegetation; light green, open spaces; blue, Lake Michigan; white, smoke plumes from mills and factories. From continually updated maps made from repetitive Landsat images, urban planners can extract a great deal of useful information, for example, the extent and direction of urban growth or data applicable to pollution control, transportation needs, tax assessments, sewage requirements and other considerations.

7. **EROSION**
This Landsat image of the Potomac-Chesapeake area of the eastern U.S. was made just after a heavy rainstorm. The silt content of the Potomac and Rappahannock Rivers (center and bottom), due to soil runoff caused by rainfall, stands out in light blue. Such images are valuable aids to erosion studies.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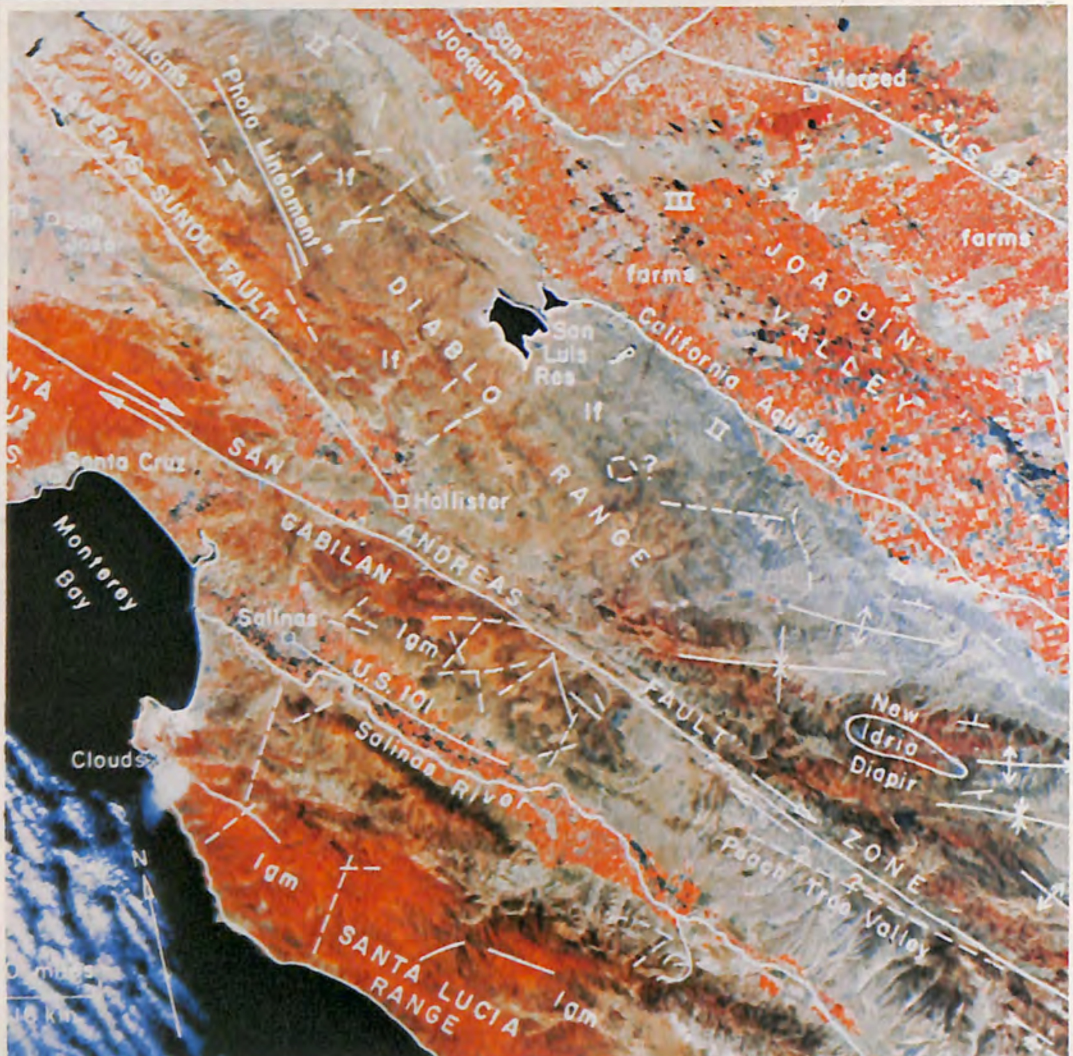

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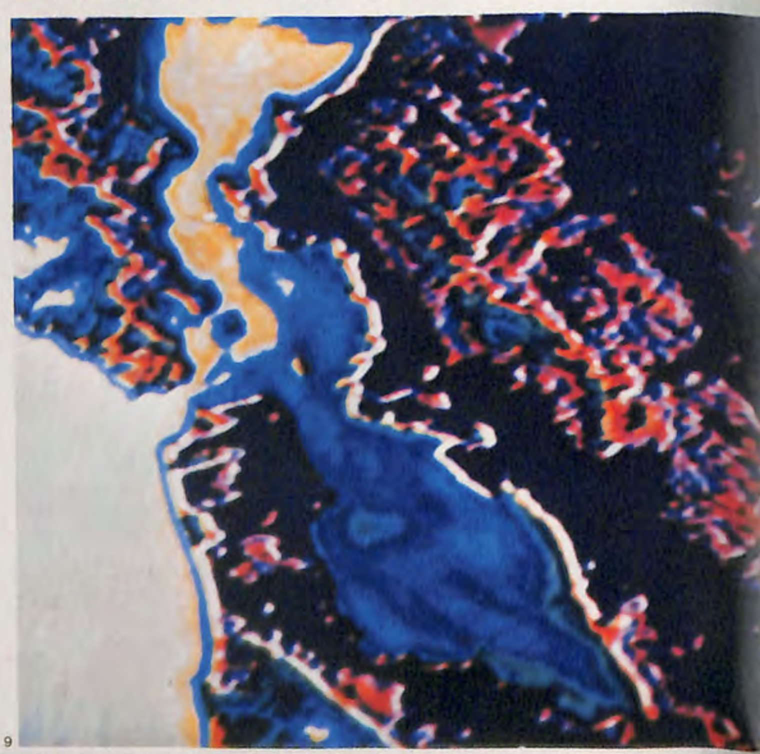

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8. GEOLOGY
Landsat's "big picture" capability reveals large-scale faults, fractures and other linear features of Earth's surface which usually cannot be detected in aerial photos. This overlay map of the Monterey, California area shows lineaments associated with earthquake, cave-in and landside activity; it identifies areas for close scrutiny in earthquake prediction research. Other Landsat images have proved helpful in locating new underground water sources and mineral deposits.

9. WATER QUALITY
Landsat's sensors can differentiate between clear and polluted water, as shown in this computer-enhanced image of the area around San Francisco Bay. In the image, clear sea water appears in yellow while shades of blue and black indicate varying levels of brackish water. The information is useful in such applications as monitoring water pollution, tracking and mopping up oil spills, charting shallow water as an aid to navigation, and selecting recreational sites.

each nine days, relaying to Earth a stream of digital data of enormous value in resource management. Focal point for signal reception and data processing is Goddard Space Flight Center, Greenbelt, Maryland; the Landsat program is managed by NASA's Office of Space and Terrestrial Applications.

Built by General Electric Company's Space Division, the Landsat satellites take advantage of the fact that all Earth features—natural or man-made—reflect light or emit radiation, like heat waves, in different bands of the spectrum and in different intensities. Landsat's Earth-viewing telescope picks up the radiation and the satellite's sensitive radiation detectors can tell the difference between one type of vegetation and another, or between densely-populated urban areas and lightly-populated farmland, or between clear and polluted water. Landsat's findings are relayed continuously to Goddard Space Flight Center, where a computerized signal-deciphering system translates the flow of data into color-coded images and tapes. For example, different agricultural crops appear on images in different colors, and diseased crops show up in colors different from healthy crops. The images and tapes, from which informative resource maps can be prepared, are available to users through the Earth Resources Observation System Data Center, Sioux Falls, South Dakota.

Generally, Landsat can provide more useful information on a more timely basis than other data-gathering methods. The system's repetitive coverage of Earth features permits frequent updating of information. Another advantage is that remote sensing produces information on features invisible to the human eye and features too vast to be encompassed in aerial photos. And Landsat surveys cost a great deal less per square mile than aerial photography or surface investigations. For example, the State of Washington, planning to inventory 10 million acres of forest, estimated that doing the job by standard air and ground methods would have taken two years and cost $10 million; Landsat use allowed a comparable inventory in half the time and at one-tenth the cost.

Although its capabilities far outstrip its limitations, Landsat has a drawback: its degree of resolution, the ability to distinguish fine detail. The satellite's resolution is adequate for many applications, but there are some cases where the need for greater detail requires complementary aerial surveys or surface studies. Even in these instances, Landsat is useful in supplying the "big picture," thereby reducing the need for ancillary studies with attendant time and money savings. But the someday operational system will require a degree of resolution sufficient to meet the needs of *all* users, a fact which was underlined by a global remote sensing survey called the Large Area Crop Inventory Experiment (LACIE).

Completed last year, LACIE was a three-year project in which Landsat was used to inventory the wheat crop, and to estimate harvest yields, in the U.S. and seven foreign nations. Overall, Landsat performed well. For example, LACIE produced an estimate of the Soviet Union's 1977 wheat crop within one percent of official Soviet figures later released. But in some other areas, Landsat estimates were less accurate. The reason is that Soviet wheat fields are typically large and easily surveyed by remote sensing techniques. But in the northern U.S. and parts of Canada, Landsat had trouble distinguishing small, narrow fields.

That problem will be solved with the advent of Landsat D, the fourth member of the satellite family now being developed by GE's Space Division. To be launched in 1981, the new satellite will be able to discriminate area features as small as one-fifth of an acre, a multifold improvement in resolution. Landsat D will incorporate a number of other improvements which will enable users to extract much more detailed information.

Even with current resolution, the Landsat system is winning wide acceptance. A matter of concern from the user's standpoint is not the technology but its continued availability. It costs considerable money, in equipment and personnel training, to set up a Landsat data analysis capability. System growth is being retarded by the fact that many potential users are reluctant to take the plunge without assurance that a permanent operational system will be established.

In his space policy declaration, President Carter provided a degree of assurance with this statement:

"The United States will continue to provide data from the developmental Landsat program for all classes of users. Specific details and configurations of the Landsat system and its management and organizational factors will evolve over the next several years to arrive at the appropriate technology mix, test organizational arrangements, and develop the potential to involve the private sector . . . A comprehensive plan covering expected technical, programmatic, private sector and institutional arrangements for remote sensing will be explored. NASA will chair an interagency task force to examine options for intergrating current and future systems into an integrated national system."

In line with that statement, NASA plans to initiate—in fiscal year 1980—a study of an Operational Earth Resources System to satisfy the continuing needs of the user community. When such a system will come about is conjectural, but it seems a fair bet for the decade of the 1980s. It also seems inevitable that a system of such vast potential will eventually expand into a global network.

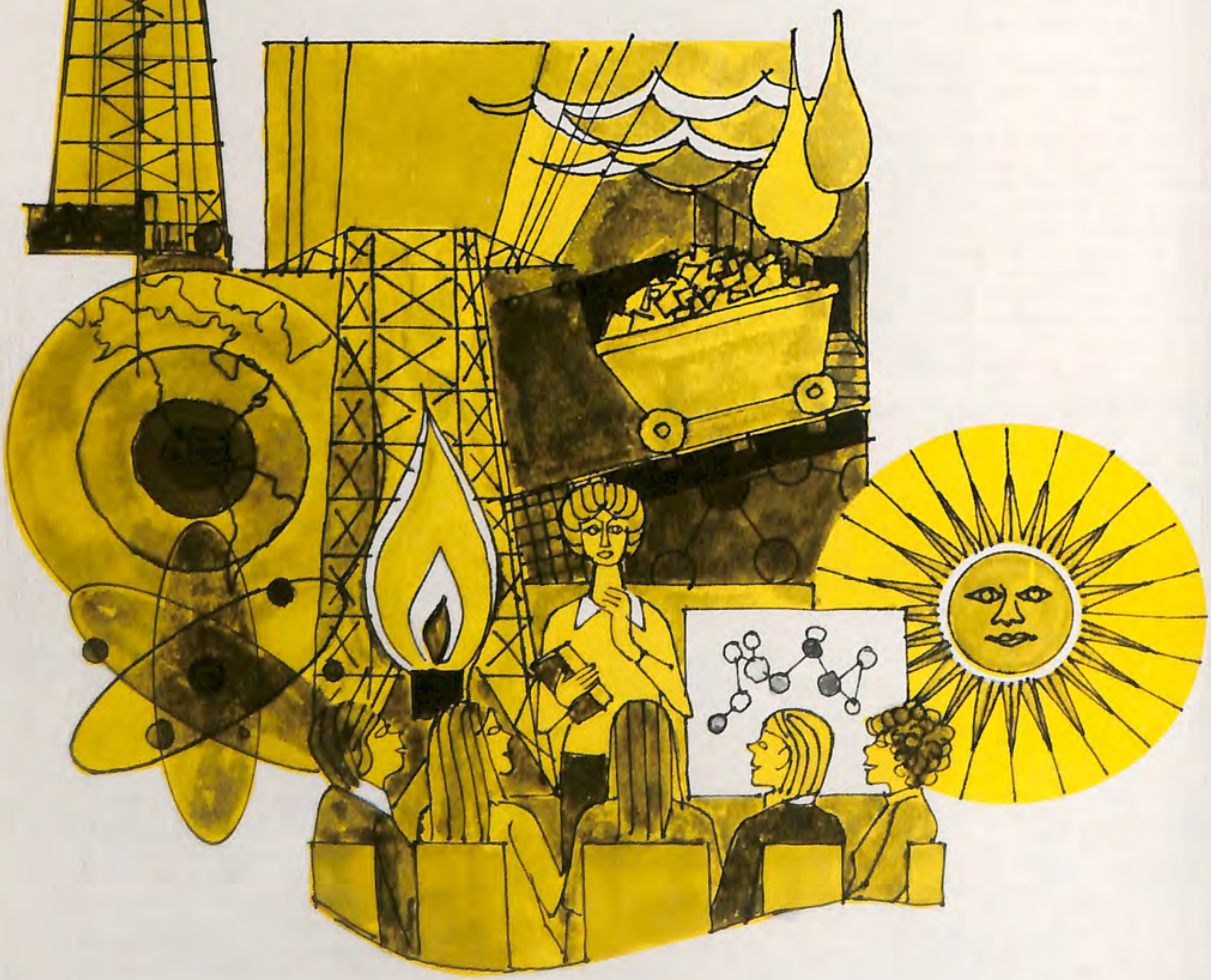
THE 1980s: Greatest Test Yet?

By HEATH LARRY
President, National Association of Manufacturers

The 1980s may well be the most critical decade that our nation has experienced in its 203 years—more critical even than during the Civil War. Then it was being tested on one issue only. Now the test will be to our entire system.

It has lately become unfashionable even for many liberal academics to decry the capitalistic system in favor of socialism. They've had to give up their dreams because, after four decades of preaching the socialist gospel, they've found no successful models. But since imperfections in others must be complained about by the liberal elite, as long as our system permits criticism, they have become less inclined to attack the system head-on than to attack it from the flank.

By "our system," I mean something very simple. I mean private ownership



of the means of production, open markets, and the freedoms to criticize government, to print, to teach, to believe. All of these characteristics are of one cloth.

And by flanking attack, I mean the assault is no longer head-on, because the critics know everyone loves his freedoms. Yet because of those very freedoms, the system is vulnerable because its leaders are people who can make mistakes like everybody else. They can be attacked for those mistakes. And justification can be found to turn to government in order to eradicate problems and, in their view, in order to permanently correct the failings of all mere mortals.

The attack occurs, no doubt, out of righteous belief in the worth of what they're doing for society. But each time they achieve success, they're just like the Lilliputians putting strings across Gulliver's body. They disable the system just a little bit more until it is no longer able to do what it ought to do, and then it can really be criticized for its failures.

Our system is more vulnerable in this decade than it has ever been. One of the principal challenges arises out of the fact that we have now had three or more decades of rising inflation. The search for solutions can no longer be postponed. Inflation cannot long be tolerated in a society predicated upon private investment and individual incentive.

But the treatment is politically perilous, too. We have several problems whose solutions must preempt the use of such new wealth as we may generate in the decade of the 1980s.

For example, we must find the means to pay back for the erosion of our capital base—pay back for what we did not do for it during the steadily rising inflation of the '60s and '70s.

Second, we have got to pay back for the environmental degradation which we permitted over several prior decades. That imposes tremendous costs, both in terms of the money spent for facilities and also in terms of operating costs.

Third, there are the problems of energy availability. For several decades, governments of both parties have priced energy below what it should have been, causing us to use it as we shouldn't have. The price had to go up. It is going to have to go even further if hard-to-find sources are to become economically usable. It is going to have to go up further still, in order for the market to ration its use in the most economic way.

We are now dependent upon the rest of the world, almost for the first time, for a major portion of our resources and our energy. It has upset our trade balances and added very strongly to inflationary pressures.

We in the U.S. must move forward if we're going to enable our society to continue to be one of growth. Growth is important. Yet we're going to have real trouble getting what we need of it, because of our need to "pay back."

That payback is going to preempt most of whatever wealth can be generated by whatever rate of productivity we can develop in the decade ahead. What's that going to mean? For a period of time, it's going to mean, unavoidably, slower growth. Can we survive such a period? We have come to expect an increase in real earnings, both for people and for capital, every year. Can a free system survive without it? I think we can, but it is going to take more dedication on the part of business people than we've seen for many years.

Let me turn for a moment to the world at large. Many are familiar with a document issued in 1974 by the United Nations—its recommendation for a New International Economic Order. It was promoted by the "Group of 77," predominately socialist countries. They seem convinced that the rest of the world owes them whatever it has, and they owe nothing in return.

This really puts competition between the socialist and capitalist systems in focus. Russia has never relented in its missionary-like zeal to prove its system superior and to overcome all other competing systems. For some years we could afford to take this somewhat casually, embracing a live-and-let-live attitude. But can we any longer? I don't think we can.

During most of the industrial age, trade was mainly in goods. One could buy and sell without caring about the ideology of the government or the other side of the transaction. As long as the goods were paid for, that was enough.

In the '80s, we may have to take an entirely different approach. The reason is that trade is becoming increasingly complex. No longer is it simple trade in goods. It largely depends now upon transfers of investment and technology.

Either the transfer of investment or the transfer of technology implies a continuity in the transaction which is not present in a simple trade transaction which is complete when the goods are shipped and paid for. But to have an investment in a socialist country, there must be a willingness on its part to recognize the concept of equity ownership. In order to transfer technology, and enable a proper payback for a patentable idea, there must be recognition of property rights in ideas as well as in investment.

Now here's where we're going to have the confrontation. We're going to need the resources of less developed countries in many cases. Yet they don't want to follow our system of government. I can understand why; the so-called underdeveloped countries learned what they know about government in the days of colonialism. Colonialism did not teach them how to make democratic capitalism work. So it's quite natural that there exists within the sovereignties of these nations an elite which believes that it alone knows how to manage the country. They're not ready for democratic capitalism.

But the educational job cannot be ignored. We can't escape it because the scope of world trade is enlarging constantly, and we're going to have to have relationships not only in trade of goods, but in investment and technology as well.

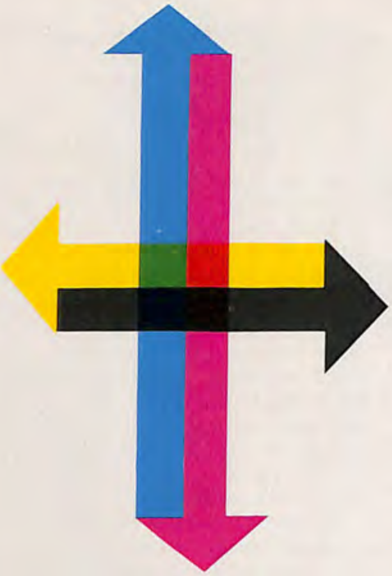
Unless we believe firmly in our own system and can persuade others—by example—that it is better than any others, we're going to fall by the wayside. We're going to become an economic island completely isolated from the rest of the world.

The educational process ought to include a strong reminder that 2000 years ago there existed all kinds of technology—technology which we're only now beginning to learn about. And a lot of it was in South Africa, Egypt and Morocco and South America—most of today's less developed countries. Tremendous knowledge and tremendous inventiveness; but it went nowhere. Why didn't it? Because nobody had an incentive to make it go. Pharaohs, kings and other rulers claimed for themselves or for their government everything that was ever developed in their economies. Individuals in private life were left with no incentives to create a commercial enterprise out of their ideas.

We never had that until Renaissance days, when the idea of respect for contracts emerged. Later occurred the revolutions in France and England, and finally in the United States, where concepts concerning the legitimacy of rewards for private ownership emerged—concepts suggesting that individuals had rights which deserved protection *against* government. Only then could we have an industrial revolution, because we had industrial democracy.

That's the message to send around the world. It's a message we can no longer delay getting across.

(Reprinted from *Enterprise*, Journal of the National Association of Manufacturers)



IGOR SIKORSKY

On September 14, 1939 the world's first successful helicopter flight was accomplished by the famous pioneer of flight, Igor Sikorsky. In this 40th anniversary year of the first practical helicopter, which went into production and, in effect, began an industry, Aerospace Magazine reflects on the helicopter through the words of Mr. Sikorsky in the following excerpts from a speech he gave at the Wings Club of New York in 1964:

"America can be proud that the true solution to the problem of human flight was definitely accomplished on American soil by Americans because, to my mind, the fact that the credit belongs to the Wright Brothers is indisputable. Their story is well known and there is no need to dwell upon it here beyond stating that while Ader and Maxim, during the last decade of the nineteenth century, demonstrated the possibility of mechanical flight and Otto Lilienthal demonstrated the possibility of developing a controllable aircraft, yet it remained for the Wright brothers to solve both problems and several others, including the important one of training and teaching themselves to fly, thus ushering in the pioneering era of actual human flight . . .

"Concerning my own entrance into the field of aviation, my interest in flying machines goes far back to the end of the last century when, as a ten-year-old boy, I tried to make flying models and once even succeeded in building a fairly large rubber-driven model of a helicopter with about a 30-inch rotor diameter. I read with intense interest the stories of Jules Verne wherein he described a helicopter and I was a strong believer in the heavier-than-air as contrasted with the dirigible . . .

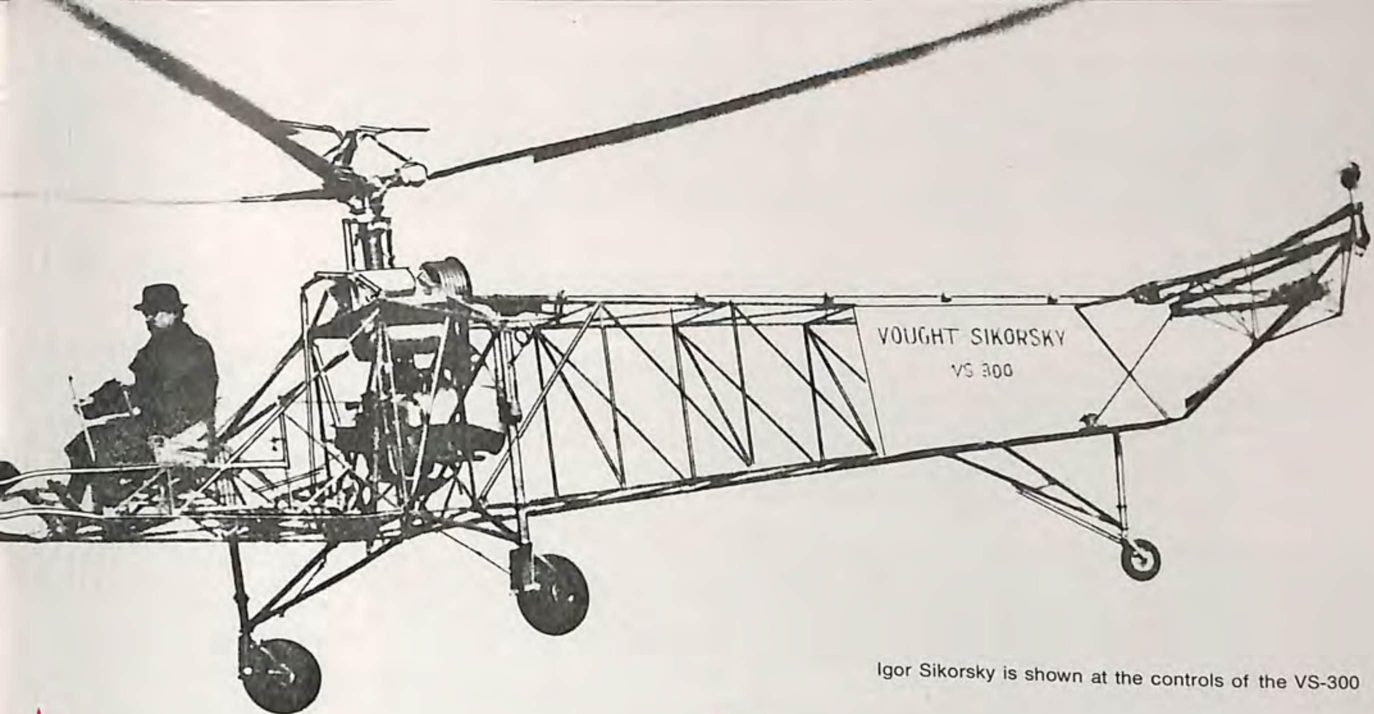
"Having made my decision to enter aviation, I reviewed my plans and decided to begin with the construction of a helicopter. Early in 1909 I visited Paris to purchase my first aeronautical engine and to become acquainted with what was being done in the then new field of aviation. At that time Paris was considered to be the center of the aviation world . . .

"Having learned what I could, I returned home, built my first helicopter, experienced my first contact with the practical work and operation of a flying machine and learned a great deal from this experience even though the helicopter would not fly . . .

"After the Revolution, I came to America and in 1923 organized the original Sikorsky Aero Engineering Corporation. Our first aircraft, the S-29, an 18-passenger, twin-engine airliner, was produced under great difficulties, the lack of a real factory, shortage of materials, tools and the like . . .

"Subsequent important airplanes were the 40-passenger S-40, the largest airliner produced in America up to that time and the S-42 Flying Clipper created in 1934 . . .

"During all the years this work was in progress, I did not forget my first interest—the helicopter—and waited for the right moment to resume this work. In 1939 I decided that the time was about ripe and I suggested to the management of United Aircraft that the construction of a helicopter be undertaken. I obtained their authorization and early in 1939 started the construction of our first helicopter. It was again a case of advanced pioneering work along lines where extremely little reliable information and no piloting experience whatsoever were available. But the ability, experience and well-trained intuition of a fine engineering group made it possible to attack the novel and difficult problem successfully. The new helicopter, designated as the VS-300, was designed in the spring, built during the summer and was ready for test in the fall of 1939. On September 14, 1939, I was successful in getting the aircraft off the ground for its first flight. We continued our experiments to improve the craft, meanwhile learning more about the controls. In 1940 I was able to remain in the air for 15 minutes and, in 1941 to establish a official world record of en-



Igor Sikorsky is shown at the controls of the VS-300

Aviation Pioneer

durance by remaining in the air 1 hour, 32 minutes, 26.1 seconds . . ."

In his autobiography "The Winged-S," Mr. Sikorsky described his first helicopter, and the initial test flights of 1939–40:

"The type of aircraft which I had been developing on paper since 1929 was a simple helicopter with one main lifting screw and one small auxiliary rotor situated at the end of a fuselage and used mainly to counteract the torque of the main lifting screw. The machine included a system of controls for changing the pitch of each of the propellers and also for varying the incidence of the blades of the main rotor along certain sections of the disc of rotation. These latter movements, sometimes called the cyclic control, enabled the pilot, by moving the stick to feather the blades so that their pitch was increased at any given point in their cycle of rotation, while at the opposite point in the cycle the pitch was simultaneously decreased. This arrangement was expected to form the means for longitudinal and lateral control, while the change of the pitch of the auxiliary rear propeller would provide directional control.

"It was again a case of advanced pioneering work along lines where extremely little reliable information was available. But the ability, experience and well-trained intuition of a fine engineering group made it possible to attack the novel and difficult problem successfully.

"The light, strange-looking machine had a four-cylinder, 75-horsepower, air-cooled engine; a three-bladed main rotor, 28 feet in diameter; a welded, tubular steel frame; a two-wheel landing gear and a completely open pilot's seat located in front in a way resembling the very early airplanes . . .

"As may be expected, the completion of the new machine marked not the end but the beginning of the most important phase of engineering work, which is the period of discovering and overcoming troubles. At first we could not accelerate the blades to normal speed because some very objectionable shaking would take place. The trouble was corrected and it became possible to increase the velocity until the machine made small hops, but then it was discovered that the control action needed a great deal of improvement.

"A considerable amount of work was done which resulted in the refinement of the machine. A new technique of flying was developed. In November 1939 we were able to make hops of one or two minutes duration, hovering over one spot or moving slowly forward . . . By the middle of the summer of 1940, the helicopter was able to remain in the air for 15 minutes under reasonably satisfactory control."

In a 1968 interview with the magazine Rotor & Wing, Mr. Sikorsky summed up his belief in the helicopter:

"In respect to the objectives of the helicopter, one of the major things which I was aiming at was that i had every conviction that the helicopter would prove a unique and extremely effective method of instrumentality for saving lives.

"It had to me a sort of romantic or philosophical appeal. The appeal is this: what kind of a gadget or machine or vehicle can give you unlimited freedom of transportation? If a man is in need, well, the airplane can come in and throw some flowers on him and that's just about all. A direct lift aircraft could come in and save his life. Direct lift aircraft can go anywhere anytime where there is air and this commodity is fairly widespread over our wonderful globe. Even if the helicopter cannot land, and these were the ideas which I had fully before I started it, the helicopter can use a hoist, in other words, or a cable and can contact anyplace on the ground, on a roof, on water, on a treetop, absolutely anyplace."

Lt. General Jimmy Doolittle, long an admirer of Igor Sikorsky, summed up Sikorsky's contributions to aviation in these words written as a foreword to Frank Delear's book, "Igor Sikorsky, His Three Careers in Aviation."

"He dared to dream dreams—to dream the near impossible—and he made those dreams come true."

BASIC RESEARCH BUDGET UP

Since the mid-sixties, most industrialized nations have consistently increased their outlays for government-sponsored research and development. During that same time period, U.S. research and development has steadily declined, detrimentally affecting the nation's productivity, international competitiveness and capability for technological advancement.

Last year this downhill trend was slowed when Congress approved a Fiscal Year 1979 budget which included sharp funding increases for basic research and moderate growth for federally-sponsored R&D in general. Earlier this year, in the Carter Administration's FY 1980 budget proposal, increasing emphasis was again placed on basic research which, said President Carter in his budget message, "holds the potential for breakthroughs to the solution of problems we face or may face in such critical areas as agriculture, health, environment, energy, defense and the overall productivity of our economy."

The Administration's FY 1980 request calls for continued *real* growth—above the rate of inflation—in basic research. It also asks for a substantial, billion-plus increase in overall R&D obligations, but the increase would not match the inflation rate. In terms of outlays, or actual spending during the fiscal year, the increase would be slightly greater than the inflation rate.

For the year beginning October 1, the Carter budget proposes $4.6 billion for basic research, an increase of nine percent overall and two percent above the presumed inflation rate. Government emphasis on basic R&D is necessary, says the Administration, because private sector groups "tend to underinvest in such research either because their resources are limited (as in the case of universities and non-profit organizations) or because the results do not lead in the near term to the development of patentable and marketable new products and processes (as in the case of private industry)."

BASIC RESEARCH BY MAJOR DEPARTMENTS AND AGENCIES
[In millions of dollars]

Department or agency	Obligations		
	1978 actual	1979 estimate	1980 estimate
Health, Education, and Welfare	1,269	1,561	1,581
(National Institutes of Health)	(1,156)	(1,429)	(1,435)
National Science Foundation	678	741	828
National Aeronautics and Space Administration	478	530	630
Energy	414	469	551
Defense—military functions	311	373	436
Agriculture	228	252	268
Interior	156	176	174
Smithsonian	35	37	39
Commerce	28	32	33
Environmental Protection Agency	5	8	17
All other	32	29	31
Total	3,635	4,210	4,589

For overall R&D, the Administration proposes obligations totaling $30.6 billion, up $1.2 billion or 4.2 percent over FY 1979. Aside from basic research, there is real funding growth provision in certain categories of defense R&D, some aspects of space and some areas of energy research and development in which the aerospace industry is involved. Here are the highlights as they pertain to aerospace-related R&D:

Department of Defense. DoD obligations of $13.8 billion are up by $882 million over 1979; this amounts to a seven percent increase, about the same as the predicted inflation rate. A major item in the defense R&D budget is $2.4 billion for support of strategic missile programs, including $670 million for full-scale development of the M-X advanced ICBM and $41 million for accelerated development of the Trident II sea-based ballistic missile. Basic research goes up from $373 million in the current year to $436 million in 1980; that works out to 17 percent.

National Aeronautics and Space Administration. For budget purposes, virtually all of NASA's funding is considered R&D. The R&D total goes up only slightly, from $4.4 billion to $4.5 billion, well behind the inflation curve. Space Shuttle funding continues at the planned rate, bolstered by an extra $185 million in a FY 1979 supplemental request. The budget calls for an 18 percent increase in other areas of space research—space science, applications and general space technology. However, these increases are mostly due to program maturity—development costs of certain major projects reaching peak levels—and the budget does not provide for any new program starts. There is also an 11.7 percent increase in the aeronautical research budget. As in most government agencies, basic research gets a large boost—from $530 million to $630 million, or almost 19 percent.

Department of Energy. At $4.7 billion, the overall DoE budget for research and development is about the same as the current year's figure. The lack of increase is explained as a reduced need for the federal government to undertake numerous large-scale demonstration projects and a plan to focus "on longer term R&D where there is less incentive for private investments." Despite the overall no-growth budget, certain areas would be substantially increased. Solar energy R&D is up 24 percent generally, 40 percent in applied solar research. Magnetic fusion research is up slightly, nuclear fission research down considerably. Basic research funding increases from $469 to $551 million, or 17 percent.

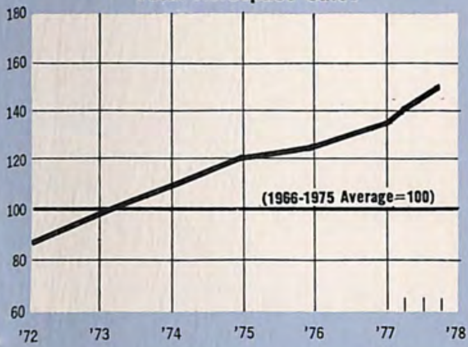
Department of Transportation. Federal Aviation Administration funding for airport and airways research and development remains at exactly the current level—$75.1 million. In other areas of engineering and development, which total $20.6 million in 1980, there is a 12 percent increase. The midair collision avoidance program will be financed by $25.6 million in 1980 funds and an additional $17.1 million in a FY 1979 supplemental request.

National Science Foundation. NSF's research and development effort is largely basic research across a wide spectrum of scientific and engineering disciplines. The agency's overall budget for 1980 is $910 million, of which $828 goes for basic research; the increase over the current year amounts to 12 percent.

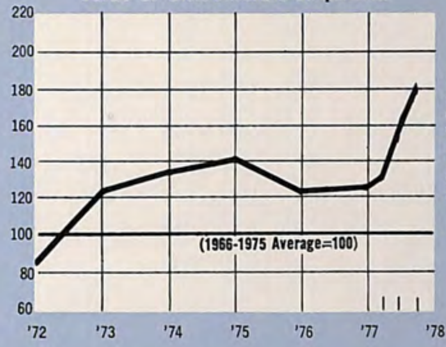
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

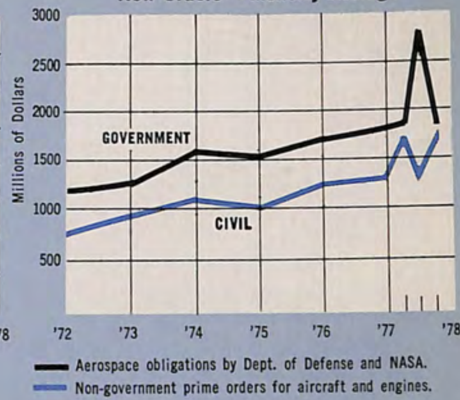


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average



ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD †	LATEST PERIOD 3rd QTR. 1978
AEROSPACE SALES: TOTAL	Billion $	Annually	26.6	31.9	34.9	36.2
	Billion $	Quarterly	6.4	8.2	9.3	9.4
AEROSPACE SALES: TOTAL	*Billion $*	*Annually*	*27.3*	*22.4*	*23.1*	*23.6*
(In Constant Dollars, 1972=100)	*Billion $*	*Quarterly*	*6.9*	*5.8*	*6.2*	*6.1*
DEPARTMENT OF DEFENSE						
Aerospace obligations: TOTAL	Million $	Quarterly	3,792	2,805	3,645	2,467
Aircraft	Million $	Quarterly	2,361	1,980	3,043	1,844
Missiles and Space	Million $	Quarterly	1,431	825	602	623
Aerospace outlays: TOTAL	Million $	Quarterly	3,411	2,392	2,282	2,333
Aircraft	Million $	Quarterly	2,031	1,639	1,799	1,799
Missiles and Space	Million $	Quarterly	1,380	753	483	534
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	541	786	648
Expenditures	Million $	Quarterly	789	736	752	737
BACKLOG (Major Aero Mfrs.) TOTAL	Billion $	Quarterly	28.6	40.3	49.9	51.5
U.S. Government	Billion $	Quarterly	15.9	22.8	28.5	28.6
Nongovernment	Billion $	Quarterly	12.7	17.5	21.4	22.9
EXPORTS						
Total (Including military)	Million $	Quarterly	1,038	1,657	2,373	2,580
New Commercial Transports	Million $	Quarterly	345	340	418	667
PROFITS						
Aerospace — Based on Sales	Percent	Quarterly	2.7	4.3	5.0	5.1
All Manufacturing — Based on Sales	Percent	Quarterly	4.8	5.0	5.9	5.4
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	903	965	992
Aircraft	Thousands	End of Quarter	650	488	528	546
Missiles & Space	Thousands	End of Quarter	114	81	82	82
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	7.05	7.51	7.64

* 1966-1975 average is computed by dividing total year data by 4 to yield quarterly averages.
† Preceding period refers to quarter preceding latest period shown.

Source: Aerospace Industries Association

AEROSPACE INDUSTRIES ASSOCIATION
1725 De Sales St., N.W., Washington, D. C. 20036

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aerospace

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THE MOONWALKERS

Notable views of notable people on aerospace matters...

aerospace perspectives

Government regulation and associated matters are topics much on the minds of industry executives and business leaders in this period of economic uncertainty. Here is a sampling of current comment.

Harry B. Combs, *president of Gates Learjet Corporation, in an address to the Society of Automotive Engineers Business Aircraft Meeting in Wichita, Kansas:*

"The American people are suffering from an overload of utter democracy. We are caught in the morass of the overwhelming government intrusion in our daily lives at a cost of money and personal freedom beyond calculation. . .

"All the regulations promulgated by federal agencies in the last 18 months would require the same amount of shelf space as all the laws enacted by Congress since 1789. Federal regulations today cost every man, woman and child in America more than $450 each per year. And the cost of just storing all the government forms Americans filled out in 1976 is $1.7 billion. . .Incredibly, the annual cost of regulation already exceeds $100 billion—or about 20 percent of the total federal budget."

Ralph Lazarus, *chairman, Federated Department Stores, Inc., speaking at the annual dinner of Future Memphis, Inc., Memphis, Tennessee:*

"Business today suffers from a degree of over-regulation which has profoundly serious implicatons for our whole way of life. There is simply no queston about that. The burden of over-regulation is hard on every business, but to small business it's catastrophic. . .

We must not forget in our frustration over this condition that government has become an enormously complex process. We are not the victims of evil men. We are the victims of a dangerous new philosophy. It provokes our legislators and the regulatory bodies they support to resort to regulation every time there is a problem. I do not happen to believe that a healthy economic society can be legislated.

"A free and healthy society depends for its existence upon a competitive economy. The kind of over-regulation we are suffering today is destroying competition. We must do something about it."

Frank Borman, *chairman, president and chief executive officer, Eastern Air Lines, in a speech to the National Aviation Club, Washington, D.C.:*

"We have had to rethink our position on deregulation. We are now convinced that it works, not only for the consumer but for the airlines as well. . .

"If we are to succeed in this new environment, we have to rethink the way we run our business. It's how well we do in the marketplace, not at the Civil Aeronautics Board, that's going to determine if Eastern—and any other airline—will survive and prosper. . .the government doesn't owe us anything except the opportunity to compete.

"The need to adapt to the new environment does not end with the airlines. If we, the regulated, have to adjust our thinking, so do the regulators. It is not enough to simply expedite route entry and to let us implement any fare reductions we want. After 40 years of shaping in detail the structure of this country's airline industry, it may be difficult to step aside and let competitive forces take over. However, that's what Congress intended, and that's what they must do. The primary role of the regulators now is to preserve competition, not competitors. In a tightly regulated industry, it may have been appropriate public policy to preserve the independence of individual carriers even when management was not efficiently utilizing the resources of the carrier. That is no longer the case. . . If a firm cannot use its resources efficiently, someone else should be given the opportunity to do so."

L. Stanton Williams, *chairman of the board of PPG Industries, Inc., writing in the company's publication* PPG Products:

"Will business be able to generate the enormous capital required to meet the nation's needs for growth and improved productivity? Perhaps the more basic and critical question is will private investors be allowed to achieve a sufficient return to elicit the necessary capital funds?

"Recent reductions in the maximum tax on capital gains are a step in the right direction, as are efforts to limit taxes and government budgets. But other things must be done. Tax laws must be modified to encourage private investment. Unfair and counterproductive regulations such as the double taxation of dividends must be reexamined, as should corporate tax rates that fail to consider the effect of inflation on depreciation.

"The proliferation of government jobs and of regulations that consume capital and cripple productivity must be stopped. Above all, ways must be found to control inflation and curb government deficit spending."

Dr. Richard L. Lesher, *president, Chamber of Commerce of the United States, writing in the Chamber's 1979 annual report:*

"Political barometers indicate that the public is reassessing government's role. Principles in vogue in government for the past four decades are being challenged. The voters are sending a message to Washington that they are fed up with politicians offering yesterday's answers to today's problems. . .

"Voters are saying clearly that they have had enough of inflation, of higher and higher taxes, of deficit spending, of too much government regulation and of government paternalism.

"What this amounts to is a belated discovery that the economic and social aims of many government activities would be better served by the self-regulating mechanisms of the marketplace. The benefits of taking government handcuffs off the private enterprise system would be immense."

AIA

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VICE PRESIDENT
FOR PUBLIC AFFAIRS • Julian R. Levine

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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.

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APOLLO: Harvest of Technology

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

July 20, 1979 marks the 10th anniversary of history's greatest scientific/technological accomplishment: the landing of men on the moon. Now is an appropriate time for reflection on what the NASA/industry Apollo program contributed to America's status as a world technological leader.

At the time of Apollo's inception, U.S. leaders had several reasons for undertaking the project—social, political, scientific and technological goals. Of particular importance, Apollo was regarded as an investment in future space capability, a focal program whose extraordinary demands dictated simultaneous advances in many areas of science and technology, advances which could later reap a harvest of space benefits envisioned.

Apollo has served that purpose well. It provided a comprehensive base for development of advanced, direct-benefit space systems. Some of these developments already exist, others are projected for the remaining years of the 20th century. Without Apollo, such developments would still be only concepts for the distant future.

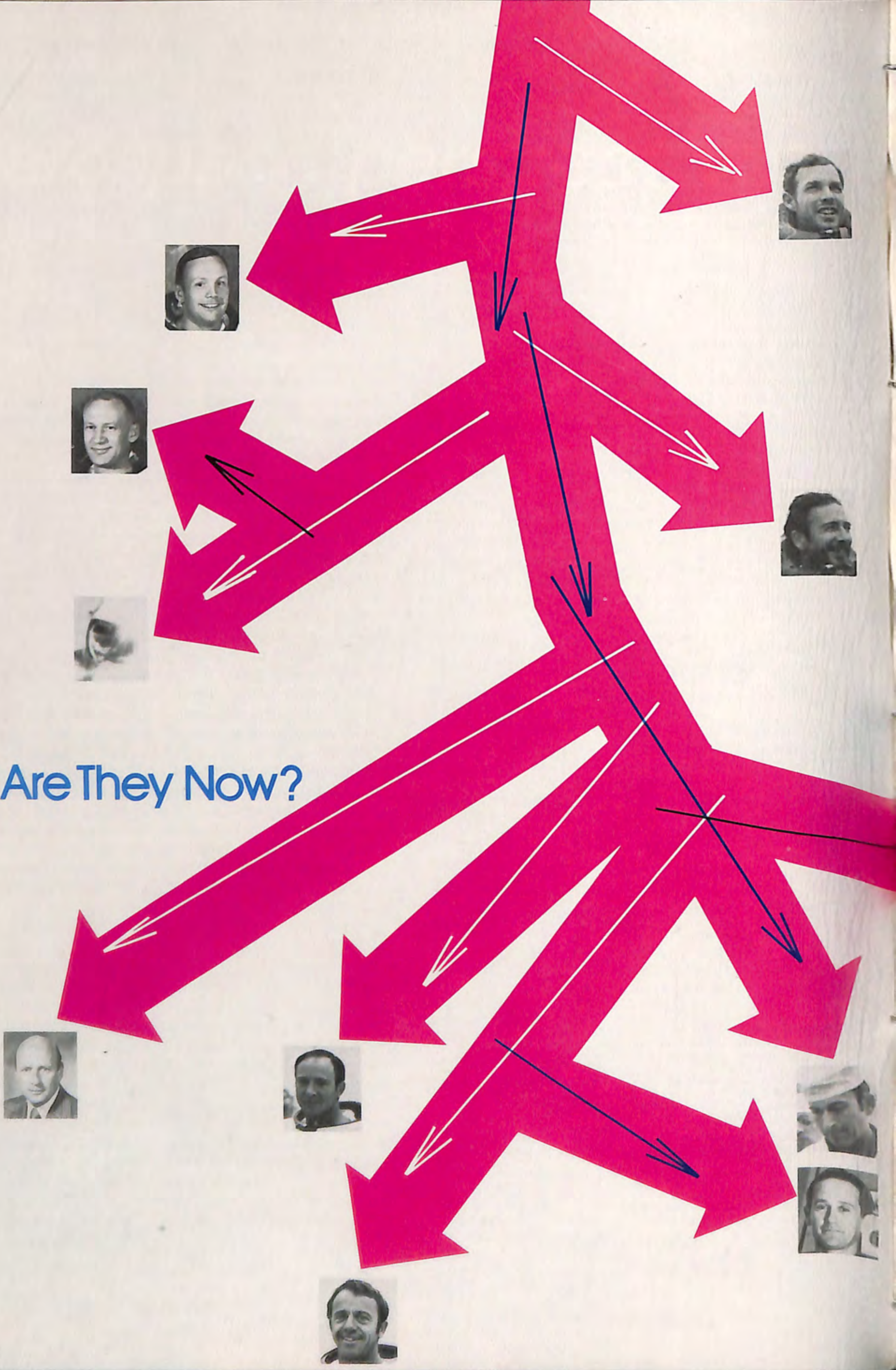
Although space research has already brought about a wide range of civil benefits, space benefit will be greatly expanded in the new era that begins next year with the debut of NASA's Space Shuttle. Some of the contemplated applications of space technology augur benefits of exceptional order. They will demand extensive development of new technology, but they will be attributable in considerable measure to the investment made in Apollo.

Apollo provided corollary benefit to the U.S. economy and standard of living because program requirements spurred explosive innovative effort, not just in aerospace, but in virtually every scientific and technological discipline. The wealth of knowledge thus acquired is applicable—and is being applied—over a broad range of civil uses.

Almost forgotten, because times have changed and the Cold War of the early 1960s has thawed to a degree, is the fact that Apollo achieved the political goal of demonstrating to the world that American technology was—and is—second to none. Such a demonstration was very important at the time Apollo was conceived because of the relationship between technological capability and free world defense. Confidence in America's ability to serve as the Western world's principal bulwark against aggression had been dealt a strong blow by the Soviet's Sputnik and subsequent space achievements. Apollo's success reassured our allies and contributed significantly to Western solidarity.

On this milestone occasion, the aerospace industry extends a salute to NASA for its role as leader of the government/industry Apollo team, which scored a monumental triumph and laid the foundation for greater exploitation of the promise of space in years to come.

Where Are They Now?



THE MOONWALKERS

By JAMES J. HAGGERTY

It happened just a decade ago. Descending on a column of rocket thrust, a NASA spacecraft named *Eagle* settled gently on the moon's Sea of Tranquillity, depositing the first two inhabitants of planet Earth ever to visit another celestial body. Thus began a 40-month program of human lunar surface investigation, man's greatest feat of exploration, a monumental triumph of American scientific and technological prowess.

With the oft-quoted words "a giant leap for mankind," Neil Armstrong took man's first steps on the moon on July 20, 1969, thereby becoming the senior member of one of the world's most exclusive groups: the Moonwalkers, the 12 Apollo astronauts who trod the surface of Earth's satellite. Their number is not likely to increase for a long time to come, since NASA has no current manned lunar landing capability and the Soviet Union seems to be channeling its space effort in other directions.

Who are the members of this select society? From the media coverage they received at the time of their exploits, one might expect that the names would spring readily to mind. However, an informal mini-survey indicates otherwise. If you can name three of the Moonwalkers, you match the average.

Who was the second man on the moon? More than half of the respondents correctly named Edwin "Buzz" Aldrin. But virtually no one could recall who was the last to leave a footprint in the lunar dust—Eugene Cernan.

A number of those queried assigned Moonwalker status to Apollo astronauts who have since become civil-life newsmakers and are thus better known to the public: Michael Collins, now Under Secretary of the Smithsonian Institution; Frank Borman, president of Eastern Airlines; and Thomas P. Stafford, now a lieutenant general and Air Force Deputy Chief of Staff for Research and Development.

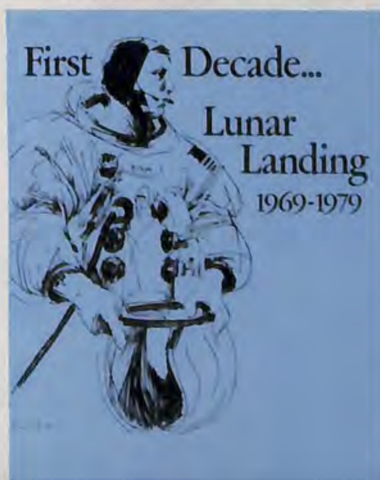
Each of that trio played an important role in the Apollo program but none was a Moonwaker. Mike Collins, Command Module pilot for Apollo 11, was the first of the "lonely astronauts" who waited in lunar orbit while their teammates descended to the moon. Frank Borman commanded Apollo 8, the first of two non-landing circumlunar missions which blazed the trail for the first moon visit. Tom Stafford was commander of the other pathfinder flight, Apollo 10; he descended in the Lunar Module to within eight miles of the moon's surface, but—according to plan—did not land.

From October 1968 to December 1972, there were 11 manned Apollo flights involving 29 astronauts. Six of the missions were lunar landings, two circumlunar trailblazers and two Apollo systems checkouts in Earth orbit. The other was the ill-fated Apollo 13, in which the astronauts flew around the moon and returned safely to Earth, but had to abort the planned lunar landing when an explosion knocked out some of the spacecraft's life support equipment. James A. Lovell, Jr. and John L. Swigert, Jr. were the Apollo 13 astronauts who would have become Moonwalkers had fate been kinder; Lovell, who was also aboard the Apollo 8 pathfinder, has a unique distinction: two trips to the moon, no landings.

Among the 12 Moonwalkers, two are still active astronauts, planning to fly again in space on NASA's Space Shuttle. The others have departed the space scene for a variety of occupations. One is a U.S. senator, another a college professor, a third an evangelist; the rest are in business, four of them engaged in aerospace activities. The average age of the group today is 49; the oldest is 55, the youngest 43.

Who are the Moonwalkers and what have they done since their lunar adventures? Here, in order of their appearances on the moon, are capsule summaries of their careers:

NASA's Apollo II commemorative logo as drawn by artist Paul Calle.



THE APOLLO ASTRONAUTS

In addition to the 12 Moonwalkers, 17 other astronauts flew in the Apollo lunar landing program. Twelve reached the vicinity of the moon but did not land. This group includes the six "lonely astronauts," the Command Module pilots of the lunar landing missions who remained in orbit while their crewmates explored the moon. They are:

Apollo 11—Michael Collins
Apollo 12—Richard Gordon
Apollo 14—Stuart A. Roosa
Apollo 15—Alfred M. Worden
Apollo 16—Thomas K. Mattingly II[2]
Apollo 17—Ronald Evans

Others who approached but did not land on the moon include the crews of Apollo 8 and Apollo 10, circumlunar trailblazing flights not intended as lunar landing missions, and Apollo 13, on which an accident forced cancellation of the planned moon landing. These astronauts are:

Apollo 8—Frank Borman, James A. Lovell, Jr., William A. Anders
Apollo 10—Thomas P. Stafford, Eugene A. Cernan[1], John W. Young[1,2]
Apollo 13—James A. Lovell, Jr., Fred W. Haise, Jr., John L. Swigert, Jr.

There were two non-lunar Apollo flights, Earth-orbital tests of spacecraft systems. They were crewed by:

Apollo 7—Walter M. Schirra, Jr., Donn F. Eisele, Walter Cunningham
Apollo 9—James A. McDivitt, David R. Scott[1], Russell Schweikart

[1] Later landed on the moon
[2] Still active astronauts

● *Neil Alden Armstrong* flew 78 combat missions as a Navy pilot during the Korean war. A 1955 Purdue graduate, he became a civilian test pilot for NASA and got an introduction to space when he flew the X-15 research airplane to an altitude of 40 miles. Selected as an astronaut in 1962, he made his first space flight aboard Gemini 8 in 1966; with David Scott, he performed the first successful docking in space. On the momentous Apollo 11 mission, he spent two hours and 16 minutes walking the moon and, with Edwin Aldrin, collected 44 pounds of lunar material for return to Earth.

After months of post-mission debriefing, Armstrong left the astronaut corps in 1970 but remained with NASA for a year, as Deputy Associate Administrator for Astronautics. Now 48, he is a professor of aerospace engineering at the University of Cincinnati. He serves on the boards of several organizations, among them Gates Learjet Corporation. He is also chairman of Gates Learjet's technical committee and active in the company's research and development effort.

● *Edwin Eugene "Buzz" Aldrin, Jr.* graduated from the U.S. Military Academy in 1951 and became an Air Force pilot a year later. During the

First of the Moonwalkers were Apollo 11's commander Neil Armstrong (left) and Lunar Module pilot Edwin "Buzz" Aldrin (right). Pictured with them is Michael Collins, who remained with the Command Module in lunar orbit while his crewmates visited the moon.

Neil Armstrong, first man on the moon, is long out of the space program but still active in aerospace work. Armstrong (left) is shown here in the cockpit of the new Learjet Longhorn 28, which he piloted to a series of business jet records earlier this year. A university professor of aeronautical engineering, Armstrong also serves as a board member and chairman of the technical committee of Gates Learjet Corporation.

Korean war, he flew 66 combat missions and destroyed two MiG-15s. Assigned to astronaut duty in 1965, he flew the final mission in the Gemini series and set an interim record for extravehicular activity by spending five and a half hours outside the spacecraft. On his second space flight, which was also his last, Aldrin landed on the moon with Neil Armstrong.

Aldrin remained with NASA for two years after the moon flight, then returned to Air Force duty as commandant of the Aerospace Pilots Research School at Edwards Air Force Base, California. In 1972 he retired from the Air Force as a colonel and wrote a book, *Return to Earth,* which describes his post-lunar experiences and adjustment problems. Now 49, Aldrin is living in Los Angeles and working as an aerospace consultant.

• *Charles "Pete" Conrad, Jr.*, a 1953 Princeton graduate, was a Navy test pilot before being selected as an astronaut in 1962. He flew two missions in NASA's Gemini program, aboard Gemini 5 in 1965 and Gemini 11 a year later. Conrad commanded the second lunar landing mission, Apollo 12; with Alan Bean, he flew the Lunar Module *Intrepid* to a touchdown on the moon's Ocean of Storms on November 19, 1969. He is one of two Moonwalkers who revisited space after the lunar experience; in 1973, he was commander of NASA's first Skylab mission, a 28-day Earth-orbital flight.

Conrad left NASA and retired from the Navy, as a captain, in 1974. He served for a time as vice president of the American Television and Communications Corporation, a Denver-based cable TV firm. Later he moved to McDonnell Douglas Corporation and is now vice president, commercial sales-international of Douglas Aircraft Company. He is 49.

• *Alan LaVern Bean* received a degree in aeronautical engineering from the University of Texas in 1955, was commissioned an ensign in the Navy and assigned to flight training. Initially a carrier attack pilot, he became a Navy test pilot and was serving in that capacity when assigned as a NASA astronaut in 1963. Although twice a backup astronaut, Bean did not fly in the Gemini program. His first venture into space was Apollo 12, on which he became the fourth man to walk the moon. Like Pete Conrad, Bean also revisited space after his moonwalk; he was commander of Skylab 3 in 1973.

Bean retired as a Navy captain but remained with the space program. Now 47, he is acting chief of the Astroaut Office at NASA's Johnson Space Center in Houston, responsible for coordinating the activities of the Space Shuttle astronauts. He hopes to be aboard one of the Shuttle flights.

• *Alan Bartlett Shepard, Jr.* graduated from the Naval Academy in 1944 and saw World War II service aboard a destroyer in the Pacific. He took postwar flight training and served as a fighter pilot and test pilot, among other assignments, before joining NASA in 1959 as one of the original seven Mercury astronauts. On May 5, 1961, he became the first American to journey into space; he flew Mercury 3 on a 15-minute suborbital flight. Grounded by an ear disorder, Shepard served as chief of the Astronaut Office until corrective surgery restored him to flight status in 1969. His second and final space flight was Apollo 14, on which he descended to the moon with Edgar Mitchell on February 5, 1971.

Shepard subsequently resumed his duties as astronaut chief, until 1974, when he left the space program and retired from the Navy as a rear admiral. Now 55, his principal occupation is chairman of the Windward Company, a beer distributor in Deer Park, Texas.

• *Edgar Dean Mitchell* graduated from Carnegie Tech in 1952, was commissioned as a Navy ensign in 1953

The unusual photo at left shows two American spacecraft on the lunar surface. In the foreground is the unmanned Surveyor 3, which landed on the moon two and a half years before the arrival of the Apollo 12 Lunar Module, visible in the background. Astronaut Alan Bean is retrieving the Surveyor's TV camera for return to Earth. Bean's companion on the second manned lunar exploration was Charles "Pete" Conrad, Jr., now an aerospace industry executive, shown at right in a recent photo.

Edgar Mitchell (left) and Alan B. Shepard, Jr. were the Moonwalkers on Apollo 14, the third lunar landing mission.

Apollo 15's David Scott (left) and James Irwin (center), shown awaiting helicopter pickup after completion of their mission, were the seventh and eighth Moonwalkers. With them in the life raft is Command Module pilot Alfred M. Worden.

and completed flight training a year later. He served in the Navy as a patrol plane pilot, carrier-based attack aircraft pilot, research project pilot and management engineer. He became an astronaut in 1966 and was assigned as Lunar Module pilot of Apollo 14. With Alan Shepard, Mitchell spent 33 hours on the moon's surface and collected 100 pounds of rock and soil samples.

Apollo 14 was Mitchell's only space mission. In October 1972 he left NASA and retired from the Navy as a captain. He founded the Institute of Noetic Sciences in Palo Alto, California and conducted research in psychic phenomena, the result of which is a book entitled *Psychic Exploration: A Challenge for Science.* Now 48, Mitchell does double duty as chairman of the Institute and as president of Edgar Mitchell Corporation (EMCO), Palm Beach, Florida.

John Young, commander of Apollo 16, views the lunar samples he brought back to Earth. His fellow Moonwalker was Charles M. Duke, Jr., shown (above).

• *David Randolph Scott,* a 1954 Military Academy graduate, completed flight training in 1955 and served as an Air Force fighter pilot/test pilot before joining NASA's astronaut corps in 1963. He flew two Apollo missions, the first as Command Module pilot of Apollo 9, a 10-day Earth-orbital flight in early 1969. Later as commander of Apollo 15, he landed on the moon on July 30, 1971, in what is known as the Hadley-Apennine region. This fourth moon visit was marked by the first use of the Lunar Rover, an electrically-powered wheeled vehicle capable of carrying both astronauts and their equipment considerable distances over the lunar terrain. With James Irwin, Scott traveled 17½ miles from the Lunar Module base, by far the most comprehensive lunar exploration up to that time. The pair spent 67 hours on the moon's surface.

Scott retired from the Air Force as a colonel but remained with NASA, initially as an operations officer for the joint U.S.-Soviet Apollo-Soyuz mission. In 1975, he was appointed director of NASA's Dryden Flight Research Center in Edwards, California. He resigned in 1977 to become a partner in Scott-Preyss Associates, a Los Angeles data processing firm. He is 47.

• *James Benson Irwin* graduated from the Naval Academy in 1951 and opted for an Air Force career. He was a test pilot and a missile project engineer before his assignment to astronaut duty in 1966. His only space mission was Apollo 15, on which he was Lunar Module pilot. He and David Scott made three lengthy lunar excursions, totaling 18½ hours, aboard their Lunar Rover and collected 170 pounds of lunar samples.

Irwin resigned from NASA and retired from the Air Force—as a colonel—in 1972. He founded a religious organization known as High Flight Foundation and located in Colorado Springs, Colorado. Now 49, he serves as president of the foundation. Irwin also wrote a book, *To Rule the Night,* which describes his early life and his Apollo 15 experiences.

• *John Watts Young* graduated from Carnegie Tech in 1952, entered the Navy, spent a year aboard a destroyer, then took flight training. He was a

Apollo 17's Eugene Cernan, commander of the final lunar landing mission, plants a flag on the moon's surface. The photo was taken by Lunar Module pilot Harrison "Jack" Schmitt. Cernan (above) is now an oil company executive and Schmitt (right) is a U.S. senator from New Mexico.

fighter pilot for four years, a test pilot at the Patuxent (Maryland) Naval Test Center for three more. Selected as an astronaut in 1962, he became one of NASA's most experienced spacemen; he shares with three others the record of having made four space flights. The first was Gemini 3 (1965), in which he and the late Virgil "Gus" Grissom teamed on the initial manned mission of the Gemini series. The following year, Young was Command pilot on Gemini 10, a six-day rendezvous and docking mission.

As Command Module pilot of Apollo 10 (May 1969), Young got his first close-up look at the moon. Apollo 10 was the final pathfinder mission, during which Tom Stafford and Gene Cernan descended in the Lunar Module to within eight miles of the moon's surface while Young remained in lunar orbit. Three years later, as spacecraft commander of Apollo 16, John Young returned to the moon and this time set foot on it.

Young, now 48, is one of the two Moonwalkers who is still an active astronaut. After the Apollo program concluded, he became chief of the Astronaut Office at Houston. He retired as a Navy captain in 1976 and subsequently won NASA's most coveted assignment: command of the first orbital flight of the Space Shuttle, expected early in 1980. That flight, his fifth venture into space, could make Young the world's most experienced astronaut.

• *Charles Moss Duke, Jr.* is a Naval Academy graduate (1957) who elected to join the Air Force. He was a fighter pilot for three years, later an instructor at the USAF's Aerospace Research Pilot School, a job he held in 1966 when he was selected for astronaut training. Duke made only one space flight, as Lunar Module pilot of Apollo 16, and landed on the moon on April 20, 1972. With John Young, he spent more than 20 hours touring in the Lunar Rover through the rugged lunar highlands near the Cayley Plains region of the moon. The team remained on the moon almost three full days.

Duke stayed on with NASA as an operations planning manager until 1976, when he left the space program and simultaneously retired from the Air Force as a colonel. For two years he operated a beer distributorship, then, in 1978, he became a partner in Campbell and Duke Investments, San Antonio, Texas. The youngest of the Moonwalkers, he is now 43.

• *Eugene Andrew Cernan,* a 1956 Purdue graduate, received his Navy commission through the ROTC program and entered flight training after graduation. He served with two Navy attack squadrons and attended the Naval Postgraduate School before joining the astronaut corps in 1963. Cernan made three space flights, the first aboard Gemini 9 in 1966. He shares with John Young the distinction of having twice visited the moon and landed on it once. On Apollo 10 (May 1969) he descended, with Tom Stafford, to a point eight miles above the moon, providing final qualification of the Lunar Module for the first lunar landing two months later. Cernan returned to the moon in December 1972 as commander of Apollo 17; on that occasion he explored the lunar surface for 22 hours with scientist-astronaut Jack Schmitt.

After his moon visit, Cernan remained with NASA for three additional years. He was senior U.S. negotiator in discussions with Soviet officials about the joint Apollo-Soyuz project of 1975 and deputy director of the project. In 1976, he left NASA and retired from the Navy with the rank of captain. Now 45, he is executive vice president-international, Coral Petroleum, a Houston-based oil brokerage firm.

• *Harrison Hagan "Jack" Schmitt,* scientist-astronaut, is unique among the Moonwalkers in that he was neither a test pilot nor a combat pilot prior to his 1965 assignment as an astronaut; he was a practicing geologist. Schmitt graduated from CalTech in 1957, studied at the University of Norway and received his doctorate in geology from Harvard. He was a teaching fellow at Harvard, worked for the Norwegian Geological Survey and for the U.S. Geological Survey; with the latter organization, he was chief of lunar geological studies. Schmitt began his NASA training by taking an intensive 53-week flight course at an Air Force installation. Later, while undergoing his own astronaut training, he also instructed other Apollo astronauts in lunar navigation, geology and feature recognition.

Schmitt's single space flight was Apollo 17, on which he and Gene Cernan landed on the moon near the Sea of Serenity. The pair made three Lunar Rover excursions, examining craters and visiting the foothills of the moon's Taurus Mountains; they set records for the longest lunar surface activity (more than 22 hours outside the Lunar Module) and the largest amount of lunar samples collected (249 pounds). On December 19, 1972, Schmitt, Cernan and Command Module pilot Ronald Evans splashed down in the Pacific, marking an end to the Apollo lunar landing program.

Schmitt stayed on with NASA after Apollo, initially as chief of scientist-astronauts and later as Assistant Administrator for Energy Programs at NASA headquarters. He resigned in mid-1975 to enter politics and in 1976 was elected U.S. senator from the state of New Mexico. Senator Schmitt is 44.

THE SHAPE OF WINGS TO COME

It's not generally known, but the original Wright *Flyer* had a flight-life span of only one day and four successful tests. The 1903 *Flyer* demonstrated the practicability of powered flight, but at the same time it uncovered deficiencies in its own design. So, on the day after the memorable moments at Kitty Hawk, the Wright brothers dismantled the machine, returned to their home in Dayton and plunged into a new round of aeronautical study and design. Within two years, they built and flew two new models of the *Flyer*, each a substantial improvement over its predecessor.

That marked the beginning of a never-ending cycle of powered airplane design and redesign in quest of improved performance—greater speed, longer range, higher altitude, more passengers or heavier payload. With each increment of performance gain came changes in airplane configuration. Sometimes the changes were slight, such as those brought about by development of wing flaps, streamlined engine cowlings and retractable landing gear. At other times, major technological advances—such as all-metal construction and jet propulsion—exerted dramatic influence on aircraft shapes. Thus, today's airplanes, particularly military craft, bear only remote resemblance to their forebears of aviation's formative years.

There is now under way a new round of aircraft design activity that bids to produce further, in some cases striking, changes in airplane configurations. The accompanying illustrations, a representative sampling of aerospace industry design thought, offer a preview of what tomorrow's planes may look like. For the most part, they are not firm aircraft designs; they are concepts which anticipate future requirements, departure points for further investigation. In some cases the planes shown are modifications of existing designs, near-term possibilities which could be flying in the 1980s; most are configurations for 1990 and beyond. Collectively, they comprise an interesting gallery of design trend, an indicator of possible or probable directions in the shape of wings to come.

(continued on page 13)

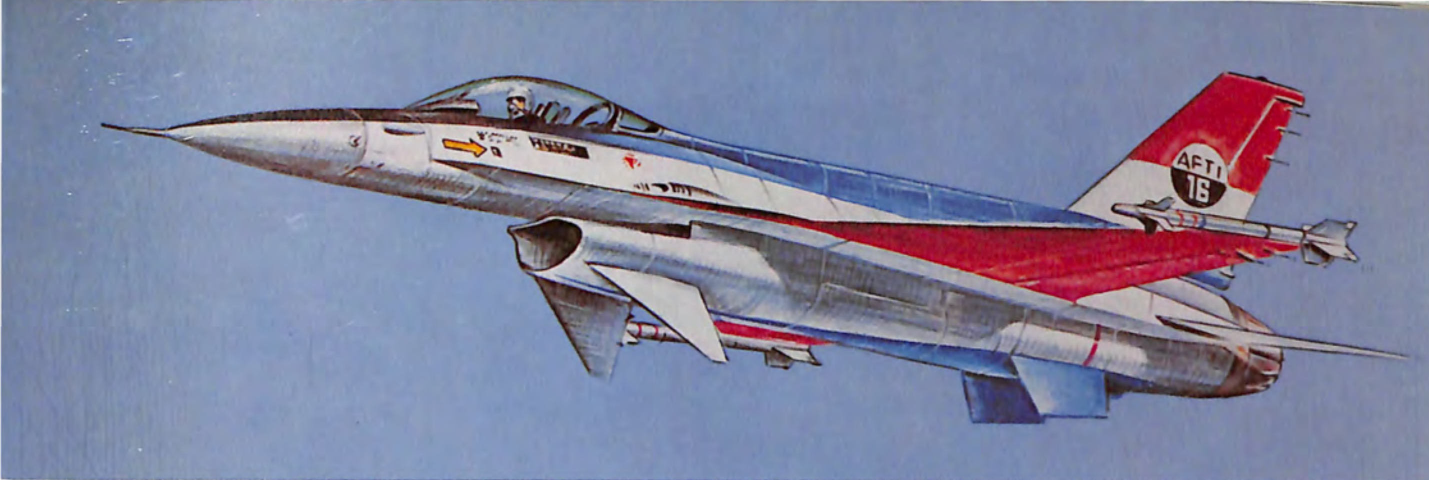
2. A near-future design, planned for flight testing in 1981, is General Dynamics' AFTI 16 technology demonstrator. Being developed under the USAF Advanced Fighter Technology Integration (AFTI) program, the design is based upon the F-16 multinational fighter and incorporates a variety of new aerodynamic, flight control and weapons control technologies.

3. This McDonnell Douglas design, also developed for AFTI evaluation, is an advanced version of the currently operational F-15 air superiority fighter. The major change is the addition of the forward "canard" wing for greater lift, stability and maneuverability in combat action.

4. McDonnell Douglas' advanced tactical fighter design features STOL (Short TakeOff and Landing) performance, attainable by a variable-angle wing along with movable exhaust nozzles which would divert engine thrust downward in STOL operations.

1

1. Multi-bladed, turbine-driven propellers with swept blades, which could provide jet-like speed with sharply reduced fuel consumption, offer an opportunity for the propeller's comeback in commercial aircraft design. Above, a propeller-driven version of the McDonnell Douglas DC-9 and below, Lockheed's RECAT (Reduced Energy Consumption for Commercial Air Transportation) design.



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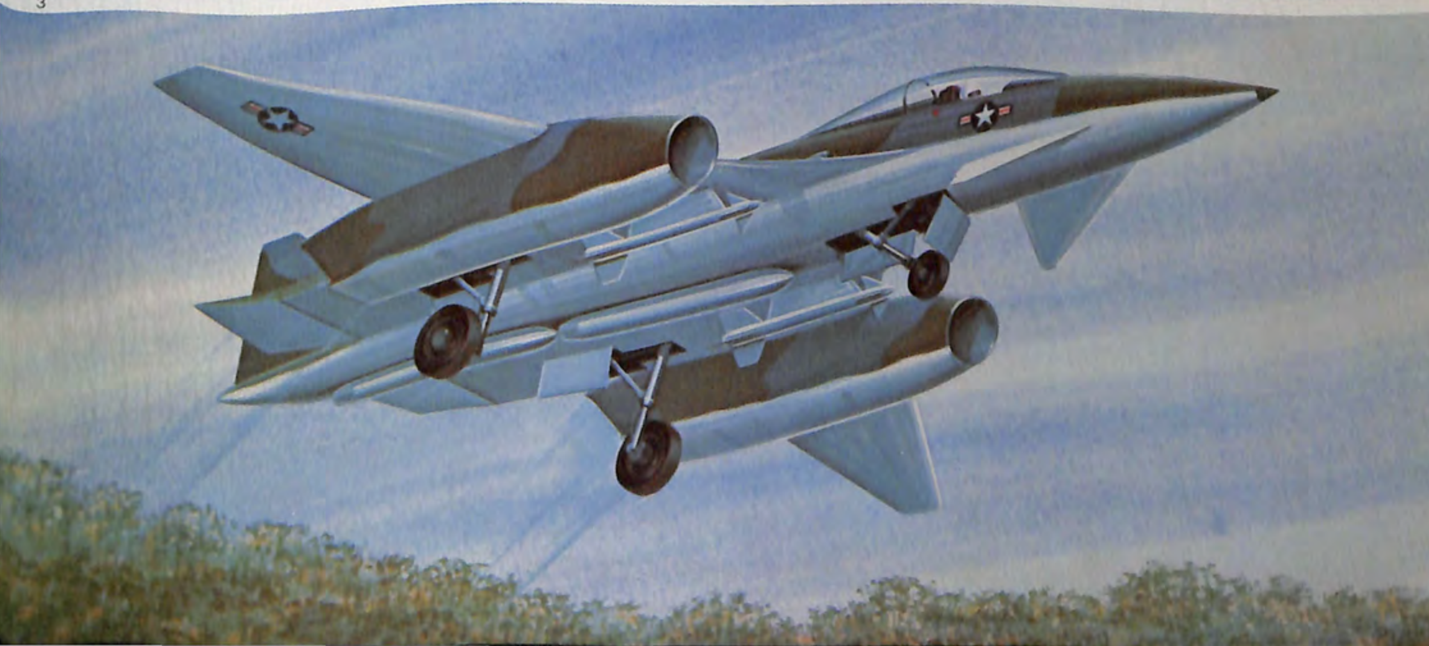

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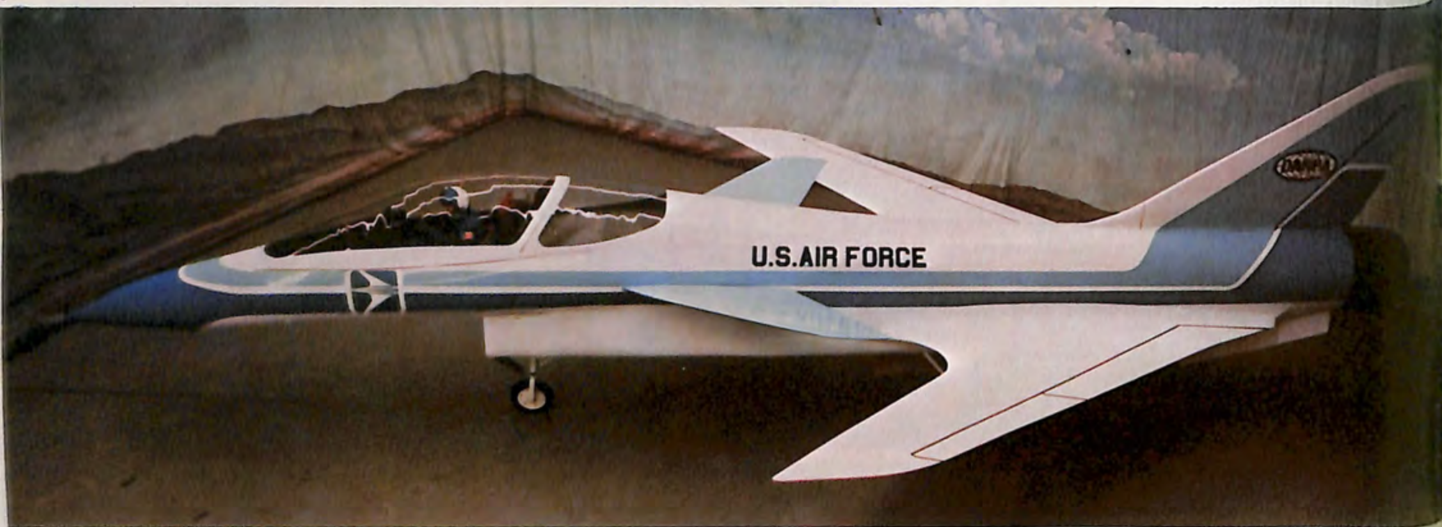
5. Northrop's advanced tactical fighter design would make extensive use of composite materials. Mounting the engine inlets atop the fuselage is a measure intended to reduce the aircraft's radar "signature."

6. The forward sweep concept exemplified by this Rockwell International fighter design is being studied extensively by several manufacturers in a project jointly sponsored by the Defense Advanced Research Projects Agency, the USAF and NASA. Made possible by advances in composite materials technology, aircraft with fore-swept composite wings could be lighter, smaller and less costly than equivalent performance planes with metal, aft-swept wings.

7. Grumman Aerospace studies have also found the forward-swept wing concept promising. This Grumman design of a supersonic vehicle features low-mounted foreswept wings coupled with aft-swept canards.

8. Among a number of Grumman advanced tactical fighter configurations studied is this twin-tailed delta wing craft, which features a top-mounted engine inlet specially designed to reduce the airplane's visibility on a radar screen.



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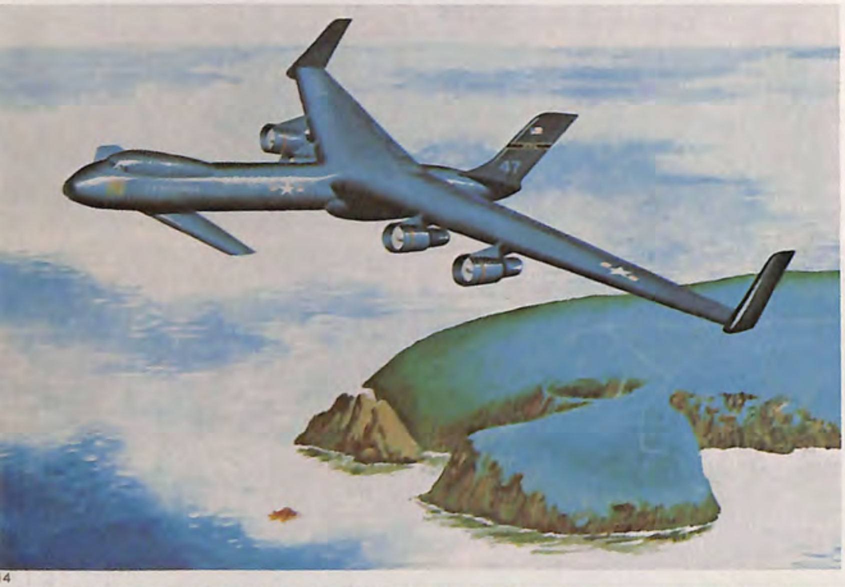
9. Among concepts studied for a future strategic bomber to replace the B-52 is this deceptively conventional Boeing design which features a number of advances. Only half the size of the B-52, the long-range bomber has two wing-mounted medium-thrust engines for cruise power and a third, high-thrust engine in the tail section, providing supplementary thrust for takeoff.

10. Rockwell based this preliminary design of an advanced strategic bomber on the "span loader", or flying-wing concept, in which the entire airframe is an airfoil. One important advantage is a simplified structure offering reduced production costs, a major consideration in military aircraft development.

11. The subject of a number of design studies is the adaptive wing, which can be rotated to different positions for best aerodynamic characteristics in a particular flight mode. In the Rockwell advanced bomber design shown, the wing is stowed for high supersonic flight and the flat body supplies the requisite lift; at lower speeds, the wing would rotate to conventional position.

12. Boeing's span loader flying wing design emerged from company advanced bomber studies. This design features laser turrets in the nose and tail for defense against missiles.

13



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13. A concept for a future sea control amphibian is Lockheed's Large Sea Loiter Vehicle, a 640,000-pound, heavy payload, long range craft which can make "sea sits" in rough ocean waters between flights. The interesting fuselage configuration is based on Lockheed's patented blended-fuselage catamaran hull. Designed for sea sitting even when wave heights top 20 feet, the wing and engines are mounted more than 26 feet above the water line.

14. This Lockheed design for an extreme range aircraft, capable of global range at jetliner speeds, would be powered by a nuclear reactor located in the aft fuselage. The plane would weigh more than 1.5 million pounds and carry 200-ton payloads.

15. Future employment of combat and logistics V/STOL (Vertical/Short TakeOff and Landing) aircraft was the subject of a Boeing study. In this artist's concept, a V/STOL strike fighter, capable of operating independently of vulnerable fixed bases, is being refueled at a remote site by a V/STOL tanker. The fighter would get near-vertical lift from a thrust diversion system; the tanker's wing-mounted ducted fans would swivel to generate vertical lift or forward thrust as required.

16. Among second-generation supersonic transport designs being studied are these by Boeing (top, right) and Lockheed.

17. Being developed by Lockheed-California under NASA study contract is this concept for a hydrogen-fueled hypersonic transport of the future, capable of carrying 200 passengers at 4,000 miles per hour. The plane would have a dual propulsion system, including turbojets for moderate speeds and ramjets for hypersonic speed.

(continued from page 8)

As always, the demand for greater performance is a major factor in determining optimum aircraft designs, particularly in military aircraft. But today there are a number of other factors: changing air tactics, the need for incorporating ever more advanced weapons systems, and the advantages offered by new technologies in such areas as aerodynamics, structures and propulsion. Fuel efficiency and environmental considerations are driving forces in designing commercial aircraft. In either military or commercial aircraft design, there is the increasingly important matter of cost; advancing technology promises ways of reducing both production and operating costs. All of these factors influence the way airplanes are shaped and therefore suggest some dramatic departures from conventional design by the end of the century.

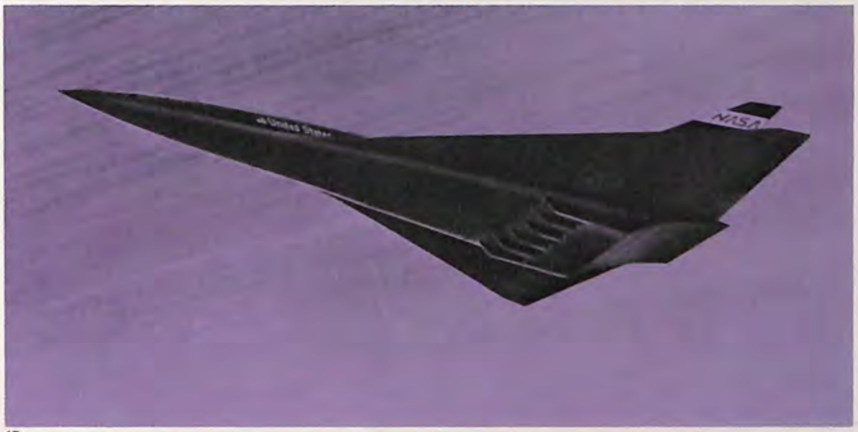
An example is the swept-forward wing, which is getting considerable research attention in military aircraft design circles. Sweeping the wings forward is by no means a new idea; it goes back more than a hundred years to pre-Wright experiments of the 1870s and the concept was flight-tested earlier in this century. In the modern era, designers have long been aware that foresweep offers theoretical advantages. But, because of different aerodynamic forces acting on the foreswept wing in high-speed flight, it demands a stronger structure than does the aft-swept wing. This would induce a prohibitive weight penalty if the foreswept wing were built of conventional metal alloys, but advances in composite materials, which are generally lighter but stronger than aircraft metals, offer a solution to the weight problem. Sweeping the wings forward has potential for making high-performance airplanes lighter, smaller and less costly than their aft-swept counterparts.

Designers are also taking a new look at the flying wing, earlier shelved because of stability problems. Here again, there is potential for high performance at reduced cost, due to the flying wing's relatively simple structure. Technological gains in several areas, particularly control systems, offer answers to the stability problem, so the flying wing is once again a contender for serious consideration.

The turbine-driven propeller may also stage a comeback because it has inherently better fuel consumption characteristics than the pure jet engine. Airplane cruise speed limitations imposed by propeller "tip speed," together with vibration and noise disadvantages, brought about the decline of the propeller in commercial aircraft design. However, recent research shows that re-shaped propellers with "swept tips" allow higher airplane speeds; parallel advances in structures and acoustics research suggest ways of alleviating noise and vibration problems. It now seems possible to design turboprop airliners capable of operating at jetliner speeds and altitudes with substantially better fuel economy.

Along with these design revivals, there are many new design techniques for improving high performance aircraft, for example, "mission adaptive" wings which change form during flight for optimum lift under different circumstances, auxiliary airfoils for high-speed maneuverability, computer-directed electronic flight controls, greater use of composite materials, different engine placement and new types of engine inlets. Further research will determine which of these promising design measures will be adopted, but a new look in aircraft shapes is clearly indicated.

16



17

New Trade Agreement Promises U.S. Export Increase

BY AMBASSADOR ROBERT S. STRAUSS
The President's Special Representative for Trade Negotiations

The U.S. international trade posture, characterized by large-scale deficits in recent years, has become a primary matter of national concern. Of special significance in efforts to reverse the unfavorable trend is a package of international trade agreements, including a separate agreement on trade in civil aircraft, which stemmed from a recently-concluded round of multilateral trade negotiations. Chief of the U.S. negotiating team in those discussions was Ambassador Robert S. Strauss, who details in the following report —prepared exclusively for *Aerospace* magazine—the provisions of the trade pact and its anticipated beneficial impact on the U.S. world trade position.

Now before the Congress for its approval is an international agreement which heralds a new system for world trade and includes the greatest changes in the history of civil aircraft trade. The agreement, initialed by the United States and most of its trading partners on April 12, climaxed a series of international discussions known as the Tokyo Round of the Multilateral Trade Negotiations.

To the aerospace industry this agreement will open the way for better access to foreign markets. It also will mean, for all of American industry, expanded business opportunities and more jobs for American workers based on an international arrangement detailing what trading nations may or may not do to support their national industries.

When approved by the Congress, these agreements will establish new rules that will increase the opportunities of both rich and poor nations to exchange goods under equitable conditions. The agreements embody the United States' belief that the promotion of fair and open trade cements peace and trust in the world and contributes toward the more efficient use of the world's human and material resources.

We are at a crucial point in the history of world trade. For example, in the civil aircraft sector, American manufacturers are facing the strongest competition in the jet age. Now we have before us the opportunity to build a viable international trading system, one in which American companies can meet that competition head on—without protectionist barriers placed in their way by foreign governments.

Over the last 30 years, the international trading system based on the General Agreement on Tariffs and Trade (GATT) has stimulated a more than tenfold increase in world trade. International trade is now well over a trillion dollar business.

But we are at a turning point today because while the world has changed, GATT's rules have not been updated since they were signed in 1947. Countries agree less and less on what constitutes fair and equitable trade practices. Although tariffs have been significantly reduced, they have been replaced by complex non-tariff barriers to trade. For example, foreign government involvement in aircraft production and marketing has allowed foreign manufacturers, whose taxpayers underwrite much of the development cost of certain civil aircraft, to underbid U.S. manufacturers in many situations.

In the meantime, the United States economy has become far more dependent on imports of oil and other raw materials and our national balance of trade is substantially in deficit. These deficits have worsened even as more of our farms and factories depend on export markets: one of every three acres in the U.S. produces for export, and one of every seven or eight manufacturing jobs depends on exports. Over half of U.S. commercial transport production and a quarter of our general aviation production are exported. That degree of performance, however, has not been enough to correct our trade balance, so the United States must strengthen its export posture. The April agreements, if approved and properly implemented, constitute a big step toward that goal.

Provisions of the MTN

The MTN puts the world trading system on a more secure footing and expands trade opportunities over the coming decade.

For the first time, the MTN establishes international rules governing a wide variety of non-tariff barriers to trade: export subsidies, government procurement restrictions, technical standards, customs valuation practices, and licensing procedures. It establishes, also for the first time, realistic international rules for aircraft and agricultural trade, and a framework for minimizing trade frictions.

Additionally, MTN improves rules on developing countries' participation in the international trading system.

Finally, the MTN agreements reduce tariffs—an average cut of about 2.5 percentage points, or about 30 percent of current tariffs, for the United States. The United States, Canada, European Community, Japan and Sweden have already agreed to eliminate all tariffs on civil aircraft, engines, and most parts by January 1, 1980. Other tariff cuts are to be phased-in over eight years to allow industries to adjust to changing economic realities, and prepare for increased international competition.

By establishing an international trade system based on fair opportunity and efficient production, the MTN establishes an environment in which American workers, business, and agriculture must prosper.

Agreement on Trade in Civil Aircraft

A year ago, as we reviewed the developing provisions of the major non-tariff codes under negotiation in Geneva, we recognized, with the Aerospace Sector Advisory Committee, that specific steps had to be taken to address the trade restrictions that the civil aircraft industry was increasingly encountering as it sought to maintain its share of foreign markets. The objective that we sought and that was agreed to in principle at the July 1978 Economic Summit meeting in Bonn was for a free and fair trade environment for civil aircraft, based on commercially competitive principles.

Through the winter and spring of 1979, our negotiators were able to reach, with the European Community, Canada, Japan, and Sweden, a precedent-setting agreement calling for fair and equal competitive opportunities for all producers of civil aircraft. For example, governments are no longer to preclude foreign suppliers from participating in the equipment competitions of nationally owned airlines, nor are they to require component subcontracts to offset the purchase of foreign-produced aircraft. Purchasers of aircraft, engines, and components or subassemblies are to be free of all governmental pressures regarding procurements, so that they can base their decisions solely on commercial and technological factors. It will take careful attention, by industry and government, to see that this standard is followed. Prior to these negotiations, U.S. manufacturers could complain about unfair foreign practices, but there was not even an internationally agreed standard of conduct on which such complaints could be based. Now, as soon as Congress and other national parliaments concur, there will be one.

To strengthen airline independence (and U.S. export opportunity) in third country markets the Aircraft Agreement precludes the attachment of inducements (such as offers of landing rights) or sanctions (such as threats to review trade policies) to the sale or purchase of civil aircraft.

The Aircraft Agreement also extends the product standards code to cover airworthiness certifications and regulations on maintenance and operating procedures. The underlying concept here is that safety evaluation of imported aircraft and components should be just as stringent as those applied to domestically produced ones, but no more so.

International Implications

Beyond economic benefits, the Tokyo Round provided a multilateral umbrella for sorting out difficult bilateral trade problems that have increased international tension and harmed our relationships with key countries—particularly those countries with whom we have important political and mutual security arrangements.

One of our highest priorities in the MTN in the past year was working out a fair arrangement on the difficult issue of civil aircraft trade, a major source of friction between the United States and the European Community. We have made significant progress. In the future, countries will be prohibited from using subsidies to displace exports, or undercut prices in third country markets. While domestic subsidies themselves are permissible, they should not be such as to adversely affect the trade interests of others. Export subsidies are prohibited.

With all members of the European Community, the MTN has enabled us to improve our economic relations, and it has renewed our confidence in each other in working toward common economic goals.

The MTN has given us the opportunity to improve our trade relationships with our neighbors to the north and south. We have successfully dealt with issues in the MTN which previously irritated our relations with Canada and Mexico. The agreements provide better arrangements for solving future economic problems, assuring continued good neighbor relations.

We have made significant progress with Japan. The MTN has helped us to defuse growing tensions between our two countries over an unbalanced trade situation. We have been able to reduce Japanese trade barriers significantly, and the concessions Japan has made in the MTN make possible more stable political relationships in the future.

The MTN has given us the opportunity to negotiate a number of useful agreements with developing countries. Admittedly, the substance is modest, but this is the first time such agreements have been reached and that is significant.

Problems remain concerning trade in services. Unfortunately, there is still a lack of international understanding of the problems in this area, and we were unable to make significant progress in the MTN. Our trading partners have agreed to a serious study of the services issue in the Organization for Economic Cooperation and Development (OECD) and the GATT, and I am confident that we will be able to make progress in this area in the near future.

The upcoming Tokyo Summit will focus on the work ahead: effective implementation of the MTN as the foundation for a stable, peaceful world economy. In the Summit—just as in the MTN—we will be looking to the developing countries for an increasing commitment to international trading rules. They will be looking to us to maintain open trade channels for their exports. The MTN has enabled us to begin a constructive dialogue with these countries, and to take concrete steps to help us develop better relationships in the future.

Our most important task in the years ahead is to make sure that the MTN fulfills its potential. The various non-tariff codes and agreements—our major achievements—amount to nothing if we do not do everything we can to enforce the rules.

We must make full use of the international trade committees, such as the Committee on Trade in Civil Aircraft, and the dispute settlement panels provided under the agreements. We must provide strong and effective leadership to make fair trade a reality.

I am confident that as Americans examine closely the MTN they will find that it deserves their strong support. I am careful not to oversell the Aircraft Agreement or the other agreements as an immediate cure for international trade problems. But I do not want to undersell these agreements either. We did not get all we wanted; however, the concessions we obtained represent an important first step—an *essential* first step—toward an enduring, stable world, just as they represent President Carter's determined efforts to balance the interests of our citizens as consumers with their interests as workers and investors.

Public Heliports: A National Need

It may surprise many people to learn that the capital city of the world's largest helicopter manufacturing country does not have a public heliport. That city is Washington, D.C., USA. Nor does Los Angeles, where about 80 percent of all U.S. rotary wing activity takes place, or many other major U.S. cities. The problem is nationwide, and although civil helicopter business is the fastest growing segment of the aerospace industry, further growth is being shackled by lack of public heliports.

The heliport problem, not widely known outside of rotary wing circles, was outlined by Sikorsky Aircraft president Gerald J. Tobias in a recent speech at the American Helicopter Society Forum in Washington, D.C. Tobias cited Washington as an example of the impact:

"There are more than 700 civil helicopters based within 250 miles of Washington that are unable to land downtown because there is no public heliport and, in order to serve this city, they must use conventional fixed-wing facilities at Washington National Airport and add to the congestion in the airways and the airport access system."

The problem surfaced in the wake of the Vietnam war, when demand for helicopter services increased sharply, said Tobias, who added:

"The first big surprise for the owners of these new helicopters was that there was no place to land them. The federal government has always accepted its responsibilities to the automobile industry and the driving public by creating the roads on which cars must travel . . . Similarly, the federal government encouraged the creation of a comprehensive airport system so that individual airplane owners would not be confronted by an impossible requirement for a prohibitive front-end investment . . . Downtown heliports fall in the same category of essential infrastructure for an essential public service . . . Yet, while the cities in some cases have accepted their responsibilities in this regard, the federal government has not yet come forward with the kind of capital or even procedural encouragement that could bring about heliports of the size needed to serve the public in a meaningful manner."

In another comment on the need for more public heliports, Robert E. Lynn, chairman of the American Helicopter Society, pointed the finger at regulations. Said Lynn, who is also senior vice president—research and engineering of Bell Helicopter Textron: "The proliferation of regulations enacted by local governments often acts to deter heliport development and hence restrict the usefulness of the helicopter." The number of government agencies who have a say in the process of heliport approval varies from city to city, but it is invariably high; in Los Angeles, for example, about 65 agencies are involved.

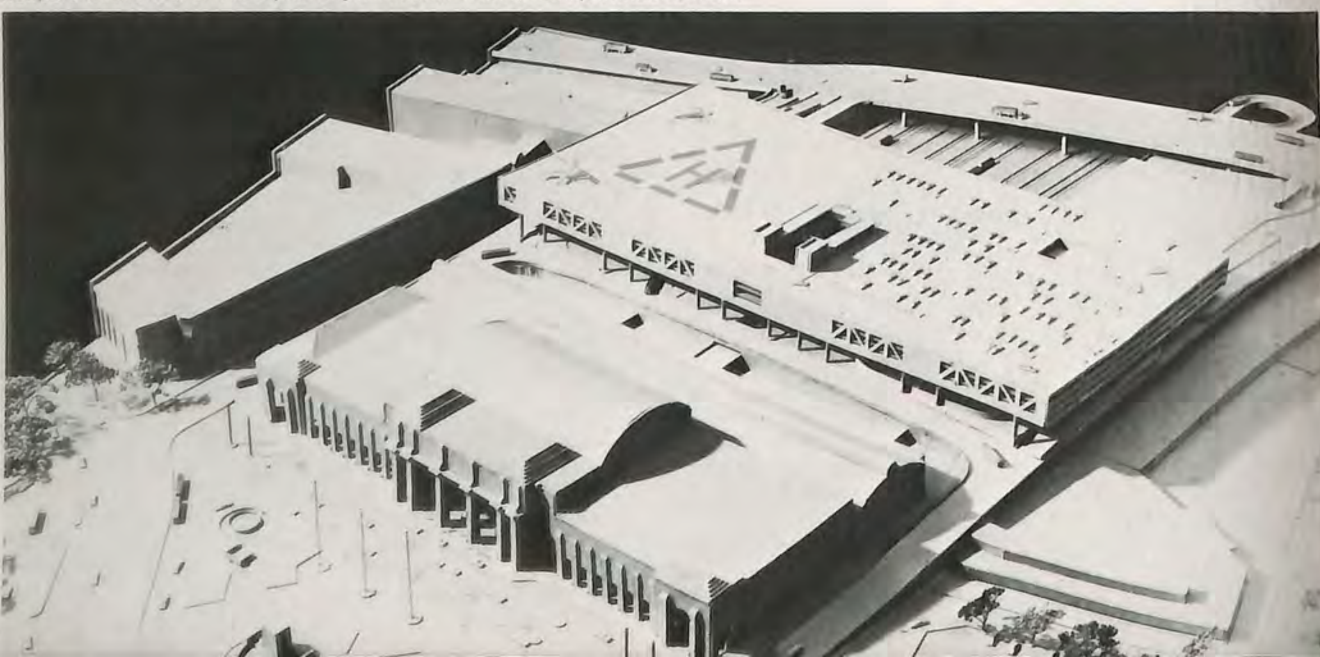
More than 2,700 commercial operators, corporations and civil government agencies are flying some 6,500 helicopters, according to the 1978 Aerospace Industries Association survey of civil helicopter owners/operators. In the absence of public heliports, these helicopters are limited to operation from airports, negating the helicopter's unique capability for point-to-point travel.

The need for public heliports is beginning to get some attention. The City of New York Aviation Department recently awarded a contract for development of an intercity heliport master plan, and Massachusetts has approved funding for a similar study in Boston. In Washington, the Federal Aviation Administration has expressed support for a public heliport and a feasibility study is under way. But many more similar actions, and follow-up construction, are necessary if the civil helicopter is to achieve its full potential.

Sikorsky's Tobias summed up the need:

"What we are looking for is capital grants for heliport construction, modest by comparison with railroads, highways or runways; regulatory understanding; and uniform realistic requirements with regard to noise, zoning and safety."

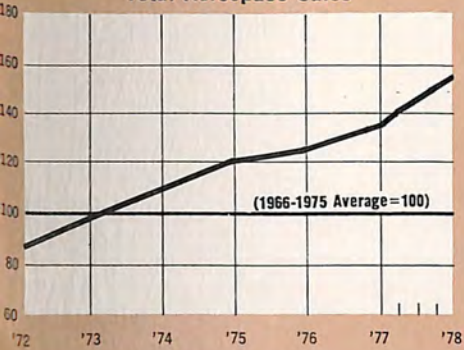
Like most major U.S. cities, Washington, D.C. does not have a public heliport, but a feasibility study is under way. This artist's conception shows a proposed heliport on the roof of the capital city's National Visitor/Transportation Center.



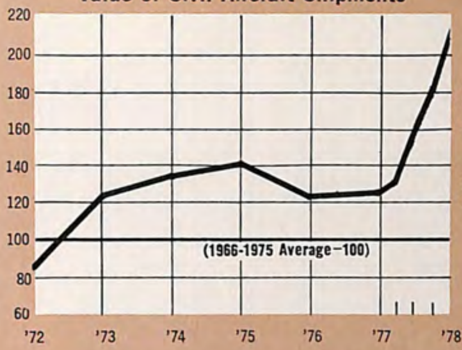
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

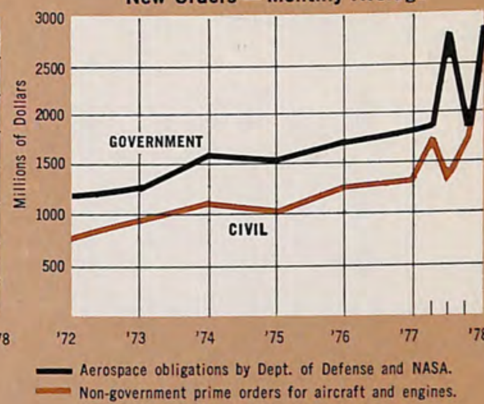


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average



ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD†	LATEST PERIOD 4th QTR. 1978
AEROSPACE SALES: TOTAL	Billion $	Annually	26.6	33.3	35.9	37.4
	Billion $	Quarterly	6.4	8.9	9.3	10.3
AEROSPACE SALES: TOTAL	*Billion $*	*Annually*	*27.3*	*23.0*	*23.4*	*23.9*
(In Constant Dollars, 1972=100)	*Billion $*	*Quarterly*	*6.9*	*6.2*	*6.1*	*6.6*
AEROSPACE PRIME CONTRACT AWARDS: TOTAL	Million $	Quarterly	5,827	13,046	9,330	16,414
U.S. Government	Million $	Quarterly	4,123	8,792	5,024	8,612
Other Customers	Million $	Quarterly	1,704	4,254	4,306	7,133
BACKLOG (Major Aerospace Mfgrs): TOTAL	Billion $	Quarterly	28.6	45.3	51.1	57.8
U.S. Government	Billion $	Quarterly	15.9	26.1	28.2	30.9
Nongovernment	Billion $	Quarterly	12.7	19.2	22.9	26.9
DEPARTMENT OF DEFENSE						
Aerospace Obligations: TOTAL	Million $	Quarterly	2,712	4,058	2,467	4,528
Aircraft Procurement	Million $	Quarterly	1,986	3,152	1,844	3,782
Missiles Procurement	Million $	Quarterly	726	906	623	746
Aerospace Outlays: TOTAL	Million $	Quarterly	2,405	1,714	2,333	2,500
Aircraft Procurement	Million $	Quarterly	1,741	1,261	1,799	2,002
Missiles Procurement	Million $	Quarterly	664	453	534	498
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	1,001	648	1,107
Expenditures	Million $	Quarterly	789	824	737	732
EXPORTS						
Total (Including Military)	Million $	Quarterly	1,038	2,230	2,580	3,218
New Commercial Transports	Million $	Quarterly	345	636	667	1,158
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	894	992	1,031
Aircraft	Thousands	End of Quarter	650	477	546	572
Missiles & Space	Thousands	End of Quarter	114	81	83	84
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	7.23	7.64	7.94
PROFITS						
Aerospace — Based on Sales	Percent	Quarterly	2.7	4.1	5.1	5.1
All Manufacturing — Based on Sales	Percent	Quarterly	4.8	5.3	5.4	5.6

* 1966-1975 average is computed by dividing total year data by 4 to yield quarterly averages.
† Preceding period refers to quarter preceding latest period shown.

Source: Aerospace Industries Association

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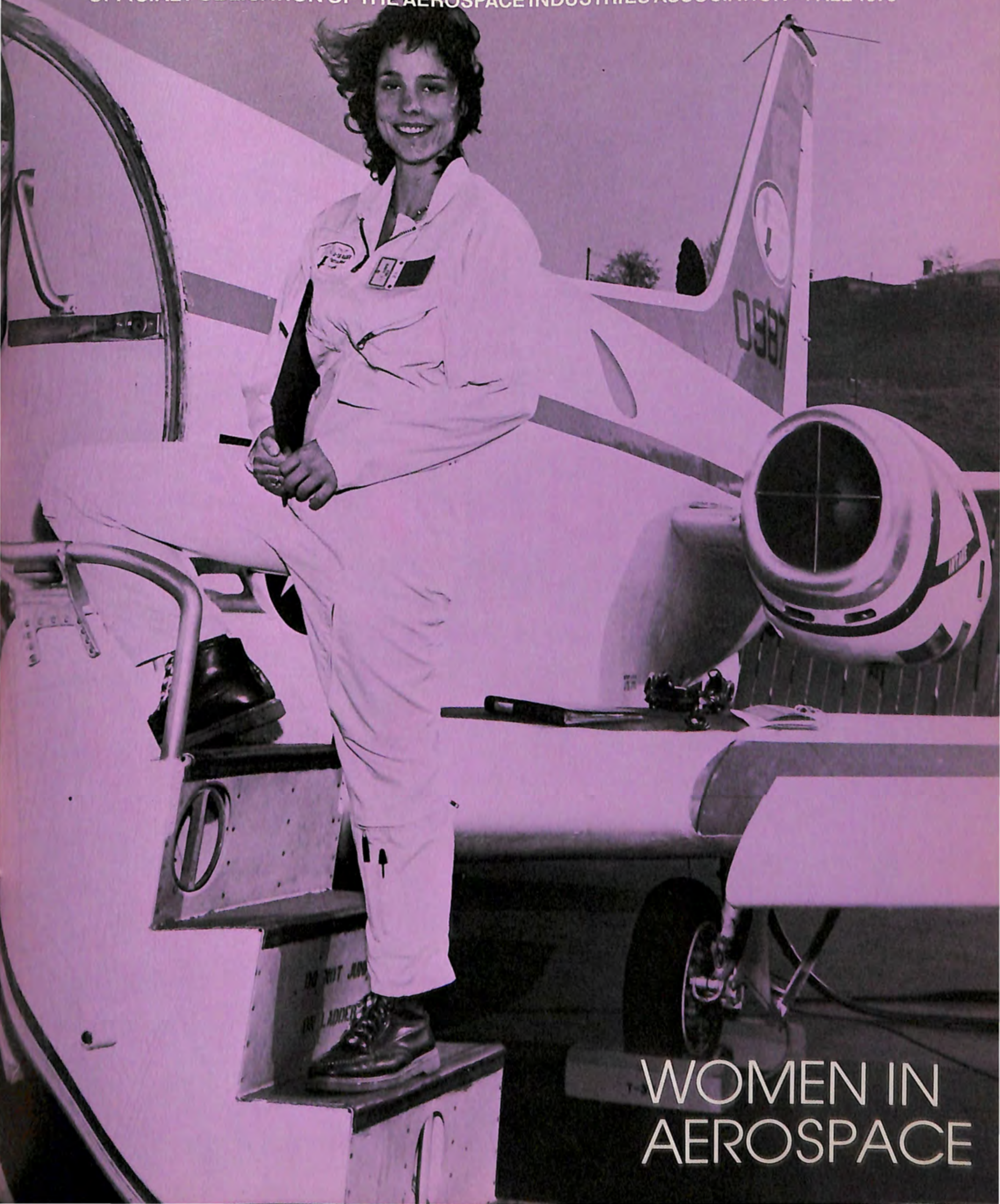

WOMEN IN AEROSPACE

Notable views of notable people on aerospace matters...

aerospace perspectives

President Jimmy Carter, *on signing into law the Trade Agreements Act of 1979 at a White House ceremony:*

"I will sign into law . . . perhaps the most important and far-reaching piece of trade legislation in the history of the United States . . . This new legislation strengthens and solidifies America's position in the international trade community. (It) will remove the barriers of fair trade and will reduce unfair trade practices which sometimes cheat those and hamper those who are interested in improving the quality of the world economy . . .

"Our nation has the most productive economy which the world has ever known. Our agricultural abundance and our technological leadership are important sources of America's innate, unshakable strength.

"This legislation will help our manufactured goods and our agricultural products to become more fully competitive on the world market . . . Increased American exports will mean new jobs for American workers, new markets for American business, more secure income for American farmers, a strengthened American dollar, and lower costs for American consumers."

William H. Gregory, *editor of* Aviation Week & Space Technology, *in an editorial comment in that magazine:*

"Some forecasters say a recession is already under way. Others say it isn't here yet but it's coming . . . Whatever happens to the general economy, the aerospace industry should escape relatively unscathed. There are three basic reasons why aerospace has built-in immunity this time around:

- Military funding will at least hold its own in real terms . . .
- U.S. and overseas airline capital investment will at least hold its own . . . Long-term economics will mandate new transports whatever the transient state of the economy . . .
- Business aircraft should also remain relatively immune from recession, at least the turbine-powered end of the spectrum . . .

"Even if a recession does come, the aerospace industry is likely to stay healthy. That in itself is a strong underpinning for the economy."

Langhorne M. Bond, *Administrator, Federal Aviation Administration, in an address to the Aero Club of Washington,*

"So far, nothing in our investigations has led me to conclude that our procedures for certifying and maintaining the safety of aircraft in this country are flawed in any basic way.

"On the contrary, the extraordinary safety record of our country's airlines is proof that the system is basically sound.

"Industry and government may be at cross purposes in some areas—but not in this one. We all want what is best for American aviation, and that is safety."

Lester A. Fettig, *former Administrator of the Office of Federal Procurement Policy in the Office of Management and Budget, writing in the* Washington Post:

"The Pentagon's assigned responsibility is to cope with potential adversaries who . . . spend even larger sums than we do on military versus civilian research and development. The Defense Department has learned since World War II that regular, substantial investments in R&D are the best, if not the only way to keep up with the growing demand for delivery of their services. The civilian agencies largely have not . . . Civilian agencies just don't have modern, disciplined programs to competitively explore, promote and apply new systems for housing, education, nutrition and the host of mission responsibilities to individuals . . .

"The shame is not that the Pentagon puts such a premium on new ways of doing business but that the civilian agencies seem unable and unwilling to do so. The shame is that our nation's base of innovation and creativity—the 'opportunities for professional excitement and achievement' so jealously found in military R&D—remains essentially disconnected from our people's needs for health care and housing and nutrition and transportation."

O. C. Boileau, *president, Boeing Aerospace Company, writing in* Government Executive *magazine:*

"For too long, government has been ignoring the danger signs which could have told us that (an) erosion is under way in the defense business. The health of the U.S. defense industry is deteriorating, and the entire process by which the armed forces acquire their weapons is in jeopardy. That process is producing too few weapon systems. It is producing profits that are too low and frustrations that are too high . . . Too many of our leaders in government seem to be looking the other way, and some defense contractors are looking more intently in the direction of non-defense business.

"One sign that should have sounded an alarm on Capitol Hill is the drastic lengthening of the time it takes to bring a major military system out of the engineering laboratories and get it into the hands of the armed services. Not so long ago, it generally took about four years. Today it takes, typically, 12 years.

"By the time we have placed a new weapon system into the hands of the troops, the technology may be obsolete . . . The complexities of modern weaponry require more time for development and testing . . . but they are exceeded today by the artificial complexities that have been erected by various agencies of the federal government . . . the mass of controls, checkpoints, budgetary hurdles and other assorted regulations imposed by government. I don't question the need for reasonable controls, nor do I pretend their proliferation is entirely to blame for today's situation. But they are taking a heavy toll in time, resources and contractor confidence."

AIA

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COVER

Linda Shaffer, radar systems engineer for Hughes Aircraft Co., flew in a modified T-39 Sabreliner to track navigation and data collection procedures. She is taking pilot flight training.

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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THE HUMAN FACTOR

BY PAUL THAYER
Chairman and Chief Executive Officer
The LTV Corporation

This guest editorial, based on Mr. Thayer's recent speech to the American Fighter Aces Association, is the first in a series of commentaries on key national issues by senior aerospace industry officials. Their views—together with the views of AIA president Karl G. Harr Jr. which will continue to appear in alternate issues of Aerospace*—are intended to give our readers broader insight into the important matters on the minds of the industry's top leaders.*

I would like to raise the subject of the human element in today's and tomorrow's military aviation. It is a subject that I believe not enough thought is given to, but one that must be highlighted, not only in terms of our Air Force but in terms of our entire military structure. In fact, it is a subject—the role of the individual—that we must begin placing more emphasis on in other aspects of our society as well.

In times of great crisis it is the human factor—the individual with his ingenuity, will and effort—that spells the difference between success and failure. Yet in today's tumultuous age I sense a danger that we are losing confidence in the individual. That in a world of high technology we tend to play down the human factor.

Ironically—or perhaps it was to be expected—we now have developing what can only be classified as a no-risk society, a demand that our environment, our lives, be so structured that nearly all danger of risk is eliminated. It is understandable, of course, that people want assurance that the air they breathe is safe and the products they eat and use present no danger to their health. But how far do we carry this philosophy? Is there not a point where, in adopting such a philosophy, we lose the will to think creatively, to compete, to strive for excellence? Is there not a point where we develop a greater reluctance to take chances in any area of our lives? At what juncture do we become a race of survivors rather than achievers and innovators?

Operation of manned aircraft is a key ingredient in our nuclear strategy. It provides us with flexibility. Unlike the missile, the manned bomber can be launched and then recalled without ever penetrating enemy airspace. If necessary, it can be re-routed, assigned different missions and used more than once. In short, it provides options that any military commander needs and would be unable to obtain otherwise.

There is no way that the importance of the human element can be overstated. As long as you have a thinking human being on the spot, you have something which no machine or technical system of and by itself can provide. And that is the greatest of human gifts, the talent for improvisation, the ability to evaluate a situation and then devise some entirely new way of dealing with it.

The one prediction that can be made with confidence is that the human element will continue to play the major role in our nation's future security. Despite all our shortcomings, despite our apparent concern with nothing but material satisfaction, I don't believe our nation's people will resign themselves to a future based on a no-risk philosophy, a future in which the individual does not have the opportunity to compete, to strive for greater excellence.

With thousands of spectators on hand for the great event, America's first jetliner—the Boeing 707 prototype known as the "Dash Eighty"—lifted off the runway at Renton (Washington) Municipal Airport and climbed steeply over Lake Washington in a preview of the commercial jet age that was to come.

It happened on July 15, 1954 and this year marks the silver anniversary of that important milestone in aviation progress, a momentous development which started a revolutionary transformation of the world air transportation system. The 707 and the other American-built jet transports which followed spurred multifold increases in passenger traffic and reestablished U.S. preeminence in commercial transport manufacture after a tentative challenge from abroad.

The initial American entry in the international jetliner competition made its flight debut five years later than the British DeHavilland Comet, which had flown in 1949 and entered commercial service in 1952. Also in development when the 707 first took to the air were the French Sud-Est Caravelle and the Soviet TU-104. But the American jet was faster and longer-ranging than its European rivals and, most importantly, it could carry almost twice as many passengers. When the world's airlines started placing orders—beginning in 1955—the 707 far outdistanced the foreign contenders. Its prinicpal competitor, in fact, was another U.S.-built jetliner, the Douglas DC-8.

Commercial service with American jet transports was inaugurated in October 1958, when Pan American World Airways introduced the 707 on its transatlantic route. American Airlines started domestic service with the 707 in January 1959, and in September of that year United Airlines and Delta Air Lines initiated DC-8 operations. A third American jetliner, the Convair (General Dynamics) 880, began service with Delta in May 1960. The U.S. jetliner family was expanded in the 1960s, first by derivatives of the three initial types, then by new two- and three-engine designs for short and medium-range operations, finally by the trio of advanced technology wide-bodied jetliners — the Boeing 747, Lockheed L-1011 and McDonnell Douglas DC-10—which are the mainstays of today's long-haul and intermediate range fleet.

The impact of these airplanes on the commercial air transportation system has been extraordinary. Speed, of course, was the primary attraction to the passenger; when they were introduced in 1958, the big jetliners offered roughly twice the speed of the commercial airplanes then in service. Where a transcontinental flight had required 10 hours, the jets cut the time to five hours or less. Transatlantic flight time was reduced from an average 12 hours to less than seven.

These dramatic time savings sparked an air travel boom of astonishing dimension. In 1958, the U.S. scheduled airlines carried 43 percent of all domestic intercity common carrier traffic; by the end of 1978, the figure had risen to 84 percent. A single statistic underlines the enormity of air travel growth in the United States: in 1958, all the domestic airlines combined carried 49 million passengers; in 1978, one airport alone—Chicago's O'Hare—handled 49 million passengers. This year the U.S. airlines will board more than 300 million passengers, a sixfold increase over 1958.

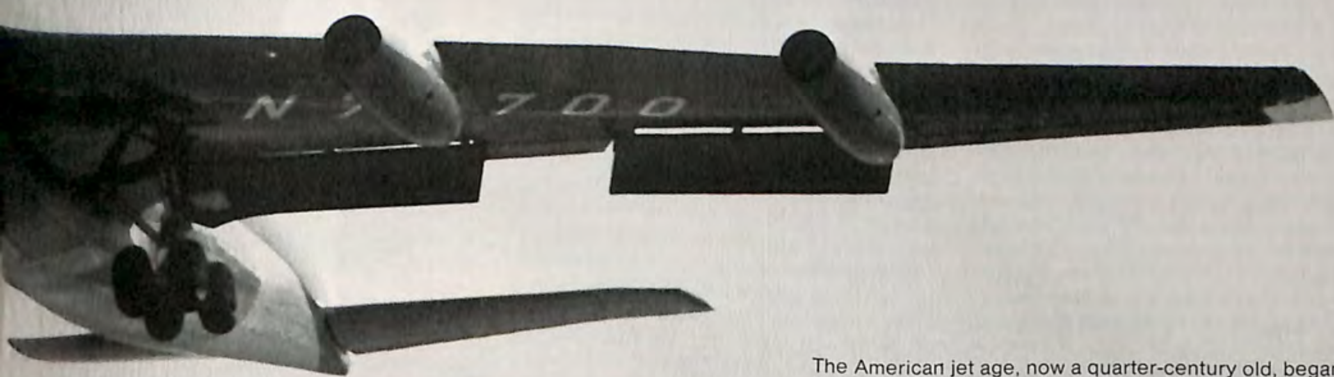
The jetliners' speed and far greater capacity provided exceptional productivity; although it cost more to operate a big jet than predecessor transports, the cost was more than offset by the greater number of passengers per flight and the greater number of flights in a given time span. Productivity and snowballing traffic gains combined to elevate the airlines to high-ranking status among American industries, with attendant benefit to the Gross National Product and employment. U.S. scheduled airline revenues climbed from $2.2 billion in 1958 to almost $23 billion in 1978. Airline industry employment increased over the same span from 143,000 to 329,000.

Jetliner productivity benefited the traveling public because it was a major factor in the airlines' ability to hold the line on ticket prices during a period of spiraling inflation. During the first 20 years of the jet age, the U.S. Consumer Price Index rose more than 125 percent—but the average price of an airline ticket increased only 43 percent. Recent events—in particular sharply rising jet fuel costs—have forced the airlines to seek fare increases, but even with the increases contemplated for the coming year airline tickets will remain a bargain in comparison with other consumer products and services.

Air safety improved significantly in the jet age, although the improvement is only indirectly attributable to the jetliners. The jet is not inherently safer than a propeller-driven airplane, but the jetliners came along at a time of rapidly advancing technology which brought about a number of safety-enhancing developments in the airplane itself and in the national air traffic control system. In 1978, the airlines' safety record was the best among all modes of intercity travel in the United States.

Production of jetliners, which have much higher dollar values than their piston-powered predecessors, has significantly influenced the sales "mix" of the the aerospace industry. In 1958, as now

U.S. JETLINERS 25th Anniversary



The American jet age, now a quarter-century old, began with the first flight of the Boeing 707 prototype on July 15, 1954.

U.S. aircraft builders predominated in worldwide sales of airliners, but in dollar value terms commercial sales represented a minor part of the industry's total sales. The industry's financial health was largely dependent on contracts with the military services, which in 1958 accounted for more than 90 percent of total industry sales. This year it is estimated that sales to the government will constitute only 55 percent of the total. There are other factors involved in this improved sales balance, but the main item has been the rapid growth in sales of high-value jetliners.

Finally, U.S. domination of the world jetliner market has had a beneficial impact on the U.S. economy in its contribution to the nation's trade balance, particularly in recent years when the U.S. as a whole experienced large trade deficits. In 1958, exports of commercial airliners amounted to $165 million. Last year, jetliner sales abroad totaled more than $2.5 billion and represented 25 percent of all U.S. aerospace exports. With a trade surplus of $9 billion in 1978, the aerospace industry led all U.S. industries in positive contribution to the balance of trade and jetliner sales to foreign airlines played an important part in the industry's international trade performance.

Since 1958, when American-built jetliners were introduced to airline service, passenger traffic on U.S. airlines has increased sixfold.

The federal government now spends something like a billion dollars a year for forms, another billion for directives telling you how to fill them out, and another $1.7 billion to store them.

Add up all the forms annually issued by federal, state, and local governments and they come to a staggering 2 billion pages. That's about 10 pages for every man, woman, and child in the United States.

There are 16 warehouses of federal records around the country containing a total of more than 12 million cubic feet of paper. Piled up, some analysts have appropriately pointed out, this material would form a structure equal in girth and a dozen times as tall as the Washington Monument. And, of course, the volume keeps growing.

Overall, American business spends approximately $30 billion a year on federal paperwork, responding to requests and requirements for information from payrolls to pensions to production, from energy to equal opportunity to the environment, from safety to sales expectations to annual surveys of scientific and technical personnel.

The 10,000 largest firms in the country expend hundreds of millions of man-hours gathering, processing, and preparing the vast range of information involved, then storing material that must be retained. The bill for this vast effort plus related costs such as computer support comes to an estimated $10 to $12 billion a year, or an average of more than $1 million for each company.

Some 5 million small businesses spend $15 to $20 billion, or an average of more than $3,000 each, which in some cases may be at least as burdensome as the much larger costs to larger organizations.

Even these astronomical numbers cover, of course, only a minor portion of the total cost of complying with federal and local regulations in many fields. Paperwork is the administrative tip of the iceberg. But it is clearly a sizable one that many people in government as well as business today feel could be cut back significantly.

At Martin Marietta headquarters, and in locations around the country, government paperwork is an ever-present fact of life. That's not to say it's all bad; some in various fields is clearly necessary. And in the conduct of government contracts, it's an essential of doing business.

On the other hand, in recent years the government paper workload has reached proportions that hardly seem credible to the average individual whose experience derives mainly from an annual income tax exercise and a driver's license renewal every few years.

For example, recently the corporate finance department compiled a partial list of business and financial reports the Corporation provides to government units at one time or another, many annually, others monthly, quarterly, or at less regular intervals. This list alone includes 150 separate documents submitted to federal and state agencies. The tabular roll call, with brief descriptions, covers 38 legal-size pages and attempts to estimate the number of man-hours required in each case to gather the material and send it on its way.

Not included in the listing, which was restricted to only one busy segment of the corporate reporting burden, were such extremely heavy areas as taxes, pensions, equal opportunity, safety and health, the environment, and Securities and Exchange Commission requirements. Even the segment that was compiled, however, yielded a conservative estimate of 34,400 man-hours expended on an annual basis. That's about 17 man-years.

Experts differ on how to translate government-paperwork man-hours into dol-

lars, and the most candid conclusion probably is that it's difficult to do so with maximum accuracy. The figure $30 an hour does, however, appear to provide reasonably for managerial, planning, professional, and clerical time-and-benefits. By that yardstick, then, the admittedly fragmentary list of 150 reports costs Martin Marietta something like $1 million a year.

How much is the Corporation's overall bill for government recordkeeping and reporting? Nobody can say with certainty, although some estimates have been made. So extensive and all-pervasive is the workload that few corporations have undertaken the awesome task of analyzing it in detail. Most figures available were developed in hearings and surveys by the government's own Commission on Federal Paperwork, set up a few years ago in response to stentorian cries of anguish from the business community and others.

The commission developed a rule of thumb, which it called "an imprecise measurement," for estimating typical costs for businesses of various sizes. The estimate for Martin Marietta comes to $6.5 million a year. Kaiser Industries, a diversified corporation farther down in the Fortune 500, conducted a painstaking two-year study and came up with its own price tag of $4.5 million, about 20% above the commission estimate in its case.

Stephen Laycock, Martin Marietta's corporate director of accounting policies and procedures, is responsible for many of the business reports that go to government agencies. His office prepared the existing million-dollar listing and also took a general look a while back at other reporting requirements.

"From our own experience," says Steve Laycock, "and what we've seen in other parts of the corporation, we estimate the total cost could be as high as $10 million a year. Some of the reporting seems unnecessary, some duplicates material we've already submitted in another form so we have to reprocess it, and the volume increases year by year. It's a real problem."

It's hard to find anyone who disagrees these days.

"Businesses rightly complain that more information than necessary is collected," concludes the paperwork commission. "As a result, they are drowning in a sea of paperwork and red tape."

The business community—led by such organizations as the Business Roundtable, the U.S. Chamber of Commerce, and the National Association of Manufacturers—has been calling for some measure of realistic relief before the tide rises even higher. Trade associations and other industry-supported groups such as the Business Advisory Council on Federal Reports and the Citizens Committee on Paperwork Reduction have been working with government agencies on a case-by-case basis in an effort to pull in the reins.

Now Congress, where some people feel the primrose path of paperwork begins, is taking a hard look at the problem. Some 20 bills have been introduced, embodying a variety of approaches including the revolutionary concept that government should pay the costs for material it requires.

The bill most likely to become law, experts say, takes a less radical approach. Sponsored in the House of Representatives by Rep. Frank Horton (R., N.Y.) with the co-sponsorship of Reps. Jack Brooks (D., Tex.), Tom Steed (D., Okla.), and Richardson Preyer (D., N.C.), it establishes (1) a central office to hold the lid on federal information requests, which come from a multitude of separate agencies, and (2) a computerized "information locator system" to keep track of information that's already in the files somewhere and so, supposedly, doesn't have to be asked for again. The Department of Defense is running a system of this kind that could be swung into action for the government as a whole.

Sen. Lawton Chiles (D., Fla.), who is expected to introduce a companion bill in the Senate, has been conducting a paperwork crusade including insistence on the inclusion of red-tape "impact statements" in new legislation.

Even with these efforts, however, neither Senator Chiles nor anyone else sees a quick or easy solution to a widespread problem that has grown over many years.

"It is kind of like fighting a pillow," he says. "You take a lick at one side and it just puffs out on the other. The task of cutting red tape and reducing paperwork has more political support than any activity we could possibly get into, and yet we find it more and more tremendously difficult to try to do anything about it." □

Reprinted from *Today*, the quarterly magazine of Martin Marietta Corporation.

Government Paperwork — What's the Cost? Industry Spends Millions Yearly

The Ninety-Nines are nearing fifty. On November 2, the international organization of licensed women pilots will celebrate the 50th anniversary of its founding with ceremonies at the site of old Curtiss Field, Valley Stream, Long Island, New York, where the organizational meeting took place in 1929.

There were, at the time, 117 women pilots in the U.S. and 99 of them responded to an invitation to organize—hence the name. Amelia Earhart was elected first president. In 50 years, the ranks of the Ninety-Nines have increased fifty-fold, to more than 5,000. The number of American women pilots has multiplied at an even greater rate; there are now more than 50,000.

Beginning at Curtiss Field—which today is a shopping mall—the Ninety-Nines established high professional standards and demonstrated their abilities as balloon, airplane and—later—helicopter pilots. They pioneered careers for women in aerospace, now a large and expanding movement.

At an ever-increasing rate, women are taking seats in airline cockpits. They have won places in NASA's astronaut corps. Except for the Marine Corps, the military services have opened their ranks to women pilots. In the aerospace industry, women are no longer confined to secretarial jobs; they hold key positions, as scientists, engineers, administrators, lawyers, sales/marketing personnel and public relations/advertising officials.

A sampling of women in industry includes:

- Charcy Evans Black, Vought Corporation, a lead flight test engineer for the Scout launch vehicle.
- Margaret A. Mead, Gates Learjet Corporation, district sales manager in four Western states.
- Mrs. Ruth Naber, Sundstrand Corporation, group engineer for actuation systems in the company's Advanced Technology Group.
- Theresa Ann Sheehan, General Dynamics Corporation, an aerodynamics engineer working with the Advanced Wing Design Group.
- Dr. Dora Strother, Bell Helicopter Textron, chief of the company's Human Factors Division and Cockpit Arrangement Group, who is also International President of The Whirly-Girls, Inc., the international association of women helicopter pilots.
- Shirley Holmgreen, The Boeing Company, aeronautical engineer and group supervisor for the 737 Aerodynamics Staff and for 727/737 Product Development.
- Susan A. Rubin, ITT Gilfillan, a senior design engineer assigned to the company's land based air defense program being developed for the Swedish government.
- Rita Marie Lavelle, Aerojet Liquid Rocket Company, director of communications responsible for external and internal communications/public relations for the company's products.
- Patti Mancini, Rockwell International Space Systems Group, vice president for external affairs and communications.
- Mrs. Louise Gilbreath, Vought Corporation, supervisor of the Corporate Com-

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1. At Rockwell's Rocketdyne Division, Pat Swanson is a project engineering manager.
2. At General Dynamics, Theresa Ann Sheehan is is an aerodynamics engineer in Advanced Wing Design.
3. Dr. Dorothy M. Simon is Vice President, Research for AVCO Corporation.
4. Sue Matheis and Don Miller are pilots/ reporters for Station KMOX-CBS Traffic Watch in St. Louis, Missouri.
5. Coast Guard LTJG Colleen Anne Cain (left) pilots a Sikorsky Sea Guard helicopter, and Lt. Vivian Suzanne Crea is qualified as a C-130 Lockheed Hercules pilot.
6. Captain Cheryl Faye Peters, one of the six women pilots flying for Piedmont Airlines.
7. In 1978, McDonnell Douglas Corporation's airplane/helicopter pilot/ flight test engineer Nelda K. Lee received the American Institute for Aeronautics and Astronautics' Young Professional Award for her contribution to the design of the F-18 graphite/epoxy wing.
8. At The Boeing Company, aeronautical Engineer Shirley Holmgreen is group supervisor for the 737 Aerodynamics Staff and 727 and 737 Product Development.
9. At Martin Marietta's Michoud Operations in New Orleans, Susan D. Lemeshewsky is a senior engineer in materials engineering.

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golden jubilee 1979 the ninety-nines

WOMEN IN AEROSPACE

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munications Department.

- Cynthia L. Baker, Hughes Aircraft Company, corporate advertising manager.
- Dr. Dorothy M. Simon, AVCO Corporation, corporate vice president-research, who has oversight responsibility for the R&D functions of the company's nine technology-based divisions.
- Sally H. Bath, Aerospace Industries Association, chief statistician for the Economic Data Services. Ms. Bath is also responsible for preparation of AIA's annual publication Aerospace Facts and Figures.
- Jean Ross Howard, Aerospace Industries Association, director of helicopter activities and editor of the AIA Directory of Helicopter Operators and the Directory of Heliports. A member of the Ninety-Nines, Miss Howard was founder and first president of The Whirly-Girls, Inc.
- Barbara J. Boykin, Aerospace Industries Association, administrator for two of the association's technical committees: the National Aerospace Standards Committee and the Aerospace Sector Committee of the American National Metric Council.
- Evelyn Bryan Johnson, manager of Tennessee's Morristown Flying Service, a veteran of 25 years in aviation who has been named by the Federal Aviation Administration the 1979 Flight Instructor of the Year.

Women are also participating in advanced training programs designed to prepare candidates for upper level aerospace industry positions. Some examples:

- Susan D. Lemeshewsky, Martin Marietta Corporation, a senior materials engineer who has won a competition for a year's assignment in the company's Technical Operations Intern Program.
- Karen Leslie Key, Bell Helicopter Textron, an executive staff assistant in the Commercial Marketing Department who is receiving advanced training to become a regional marketing director.
- Natalie J. Krahl, General Dynamics Corporation, assistant project engineer in the Range Systems Project Office, whose management ability won her company sponsorship in the UCLA Engineering Executive Program, a two-year course.

In the airline industry, women pilots represent a small segment of the total pilot complement, but they are making inroads into what, not long ago, was an entirely male occupation. There are 110 women airline pilots and most of the major airlines have at least one.

In government aerospace operations, six women recently scored a breakthrough when they became NASA's first women astronauts. All mission specialists—scientists and engineers who handle multiple tasks associated with handling Space Shuttle payloads and experiments—the six include: Dr. Anna L. Fisher, an M.D. specializing in emergency medicine; Dr. Judith A. Resnik, electrical engineer; Dr. Kathryn D. Sullivan, geologist; Dr. Margaret Rhea Seddon, a surgeon and a member of the Ninety-Nines; Dr. Shannon W. Lucid, biochemist; and Dr. Sally K. Ride, physicist.

Among non-astronaut women in aerospace programs, Ann F. Whitaker is chief of the Physical Sciences Branch at NASA's Marshall Space Flight Center; Barbara G. Askins, 1978 National Inventor of the Year, is a research chemist in Marshall's Space Sciences Laboratory; Trudy Tiedemann is a public information specialist at NASA's Dryden Flight Research Center; Jennifer L. Baer is propulsion system project engineer for the HiMat (Highly Maneuverable Aircraft Technology) program in flight status at Dryden; Harriet Jacqueline Smith is project manager for NASA's F-14 research program; JoAnn Morgan is an electronics engineer on the Space Shuttle Launch Processing System; Judith A. Anderson is a systems engineer on the Space Shuttle program at Kennedy Space Center; and Ann Montgomery is site manager for the Orbiter Processing Facility at Kennedy.

In government aviation activities, more than five percent of the Federal Aviation Administration's corps of air traffic controllers are women—more than 1,500 of the 27,000 total. In lesser numbers, women are working in such other FAA jobs as electronic technicians, engineers and flight standards inspectors; there are 250 women in those categories. Among women executives in FAA are Joan Barriage, chief of the Flight Standards Division, Great Lakes Region, and Mary Jo Oliver Knouff, acting chief of the FAA Aviation Education Programs Division.

In a 1977 development, belated recognition was granted the Women Air Force Service Pilots (WASPs) who, during World War II, flew 60 million miles on ferry, tow target and test flight missions to free male pilots for combat duty. Congress passed and President Carter signed a bill authorizing veteran status for the remaining 800 eligible WASPs.

Following in the WASPs' footsteps, a large number of women are now serving as active duty pilots with the military services and the Coast Guard. In 1973, the Navy became the first service to open aviation training to women; today there are 27 women officers wearing the naval aviator's badge. The Army now has 40 women aviators, 20 of them warrant officers, all of them rated in rotary-wing aircraft. In the Air Force, there are 22 women officer pilots and six navigators; women are also serving as crew chiefs and weapons controllers. The Coast Guard has three women aviators, two of them helicopter pilots and the third a transport pilot.

Women in aerospace have come a long way in half a century and they owe their current status to the pioneering effort of the Ninety-Nines. In a salute to the Ninety-Nines and to women pilots in general, Senator Barry Goldwater said:

"It is impossible for me to overestimate what women flyers have meant to the development of aerospace pursuits in the years past. And it is hard to imagine what heights they will help the industry achieve in the future."

10. The 1978 National Inventor of the Year, Barbara S. Askins is a chemist at the NASA's Marshall Space Flight Center.
11. Susan Rubin is a senior design engineer at ITT Gilfillan.
12. Karen Leslie Key is demonstrator pilot/executive staff assistant in advertising and market research at Bell Helicopter Textron.
13. Surgeon Dr. Margaret Rhea Seddon, one of NASA's six women astronauts.
14. At Sundstrand Corporation, Ruth Naber is group engineer for the Advanced Technology Group.
15. Margaret Mead, district sales manager at Gates Learjet, is regional sales manager for new business jet aircraft.
16. The youngest U.S. airline pilot, 22-year-old Kim Goodman, flies Western Airlines Boeing 737s as a second officer
17. At LTV's Vought Corporation, Charol Evans Black is lead flight test engineer. She monitored eight of the last thirteen launches of the Scout rocket.

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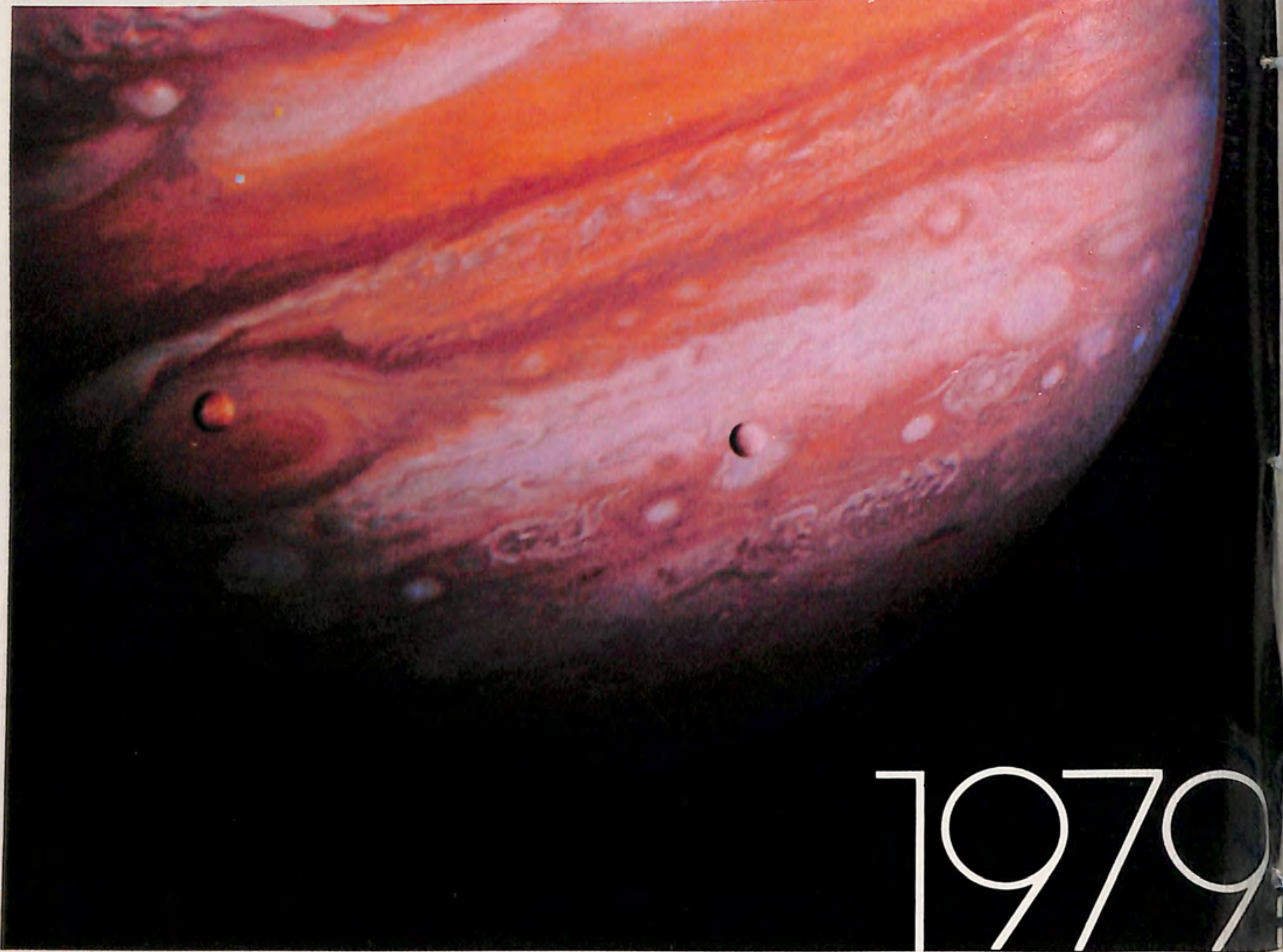

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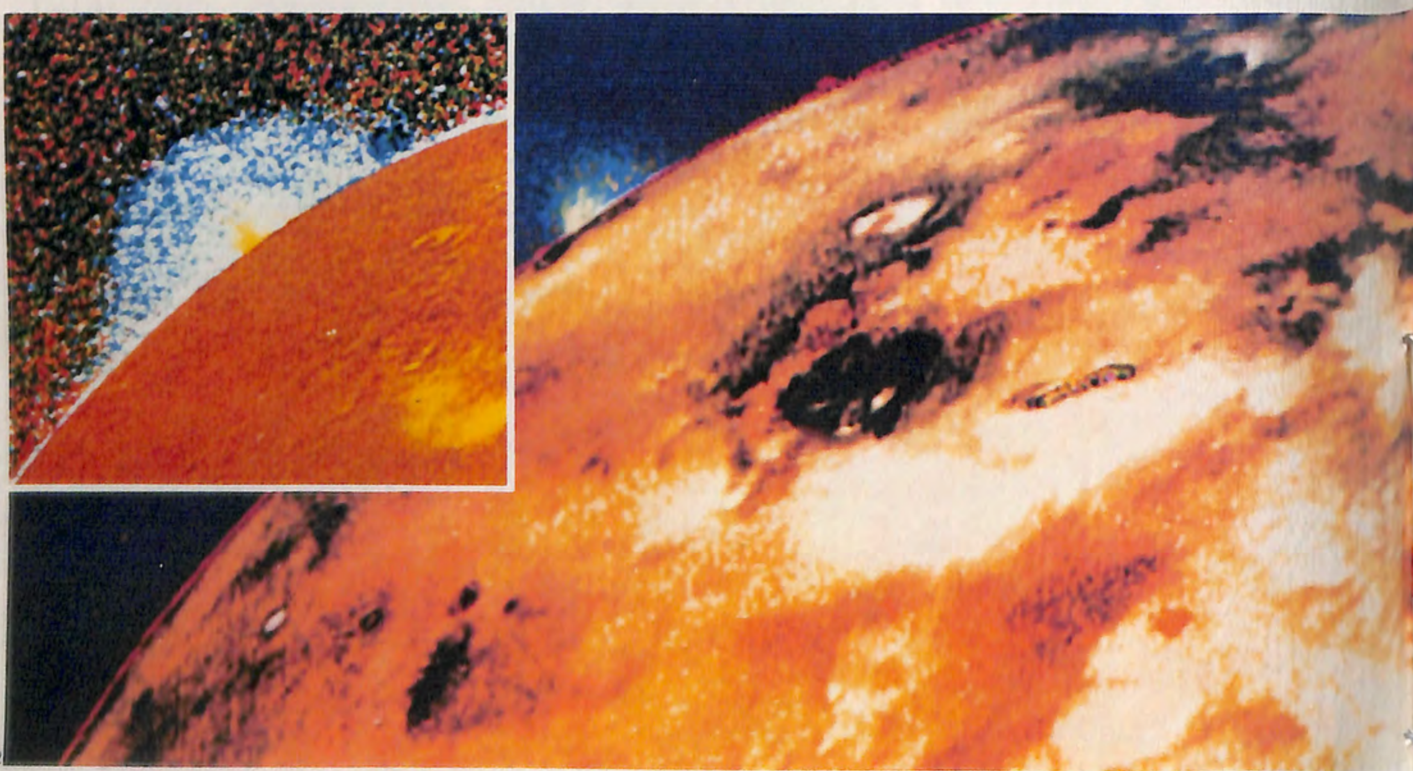

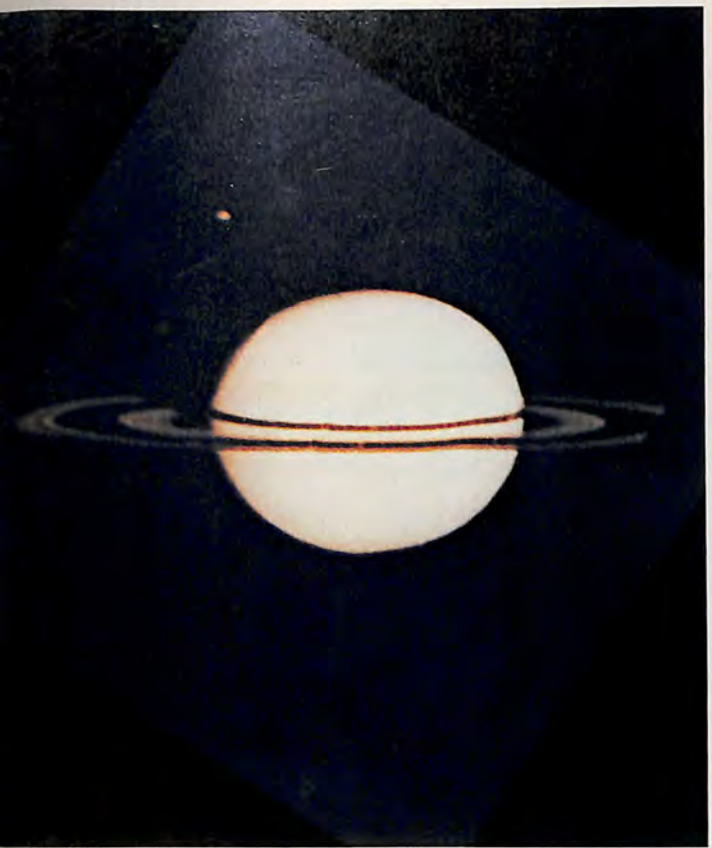

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PLANET YEAR

1. Voyager 1 took this picture of Jupiter and two of its moons, Io (left) and Europa. The immensity of the Jovian system is underlined by the fact that the moons, seemingly close to Jupiter, are actually hundreds of thousands of miles distant and the planet itself was 12.4 million miles from Voyager when the photo was taken.

2. This is a historic photo of a volcanic eruption on Jupiter's innermost moon, Io, the first volcanic activity found outside Earth. The related image is a computer-processed blow-up of the 100-mile-high eruption.

3. From a distance of 1.8 million miles, Pioneer 11 took this image of Saturn, its rings and its largest moon, Titan (upper left).

4. This Pioneer 11 view of Saturn's rings shows detail never before seen. The spacecraft's imaging equipment and other instruments discovered two hitherto unknown rings.

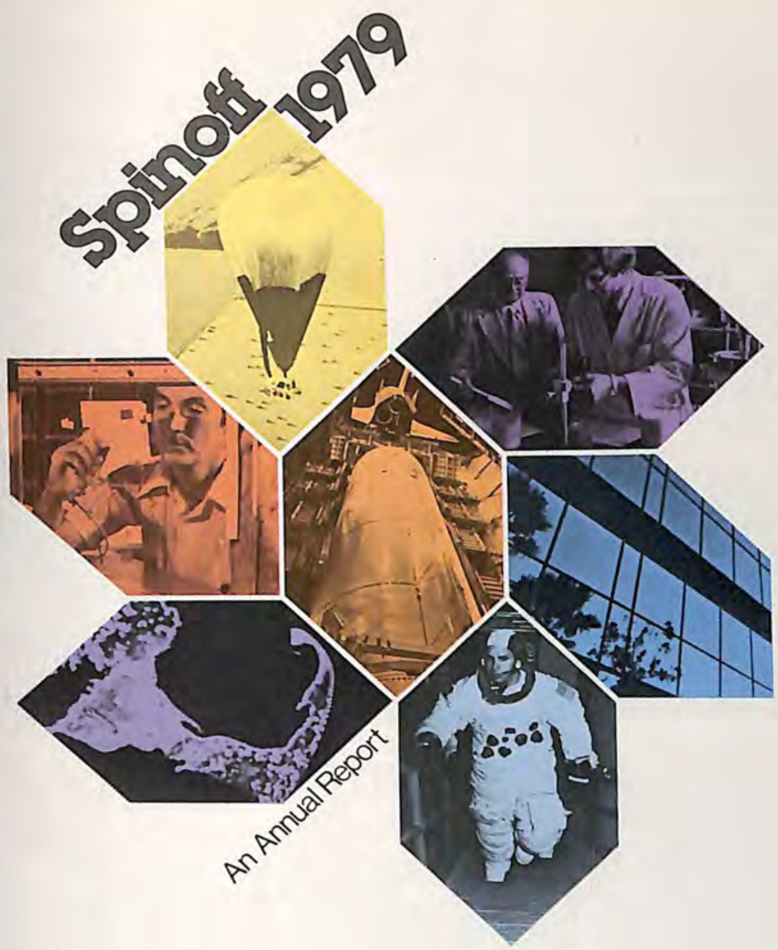
For NASA, 1979 has been "The Year of the Planets," with seven different spacecraft returning photos and data from Venus, Mars, Jupiter and Saturn. ■ Over an eight-month span from January through August, Voyagers 1 and 2 provided thousands of images and a wealth of other information about the superplanet Jupiter and several of its moons. A scientific highlight was the discovery of live volcanoes on the moon Io, the first identification of volcanic activity anywhere except on Earth. ■ Most recent of the planetary encounters was the first visit to Saturn of an Earth vehicle, Pioneer 11's September fly-by of the multi-ringed planet after a six-year, two-billion-mile journey. The Pioneer mission was especially exciting to the scientific community because Saturn is so far from Earth it cannot be viewed in desired detail from ground-based telescopes. Pioneer 11, built by TRW Inc., sent back scores of photographs and volumes of instrument data which will be undergoing analysis for months. Among preliminary findings were discovery of two new rings around Saturn and identification of a new object orbiting the planet, perhaps a very small 11th moon. ■ Scientifically, the information supplied by these and other spacecraft is immensely important and it also has potential for practical application. Through "comparative planetology"—relating phenomena on one planet to conditions on another—scientists are learning more and more about the processes which govern Earth, a step toward future management of these processes to man's advantage—control of weather, for example. ■ NASA's planetary exploration program will continue next year, when Voyager 1 will reach Saturn, and again in 1981 when Voyager 2 arrives at the ringed planet; these encounters will amplify the information provided by Pioneer 11. Jupiter will get a more extensive look in the mid-1980s, when two Galileo spacecraft—an orbiter and an instrumented probe which will drop through the Jovian atmosphere—begin their investigations; the thousand day trip to Jupiter will get under way late in 1982 or early in 1983. Distant Uranus, some two billion miles from Earth, will be close-encountered for the first time in 1986 by Voyager 2.

Grumman's Dormavac, a spinoff from the company's work on space environmental control, provides a commodity-preserving environment for long-term protection of perishables without freezing.

Spinoff 1979

McDonnell Douglas subsidiary Vitek Systems, Inc. is producing for hospital use the AutoMicrobic System, a laboratory aid which sharply reduces the time required to detect and identify harmful microorganisms in human specimens. The system derived from a McDonnell Douglas space medical study conducted for NASA.

The *American Enterprise*, a high-speed crewboat designed to serve offshore oil rigs, is powered by a Rocketdyne waterjet propulsion system which is a direct derivative of space-use turbopumps.



To get the great thrust needed to boost spacecraft to orbit, space launch vehicles burn enormous amounts of fuel—tens of thousands of gallons each minute. The job of feeding liquid propellants to the rocket engines under high pressure is handled by systems called turbopumps.

These high capacity products of aerospace research and development are finding new utility in non-aerospace applications. Rocketdyne Division of Rockwell International, the principal manufacturer of space-use turbopumps, is now producing direct derivatives called Powerjets as propulsion systems for high speed boats and small ships. These jetlike systems gulp large amounts of water, increase its pressure, then expel it at high velocity to generate propulsive thrust. Powerjets are in service aboard The Boeing Company's 45-knot, 300-passenger Jetfoil boats, which are providing high speed transportation in several European, South American and Asian locales. The latest application of the Powerjet is in a 38-knot crewboat designed to serve the offshore petroleum industry.

The Powerjet line is one of some 60 examples of aerospace technology transfers contained in NASA's Spinoff 1979, an annual publication which details how the secondary use of technology originally developed for aerospace programs is being reapplied in a broad variety of civil-use products and processes. Thousands of spinoffs have emerged since the 1962 establishment of NASA's Technology Utilization Program, which seeks to promote wider use of already-developed technology and thus realize a dividend on the national investment in aerospace research and development.

Among other examples of innovations derived from aerospace technology are these:

The technology once used to locate a spacecraft in orbit and maintain a fixed position is being applied to deepsea oil drilling operations. For deepsea work, oil explorers use drillships, connected to the wellhead thousands of feet below by a cylindrical steel tube through which the drilling equipment is lowered. The drillship must maintain a precise position, often for months; excessive ship movement could snap the drill tube at a cost of millions. Both Honeywell Inc. and TRW Inc. have adapted spacecraft positioning systems to this need; the systems determine the position of the ship relative to the wellhead and a computer directs the ship's engines or thrusters to nudge the vessel forward, backward or to either side to maintain the precise position desired.

Crude oil moving through the Alaska pipeline must be kept at relatively high temperature to maintain fluidity. General Electric Company's Space Division provided the answer with a highly effective insulating material called Therm-O-Trol. GE also produces Therm-O-Case, a multilayer insulating system for Alaskan oil wells which prevents transfer of heat from hot crude oil to the surrounding permafrost soil; heat transfer could melt the permafrost and cause surface dislocations that might destroy the well casing. Therm-O-Trol and Therm-O-Case stemmed from GE Space Division's heat transfer/thermal control work on Gemini, Apollo and other NASA programs.

Lockheed Missiles and Space Company developed for NASA a Laser Doppler Velocimeter (LDV) for measuring airflow disturbances in wind tunnels and in flight. The system is now being used in a NASA/Federal Aviation Administration safety program involving study of normally invisible vortices, air whirlpools at the tips of a jetliner's wing which can be hazardous to small airplanes following closely behind. The LDV also has civil utility as a highly-accurate wind measurement device for meteorological use or as a means of tracking smokestack pollution dispersion patterns.

The experience Grumman Corporation gained in developing the environmental control system for the Lunar Module has been reapplied in a commercial product that can preserve perishable commodities for long periods without freezing them. Called Dormavac and marketed by Grumman Allied Industries, the system provides a commodity-preserving environment within a large aluminum trailer which can be transported by truck, rail or ship.

McDonnell Douglas Corporation conducted a NASA study aimed at development of an automatic system for detecting and identifying pathogens, or harmful micro-organisms, a system intended for health care on long-duration space missions. After years of additional research and development, the company has brought the system to the commercial market. Called the AutoMicrobic System (AMS), it identifies the presence of pathogens and specifies the type in a fraction of the time required by traditional laboratory methods. The system also minimizes human error, increases laboratory output because it can handle a great many specimens at one time, and reduces patient stay-time in the hospital. Already in service at a number of hospitals, AMS is produced by Vitek Systems, Inc., a McDonnell Douglas subsidiary.

Spinoff 1979 is a 116-page paperback volume which treats both spinoff and direct-benefit space applications in text/photo fashion, with 156 photographs in full color. It is available at $4.10 per copy from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

In the national effort to reduce the United States' dependence on foreign oil through development of alternative energy sources, the aerospace industry is playing a significant role. By virtue of its long experience in high technology programs, the industry brings to the energy quest a unique and important capability for innovative development and high technology program management. The nature of that capability and how it is being applied is the subject of a study by Aerospace Industries Association's Aerospace Research Center. The study, entitled "The Energy Mission: An Aerospace Perspective," is excerpted on the following pages. Copies of the full report may be obtained by writing Allen H. Skaggs, Director, Aerospace Research Center, 1725 DeSales Street, N.W., Washington, D.C. 20036.

AEROSPACE AN

Efficient energy conservation, use and storage have long had a high priority for designers of aricraft and space systems. Powered flight itself is a critical exercise in energy management. . . . Energy management became an even greater challenge as man sought to extend flight beyond Earth's atmosphere. The aerospace community again responded, this time with powerful rocket engines based on advanced technology and new fuels. Complex long-term space missions created a demand for highly reliable onboard systems for generating electric power, precisely managing its consumption and providing for its storage. Photovoltaic cells, fuel cells and lightweight high capacity batteries were developed by NASA and aerospace companies to meet these needs. Advanced power and propulsion systems for future space missions are under continual development . . .

Aerospace companies hold Department of Energy (DoE) contracts in nearly every emerging technology. . . . The unique character of the industry suggests that its potential for solving energy problems is just beginning to be tapped. Aerospace companies have played a central part in maintaining national security since the early days of aviation. They have pioneered mankind's expansion into space. They have repeatedly accomplished complex missions in the national interest. These experiences have molded a high technology industry with these particular attributes for successfully pursuing the goal of assured national energy efficiency:

- *Management of complex long-term projects*
  Single aerospace programs have often run into billions of dollars and have taken more than 10 years from concept to completion. Effective management of these programs has honed the dynamic management skills of the industry —skills which are directly applicable to the many programs and projects DoE is pursuing.
- *Strong government/industry relationship*
  Long-term joint pursuit of national defense and aerospace goals has developed an effective planning and policy-making relationship between the industry and the government. This ability to successfully work together on government-funded programs is essential for solution of energy problems.
- *Research laboratories*
  The continuing development of more advanced weapons systems and space vehicles requires the industry to push forward many state-of-the-art technologies. In many of its products, revolutionary advances in performance and capability are required. To meet this demand, the industry maintains many high quality research laboratories which have a proven record of giving birth to and developing new technology. The diverse technical disciplines and the capability of these labs are critical to the solution of many technological energy problems.
- *Systems analysis and engineering*
  Analyzing complex scientific and technological problems, involving many interrelated factors, and then engineering and implementing solutions which guarantee the desired result is a capability for which the aerospace industry is renowned . . .

Here is an overview of the aerospace industry's "energy mission."

SOLAR TECHNOLOGIES

Aerospace companies have become leaders in developing a variety of solar technologies. Some of these technologies are:

Photovoltaics

For almost twenty years, arrays of photovoltaic cells have been used to provide electrical power for satellites and other spacecraft. The ability of these simple semiconductor devices to convert incident sunlight directly to electricity makes them ideal solutions to the problem of providing reliable, long term electrical power with a minimum weight penalty. Aerospace companies working with NASA pioneered their development and continue to improve the technology. Current efforts focusing on increasing their energy conversion efficiency and reducing manufacturing costs may make solar cells cost competitive for a wide variety of small and large scale electrical needs.

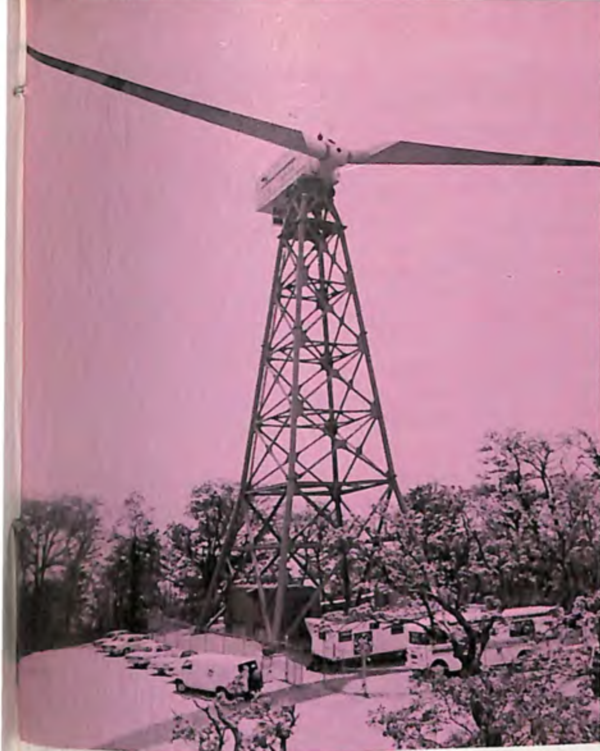
Solar Thermal Electric

The solar thermal concept entails using the energy of the sun to heat fluids which drive electricity generating machinery such as turbines, or which provide heat for energy intensive industrial processes. The technical or engineering feasibility of such systems should be proven in several DoE sponsored experimental projects. One of these, a solar power tower concept developed by aerospace companies, employs computer controlled sun-tracking mirrors to concentrate heat onto a central receiver/boiler, the power "tower." The resulting steam drives a turbine to produce electricity. The pilot plant, to be completed in 1981, will generate 10 megawatts of power and will be the world's largest application of solar thermal technology in which electrical energy is produced for the utilities. Aerospace contractors have been selected for design and construction of the collector mirrors and for system management of the program.

Another project employs large hemispherical bowl-like distributed collectors to provide steam for electrical generators. The goal is construction of a five megawatt plant in the mid 1980's. Aerospace companies are also engaged in the development of these solar collector systems.

Solar Heating and Cooling

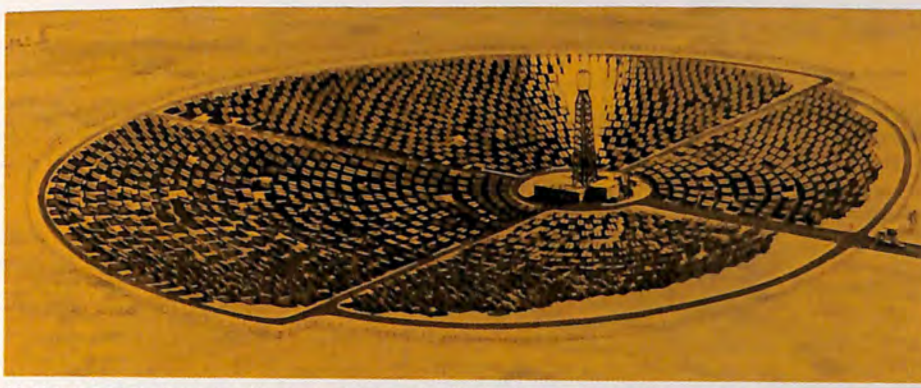
High altitude air travel and space travel posed difficult problems for aerospace engineers responsible for providing safe and comfortable cabin environments for passengers and crew. Skills gained in solving these environmental problems, combined with skills in development and use of advanced materials, thermodynamic design, systems inte-



Representative of aerospace industry work on wind energy systems is the world's largest "windmill," which recently went into operation at Boone, North Carolina. Developed by General Electric Company's Space Division, the system converts wind force to electricity and feeds two million watts—enough to meet the needs of several hundred homes—into the lòcal power grid. The modern windmill is part of a DoE/NASA wind energy technology program in which The Boeing Company, Grumman Corporation, Lockheed Corporation, Rockwell International, and Westinghouse Electric Corporation are also participating.

The barge-mounted system shown is a first-of-its-kind power plant operating on the Ocean Thermal Energy Conversion (OTEC) concept of using the solar energy stored in warm surface waters to generate electricity. The Mini-OTEC system, developed by Lockheed Missiles & Space Company, has operated successfully since mid-summer at a site off the island of Hawaii. Intended only as a small-scale concept demonstrator, Mini-OTEC generates only 50,000 watts, but larger and more advances OTEC plants could meet the electricity needs of a population of 200,000.

ENERGY



Under construction near Barstow, California is "Solar One," an experimental solar-powered electric generating facility designed by McDonnell Douglas Astronautics Company. The system employs a field of some 2,000 sun-tracking mirrors which reflect solar heat to the central receiver shown; the receiver is a boiler which produces steam to drive an electricity-generating turbine. Solar One is designed to generate 10 million watts, enough to serve a community of 7,000 people. McDonnell Douglas Astronautics is design integrator for the DoE project; Rocketdyne division of Rockwell International is a major subcontractor.

The fuel cell powerplant, long used by NASA to provide spacecraft electrical power, is finding new utility as a pollution-free source of electricity for consumer use. Among a number of fuel cell development programs is the one shown in artist's concept—a multi-module system capable of generating almost five million watts of electricity. Developed by Power Systems Division of United Technologies, it will go into operation next year on the Consolidated Edison grid in lower Manhattan.

gration and other areas of aerospace expertise are enabling aerospace firms to make a significant contribution to solar heating and cooling technology. All buildings—residential, commercial and industrial—are potential markets. High efficiency solar collectors, advanced solar heat pumps, and innovative "total systems" are being developed by aerospace companies, either independently of for DoE.

Wind Power

The key component for transforming wind energy into more useful forms, such as mechanical power or electricity, is the aerodynamic rotor. . . . Wind power systems under development by aerospace companies incorporate rotors from 25 to 300 feet in diameter, and are capable of producing from a few kilowatts to thousands of kilowatts.

Solar Power Satellite

One of the most daring and challenging concepts proposed as a means of capturing vast amounts of solar energy is the Solar Power Satellite (SPS) system. These satellites, possibly 50 square kilometers in size, would be put into geosynchronous orbit, 35,800 kilometers high, where they would convert solar energy to electricity and beam it to earth via microwaves for distribution to electrical utility grids. Recognizing the potential of this system, NASA and DoE are spending $15.6 million jointly to evaluate the feasibility of the concept, assess its economic practicability and its environmental acceptability. The reference system satellite now being studied would provide 5,000 megawatts of power. Final recommendations of the program are due in June 1980.

Ocean Thermal Energy Conversion (OTEC)

Aerospace companies working with the National Science Foundation were the first to evaluate the feasibility of large scale OTEC systems and continue to be the leading designers and prime candidates for fabrication of OTEC pilot plants for DoE. . . . Huge exchangers are required to extract heat from the sun-warmed uppermost levels of the ocean for boiling a highly volatile liquid whose vapor will drive an electricity generating turbine. A unique combination of skills is required to design and integrate the exchangers into a practical system: systems management and large hardware know-how capability, special materials technology, thermodynamics and structural analysis capabilities, experience in solving marine bio-fouling problems and designing deep submersible vehicles. DoE, therefore, is relying on the aerospace industry to develop the first working OTEC systems.

Ocean Kinetic Energy

The kinetic energy of ocean waves and tides is another potential source of nearly limitless energy. . . . Improved energy storage techniques are needed to make tidal systems economical. Several aerospace companies are pursuing research in these areas.

FUSION TECHNOLOGY

Harnessing the nuclear fusion process—the basic energy producing reaction of the sun and also the hydrogen bomb—would give mankind a virtually unlimited, clean source of energy. The fuels deuterium and tritium are available from sea water. Unlike the fission process, fusion produces little radioactive waste. The feasibility of sustaining fusion for production of commercial power is only now being tested in the laboratory. If an experimental fusion reactor can be developed in the 1980's which produces more energy than is put in, DoE says, a demonstration power plant could be running before the end of the 1990's . . .

As contractors for design and development of reactors and their subsystems, aerospace firms are applying their advanced technology experience in plasma physics, extremely high temperature-high strength materials, cryogenics, super-conducting magnets and overall systems analysis and engineering to help harness fusion power for practical use.

COAL TECHNOLOGIES

Several innovative coal technologies are being investigated by aerospace firms.

Magnetohydrodynamics

One of the promising technologies for extracting electrical energy from coal is magnetohydrodynamics (MHD). MHD devices generate electricity directly from a very high temperature ionized gas produced by burning coal combined with a "seed" material such as potassium. Waste heat from this process can be used to drive a turbine generator, thereby producing additional electricity from the same coal. MHD systems have the potential of producing 50 percent more electricity from the same amount of coal than conventional coal fired utility plants, with greatly reduced sulfur emissions . . .

Several aerospace companies are engaged in pioneering developments in this technology. Their experience with extremely high temperature, heat resistant materials, superconducting magnets and overall systems integration makes them well qualified.

Coal Gasification and Liquifaction

Although coal gasification and liquifaction are prinicipally the province of traditional energy companies, several aerospace companies are working either independently or with DoE to demonstrate the feasibility of deriving both low and high BTU gas and synthetic liquid fuel from coal. One project, based on liquid rocket technology developed for the space program, involves the construction of an experimental facility which will convert 100 tons of coal a day into high BTU pipeline quality gas.

FUEL CELL TECHNOLOGY

Chemical fuel cells were put to use by aerospace engineers during the 1960's to supply spacecraft power. Today, cells small enough to supply a small apartment house and large enough to supplement a metropolitan utility grid are within the state-of-the-art. . . . Today's fuel cells can be made to operate on a variety of conventional fuels, such as natural gas, propane, diesel oil or processed coal, extracting energy from these sources more cleanly and efficiently than conventional powerplants. One aerospace company with extensive experience in developing fuel cells has provided a 4.8 megawatt unit to a New York utility to supplement Manhattan's electrical supply. Other utilities are also ordering multi-megawatt fuel cells to meet part of their electrical demands.

CONSERVATION

Some areas where aerospace companies are active in energy conservation include:

Energy Management

Aerospace companies are designing and marketing computer controlled energy management systems. These systems automatically control heating and air conditioning systems and other high energy consumption equipment in industrial plants and commercial buildings so as to maximize total energy conservation.

Energy Conversion

Several companies are involved in the effort to increase the efficiency of fossil fuel power plants. Waste heat recycling systems and more efficient industrial gas turbines based on aerospace technology are being developed. Advanced research on the combustion process may lead to a broader range of useable fossil fuels, such as powdered coal or residual fuels, for power generation.

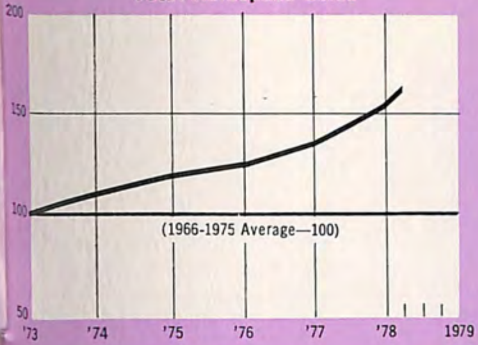
Energy Storage

Compact, high power electrical batteries are required for space missions. Automobiles and small industrial vehicles are now being built, combining such batteries with fly wheel energy storage devices. An entire panoply of potential storage systems like these is emerging from aerospace research.

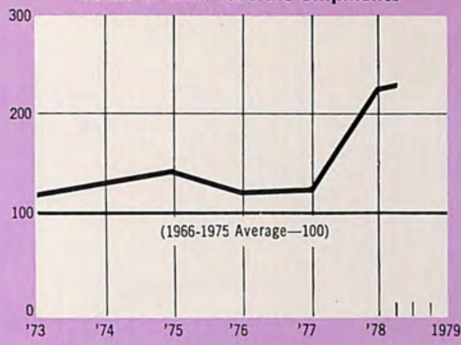
AEROSPACE ECONOMIC INDICATORS

CURRENT

Total Aerospace Sales

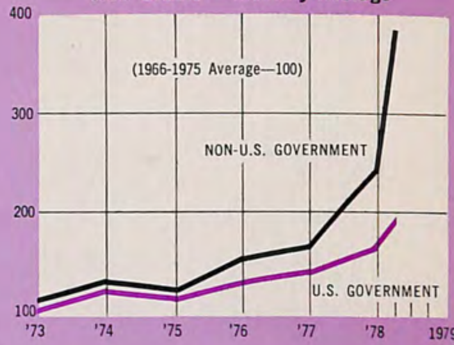


Value of Civil Aircraft Shipments



OUTLOOK

New Orders — Monthly Average



ITEM	UNIT	PERIOD	AVERAGE 1966-1975 *	SAME PERIOD YEAR AGO	PRECEDING PERIOD†	LATEST PERIOD 1st QTR. 1979
AEROSPACE SALES: TOTAL	Billion $	Annually	26.6	34.1	37.5	39.7
	Billion $	Quarterly	6.4	8.5	10.3	10.7
AEROSPACE SALES: TOTAL	*Billion $*	*Annually*	*27.3*	*23.2*	*24.0*	*24.8*
(In Constant Dollars, 1972=100)	*Billion $*	*Quarterly*	*6.9*	*5.8*	*6.6*	*6.7*
AEROSPACE PRIME CONTRACT						
AWARDS: TOTAL	Billion $	Quarterly	5.8	10.1	15.5	15.9
U.S. Government	Billion $	Quarterly	4.1	5.6	8.4	7.5
Other Customers	Billion $	Quarterly	1.7	4.5	7.1	8.4
BACKLOG (Major Aerospace Mfgrs): TOTAL	Billion $	Quarterly	28.6	47.6	56.9	63.0
U.S. Government	Billion $	Quarterly	15.9	26.6	30.1	32.0
Nongovernment	Billion $	Quarterly	12.7	21.0	26.8	31.0
DEPARTMENT OF DEFENSE						
Aerospace Obligations: TOTAL	Million $	Quarterly	2,712	3,123	4,528	3,828
Aircraft Procurement	Million $	Quarterly	1,986	2,638	3,782	3,194
Missiles Procurement	Million $	Quarterly	726	485	746	634
Aerospace Outlays: TOTAL	Million $	Quarterly	2,405	2,045	2,500	2,514
Aircraft Procurement	Million $	Quarterly	1,741	1,672	2,002	2,025
Missiles Procurement	Million $	Quarterly	664	373	498	489
NASA RESEARCH AND DEVELOPMENT						
Obligations	Million $	Quarterly	780	874	1,107	977
Expenditures	Million $	Quarterly	789	776	731	850
EXPORTS						
Total (Including Military)	Million $	Quarterly	1,038	1,830	3,227	2,899
New Commercial Transports	Million $	Quarterly	345	316	1,166	1,195
EMPLOYMENT: TOTAL	Thousands	End of Quarter	1,166	925	1,031	1,064
Aircraft	Thousands	End of Quarter	650	501	572	592
Missiles & Space	Thousands	End of Quarter	114	82	84	86
AVERAGE HOURLY EARNINGS, PRODUCTION WORKERS	Dollars	End of Quarter	4.38	7.29	7.94	7.98
PROFITS						
Aerospace — Based on Sales	Percent	Quarterly	2.7	4.1	5.1	4.7
All Manufacturing — Based on Sales	Percent	Quarterly	4.8	4.7	5.6	5.6

* 1966-1975 average is computed by dividing total year data by 4 to yield quarterly averages.
† Preceding period refers to quarter preceding latest period shown.

Source: Aerospace Industries Association

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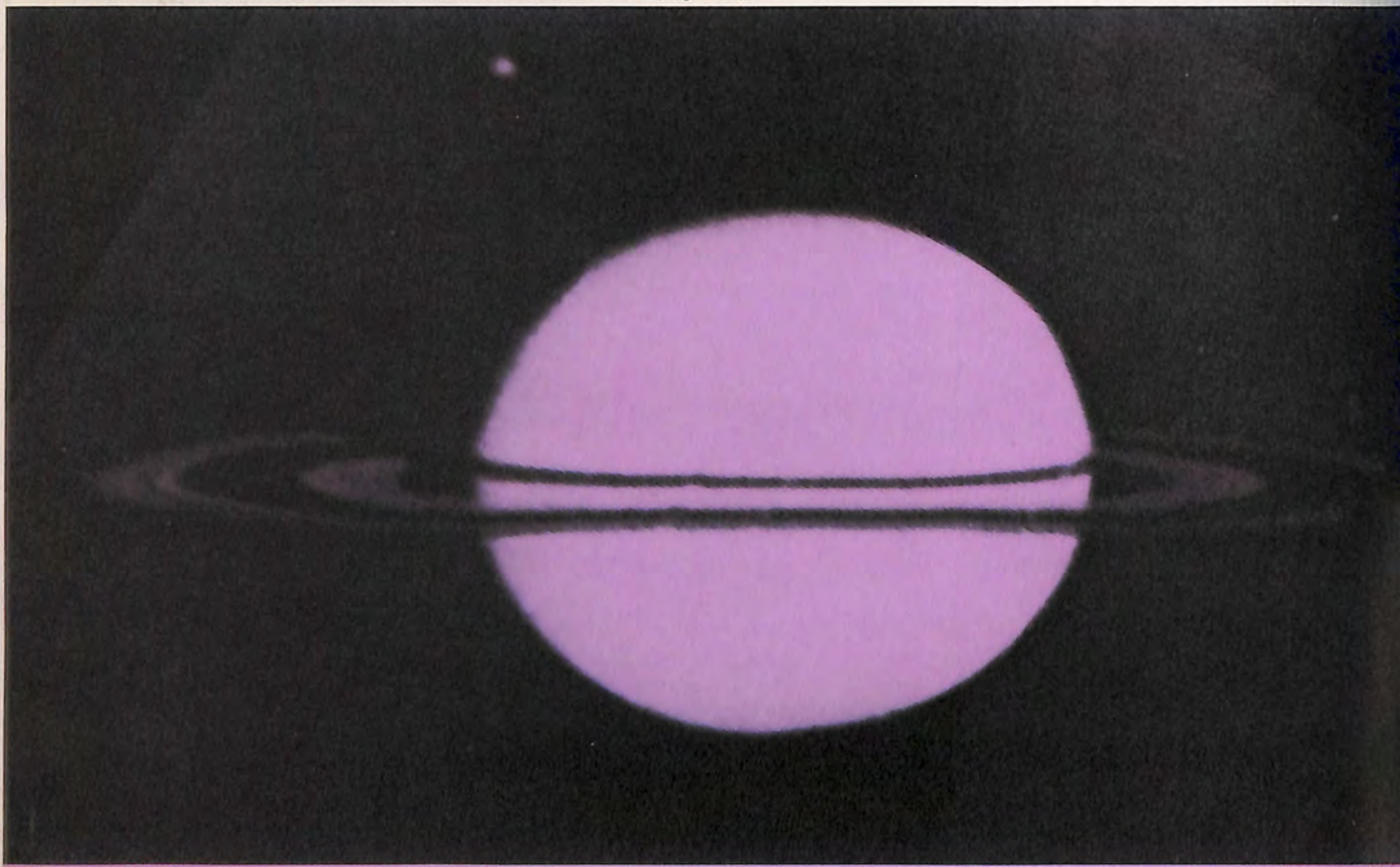
1725 De Sales St., N.W., Washington, D.C. 20036

Saturn, as viewed by NASA's Pioneer 11. *(See 1979: Planet Year, page 10.)*



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 Inc.
E-Systems, Inc.
The Garrett Corporation
Gates Learjet Corporation
General Dynamics Corporation
General Electric Company
General Motors Corporation
  Detroit Diesel Allison Division
The BFGoodrich Company
  Engineered Systems Division
Goodyear Aerospace Corporation
Gould Inc.
Grumman Corporation
Heath Tecna Corporation
Hercules Incorporated
Honeywell Inc.
Howmet Turbine Components Corp.
Hughes Aircraft Company
IBM Corporation
  Federal Systems Division
ITT Telecommunications & Electronics Group-
  North America
  ITT Aerospace/Optical Division
  ITT Avionics Division
  ITT Defense Communications Division
Lear Siegler, Inc.
Lockheed Corporation
Martin Marietta Aerospace
McDonnell Douglas Corp.
Menasco Inc.
Northrop Corporation
Parker Hannifin 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 Advanced Technology Group
Teledyne CAE
Textron Inc.
  Bell Aerospace Textron
  Bell Helicopter Textron
  Dalmo Victor Operations
  Hydraulic Research
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TRW Inc.
United Technologies Corporation
Vought Corporation
Western Gear Corporation
Westinghouse Electric Corp.
  Public Systems Company

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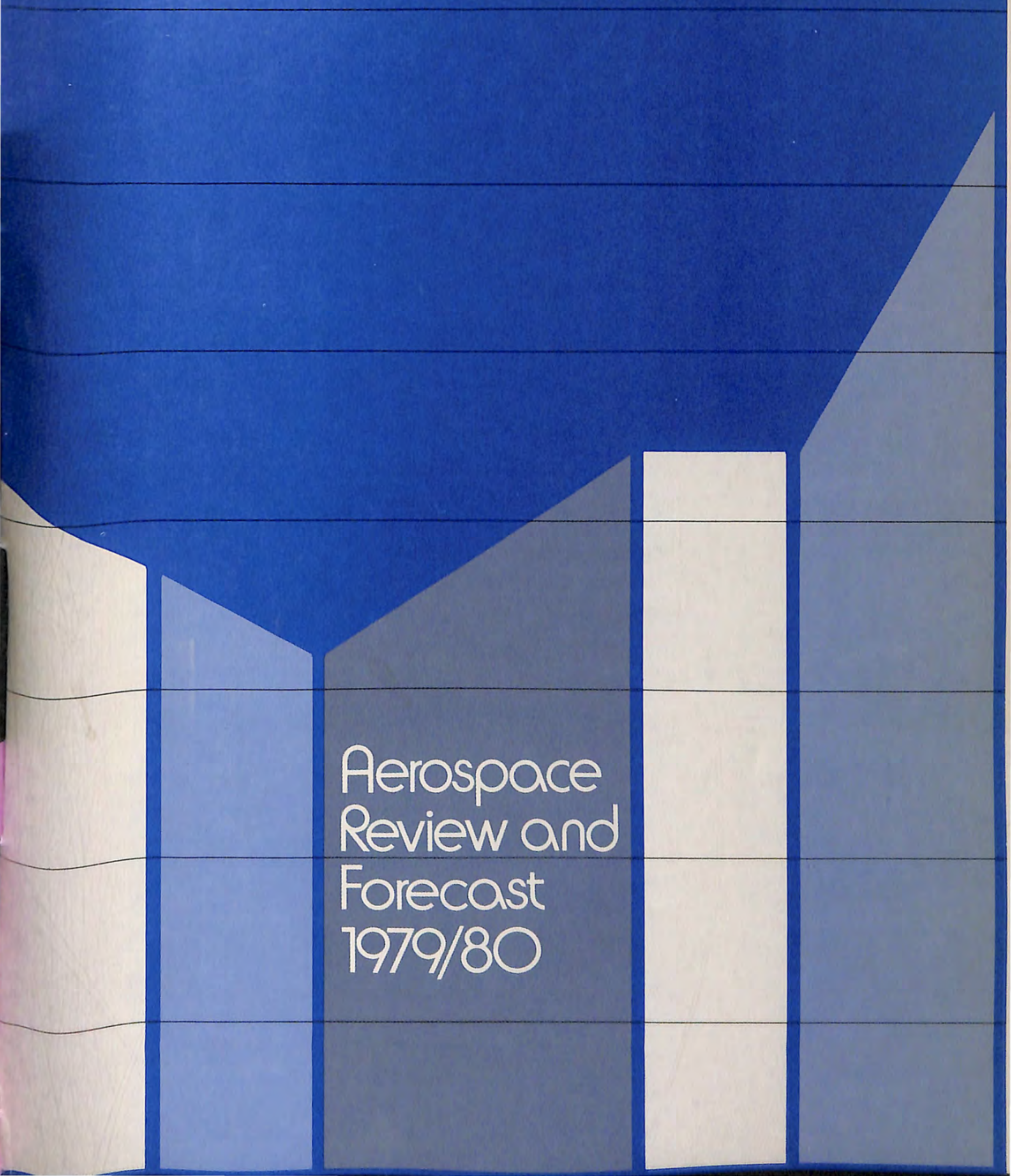

Aerospace Review and Forecast 1979/80

Notable views of notable people on aerospace matters...

aerospace perspectives

Arthur F. Burns, *former chairman of the Federal Reserve Board, before the annual meeting of the International Monetary Fund and The World Bank in Belgrade, Yugoslavia:*

"The precise therapy that can serve a nation best is not easy to identify, and what may work well in one country may work poorly in another. In the case of the American inflation, which has become a major threat to the well-being of much of the world as well as of the American people, it would seem wise to me at this juncture of history for the government to adopt a basic program consisting of four parts.

"The first of these would be a legislative revision of the federal budgetary process that would make it more difficult to run budget deficits and that would serve as the initial step toward a constitutional amendment directed to the same end. The second part would be a commitment to a comprehensive plan for dismantling regulations that have been impeding the competitive process and for modifying others that have been running up costs and prices unnecessarily. The third part would be a binding endorsement of restrictive monetary policies until the rate of inflation has become substantially lower.

"And the fourth part would consist of legislation scheduling reductions of business taxes in each of the next five years—the reduction to be quite small in the first two years but to become substantial in later years. This sort of tax legislation would release powerful forces to improve the nation's productivity and thereby exert downward pressure on prices; and it would also help in the more immediate future to ease the difficult adjustments forced on many businesses and their employees by adoption of the first three parts of the suggested program."

Clare Boothe Luce, *at the U.S. Military Academy, West Point, New York, where she was presented the Sylvanus Thayer Award:*

"We seem to have entered that period which history tells us always marks the hour of greatest danger to a democracy. This is when its citizens persist in raiding their own treasury, and, when faced with a strong and avowed enemy . . . they substitute the ideal of peace for the idea of national security. It is then that a democracy is doomed to depression and defeat unless it is rescued from the follies of its unthinking majority by those thinking minorities which Thomas Jefferson called 'The natural aristocracies of brains and talent' . . .

"It is certainly arguable that the conquest of the U.S. by force of arms is not likely in this century. For even if our military position grows considerably weaker, we would still retain a fearsome nuclear second-punch capacity. What now seems more likely to happen is the collapse of our industrial system, which is today not only inflation ridden but is over 50 percent dependent on Middle East oil. The truly shameful and humiliating fact is that six years after the Arab oil embargo, our government still has no realistic policy—political or military—for securing our access to Arab oil in the amounts, no less at the prices, necessary to maintain the productivity of our economy."

T. A. Wilson, *chairman of the board and chief executive officer, The Boeing Company, in an address at the Wright Memorial Dinner in Washington, D.C., following his acceptance of the Wright Memorial Trophy:*

"Our present energy situation is largely due to our past mistakes. After the 1973 oil embargo we had price controls on domestic oil, even though the price of foreign crude was rising rapidly. This had a chilling effect on domestic oil production but helped keep consumption at a high level. As a result, we've become used to a steady supply of underpriced fuel. Had the free market system been allowed to work during the past six years, U.S. consumption might have declined on a steady and predictable basis as worldwide petroleum prices went up. . .

"In the final analysis, economics will determine how we solve our energy problems. There will be a supply of *expensive* petroleum out there for the balance of this century, but we should be developing alternate energy sources while we can do so on a well-planned, cost-effective basis. There are no easy solutions to energy problems. Increased costs and periodic shortages in the near term will require some painful adjustments in our life styles, but, in the long term, I am optimistic. We have the technological resources to create a new energy base if we just put our know-how to work."

Thomas A. Murphy, *chairman, General Motors Corporation, at the Greater Detroit/Michigan State University Management Conference, Troy, Michigan:*

"Make no mistake—America needs nuclear energy. We need those plants still to be built and we need those plants already providing 12 percent of our electricity nationally and as much as 50 percent in some sections of the Midwest and Northeast. We have the knowledge, the necessary technology, and the experience to operate them safely. . .

"There are risks involved in nuclear generation; no one denies that. But they are controllable risks . . . When electricity was first offered for home use several generations ago, there were similar fears of risk. In fact, after World War II, some farmers in outlying areas looked with suspicion on all those high-voltage wires being strung across their land by REA co-ops. They feared that so much energy compressed in such a tiny space would surely burst and explode someday—and we'd all be consumed in a fiery holocaust.

"This is not too far removed from the perception that the American public is being sold be many of our 'No-Nukes' militants. In my opinion, the oversimplified slogans they parade through the streets are a cynical affront to the intelligence of a democratic and self-determining people. I will go even further. I find a disturbing parallel between such tactics and those acts of political terrorists. To reduce one of our nation's—and the world's—most complex and urgent problems to misleading slogans, and to use fear of the unknown as a callous substitute for reason, is a form of ideological terrorism. And I abhor it just as much as I do physical terrorism."

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A Book Review

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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The 'Uncertainty' Factor

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

The U.S. aerospace industry begins the new decade with a substantial backlog of orders, improved financial health and prospects for increased activity in the 1980s. The bright outlook, however, is based on current statistics and predictable trends. Our optimism must be tempered by the realization that the industry's future—and that of all American industries—is inextricably linked to unpredictable political, social and economic developments in a rapidly changing world. Such developments may present new opportunities, but they seem more likely to engender new difficulties. Thus, we must qualify our projections by applying an "uncertainty" factor.

Assurance of adequate energy supplies ranks high on any list of uncertainties. There is no need to elaborate on the implications to industry of further energy supply disruptions. This area is one which suggests opportunity as well as problems, since the high technology expertise of the aerospace industry can be—in fact, is already being—applied to advantage in the national quest for alternative energy sources.

A related matter is the supply of other materials critical to aerospace manufacturing operations. Since we are dependent on foreign sources for some such materials, there looms the possibility that we might have to face a situation analogous to the oil problem, wherein uncontrollable political developments outside the U.S. could jeopardize our supply.

Another matter of concern is growing foreign competition. The world aerospace market is larger than ever, but there is question as to what share of it American manufacturers will be able to realize. The European aerospace industry, bolstered by the backing of its various governments, is providing strong competition and we look for accelerated effort from that quarter. The Japanese aerospace capability has so far been of modest order, but the appeal of the very large market may prompt upgraded capability, heightening an already intense degree of world competition.

We anticipate escalation of the trend wherein Third World countries are seeking greater control over "global" resources. These nations have been effectively promoting the premise that the world's extraterritorial resources belong to the world at large. They suggest that, in exchange for access to these resources, industrialized nations should share resultant benefits and transfer to international control the technology involved in utilizing the resources. Whether this concept will be incorporated in international law remains to be seen, but the possibility is disturbing. It has broad implications for the industries of the developed nations.

Finally, there is America's defense posture and its ability to respond to challenge in an increasingly restive world, a matter of paramount importance not only to our own security and economy, but to the continuation of civilized world order. Events in Iran and Afghanistan have understandably intensified fear and uncertainty. On the other hand, the reaction of the American people to such events has been heartening. There is growing support for increased U.S. defense effort and there are clear indications of a strengthened national will to resist outrage and aggression. Thus, there is reason to hope for a real resurgence of national unity, an optimistic note on which to begin a new decade.

Aerospace Review and Forecast 1979/80

The aerospace industry closed out the decade of the seventies on a high note. Although statistical data will undergo refinement in coming months, preliminary estimates for 1979 show new peaks in sales, backlog, earnings, exports and contribution to the U.S. balance of trade.

Here are the highlights:

• Total industry sales amounted to $45,5 billion, an increase of some $8 billion over the preceding year. The sales figure represents an all-time statistical high, but it is distorted by the effects of the nation's exceptionally high inflation rate during the year. Nonetheless, 1979 sales volume amounts to an increase of more than 20 percent over 1978, so the gain outstripped the inflation rate by a generous margin.

In the interests of perspective, it is the industry's practice to compare each year's sales volume with that of the peak year—1968—by converting to constant dollars. On that basis, 1979 sales constitute roughly three-quarters of the 1968 volume; in constant dollar terms, 1979's $22.7 billion compares with $29 billion in 1968, so the industry is still well below the peak. However, 1979 constant dollar sales are higher than those of any other year in the decade of the seventies.

• Backlog at the end of 1979 was $68.4 billion, up about $11.5 billion over the 1978 figure.

• Aerospace exports reached a new record level of $11.6 billion, up about 15 percent over 1978, which was itself a record year. The export volume is remarkable because it was achieved despite a sharp drop—almost $2 billion—in shipments abroad of military equipment. This decline was more than compensated by a big increase—about $3.5 billion—in civil exports.

• At a time when export sales are more important than ever to the U.S. economy, the aerospace industry recorded its highest-ever international trade surplus—more than $10 billion, about $1 billion above 1978, the previous record year.

• Profit after taxes, measured as a percentage of sales, increased from 4.4 percent in 1978 to 5.1 percent in 1979. The aerospace profit rate edged closer to, but remained well below, the average for all U.S. manufacturing corporations, which was 5.8 percent.

• Employment—1,120,000 at year's end—reached its highest level of the decade.

• A matter of particular interest is the fact that, once again, the largest increment of sales gain was in the commercial area, particularly airline transport aircraft. This underlines a significant trend, in evidence throughout the seventies, with regard to the changing aerospace industry's business mix. In the first year of the seventies, defense business accounted for about two-thirds of all sales of aerospace products and services; at that time, commercial sales represented only 18 percent. Although the level of military sales increased during the seventies, commercial activity increased at a much more rapid rate, with the result that commercial aerospace sales almost matched defense aerospace volume in 1979. The trend is expected to continue.

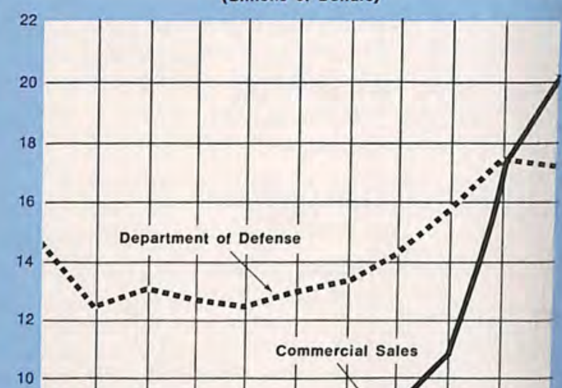
In summary, the industry experienced in 1979 a continuation of the ascending trend in its activity curve, which had been relatively flat for most of the seventies, turned upward in 1976/77, then climbed at a higher angle in 1978 and 1979.

FORECAST

The most significant projection for 1980 is that commercial aerospace sales are expected to outstrip sales to the Department of Defense for the first time in the industry's modern history. Sales of aerospace products and services to the commercial sector are estimated at $20.2 billion in 1980, while DoD sales are expected to drop slightly below the 1979 level to $17.4 billion.

The industry estimates overall 1980 sales at $49.2 billion, which would represent an increase of about eight percent. The total sales figure is compounded of aerospace sales of $41 billion and non-aerospace sales of $8.2 billion. Industry employment is expected to increase only slightly, to 1,131,000.

AEROSPACE INDUSTRY SALES BY CUSTOMER
(Billions of Dollars)



SALES BY CUSTOMER

In 1980, for the first time in modern history, the aerospace industry is expected to sell more of its aerospace products and services to commercial customers than to the Department of Defense. Commercial aerospace sales in 1980 are estimated at $20.2 billion, compared with $17.4 billion in sales to military customers.

Projections for years beyond 1980 are clouded by a number of uncertainties, but the following is a general view of what the industry sees for the decade of the 1980s:

Defense. The aerospace industry begins the new decade with a substantial backlog of military orders, though one not appreciably higher than it was at the end of 1978. President Carter has announced Administration plans to increase defense funding for the fiscal years 1981-85 to levels averaging 4½ to 5 percent above the rate of inflation. This augurs greater industry defense activity, but not as great as one might expect. Much of the increased funding will go into personnel, operations and maintenance accounts, and a major portion will go for non-aerospace procurement—shipbuilding, for example.

On the basis of stated DoD plans for weapons development and production—for instance, the MX strategic missile system and the family of cruise missiles—the industry anticipates increased workload in the missile area along with long-term production of several relatively new aircraft. On the other hand, production of some major aircraft types is winding down. Generally, if Congressional appropriations support Administration plans, the aerospace industry can expect somewhat higher levels of DoD sales, but the activity gain will not be of dramatic order.

Space. NASA's long-range plans for the era of the Space Transportation System contemplate substantially increased space mission frequencies and payload deliveries, which would involve correspondingly increased industry activity in development and fabrication of space systems. However, Administration projections for space funding in coming years suggest that the space plan will undergo downward revision. The advent of the Space Shuttle and NASA's planned emphasis on pursuing space-derived Earth benefit will offer many opportunities for demonstrating the very real practical benefits, both civil and military, that exploitation of the space medium affords. This could revive public interest in space and bring about higher levels of funding support. Thus, there is a possibility that the industry's space activity will grow in the latter years of the decade, but for the near term space workload should remain at something approximating the current level.

Commercial Sales. The commercial area—particularly production of commercial transport aircraft—offers the greatest potential for expansion of the industry's workload. Projections indicate that world airline traffic will almost double by 1989, creating a very large requirement for new airline aircraft. Additionally, some 3,000 of the 5,000 jet transports in commercial service today are more than nine years old, about 1,500 of them more than 12 years old. The need for greater fuel efficiency and lower maintenance costs dictates replacement of these aging aircraft; also, many of them will be forced into retirement by government regulations. A consensus estimate of the combined new lift/replacement world market for the 1980s is about $100 billion. In addition, civil helicopter production is experiencing extremely rapid growth and is expected to become a more significant portion of the industry's commercial business; the world market for the coming decade is estimated at $10 billion.

Expectations for expanded commercial activity could be sharply altered by heightened U.S. economic troubles and by further adverse developments in the energy situation. For example, will there be adequate fuel to serve the projected traffic growth? If so, will its cost be so high as to send airline fares beyond affordable limits and thus dramatically reduce passenger demand? There are several other factors which have strong bearing on the airlines' ability to finance needed new airplanes. So the aerospace industry's future level of commercial activity is largely dependent upon whether the airlines will achieve the financial health essential to their re-equipment plans; if they can, the commercial potential for the aerospace industry is greater than at any time in its history.

AEROSPACE INDUSTRY SALES
(Billions of Dollars)

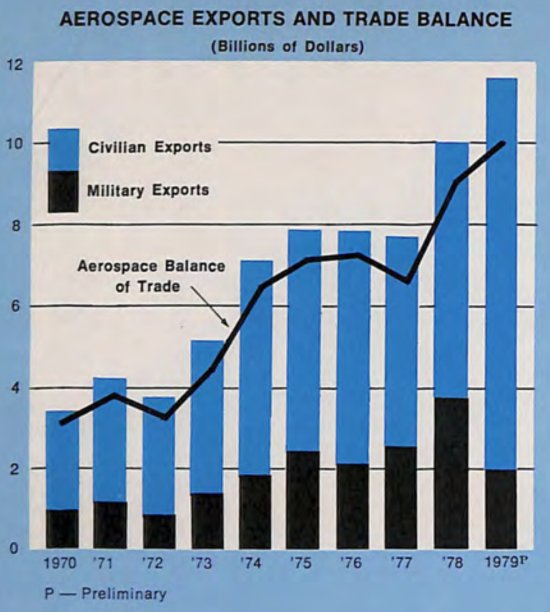
Source: Aerospace Industries Association
P — Preliminary
E — Estimate

BACKLOG OF MAJOR AEROSPACE COMPANIES
(Billions of Dollars)

E — Estimate

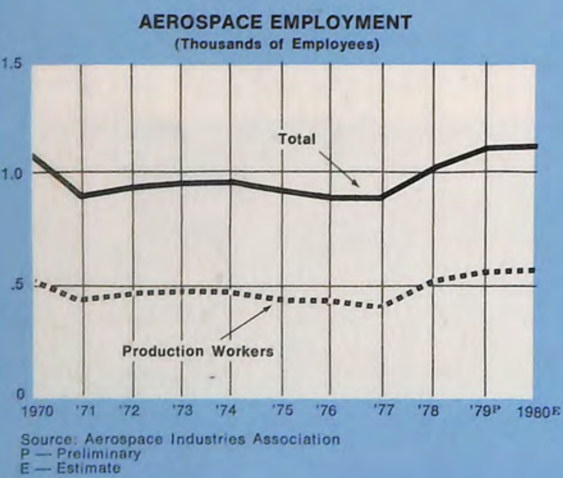
TOTAL SALES AND BACKLOG

The aerospace industry's total sales in 1979 amounted to $45.5 billion, up some $8 billion over 1978. The 1979 figure is compounded of $38.2 billion in aerospace products and services and $7.3 billion in non-aerospace sales. The total amounts to a statistical record, but in inflation-adjusted terms it is more than $6 billion below the industry's *real* peak year 1968. The industry's backlog at yearend 1979 was $68.4 billion and Aerospace Industries Association predicts total sales of $49.2 billion for 1980. Defense aerospace sales are expected to decline slightly but another large increase in commercial sales is forecast.



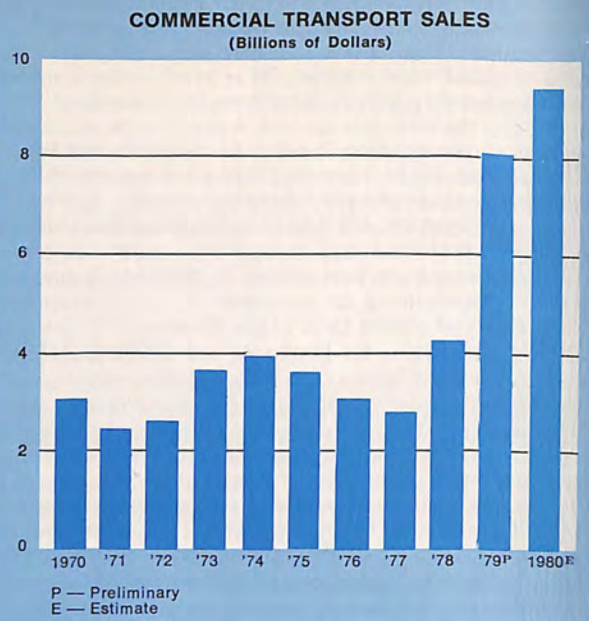
EXPORTS AND TRADE BALANCE

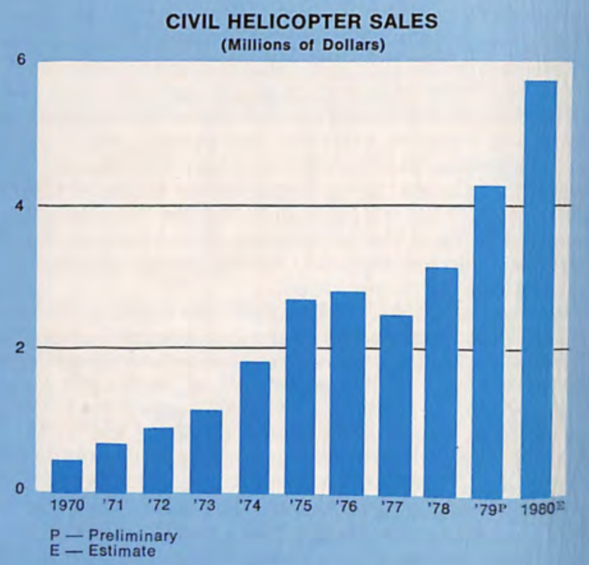
The aerospace industry's performance in export sales reached an all-time high in 1979, as did the industry's contribution to the U.S. balance of trade. Exports totaled $11.6 billion, an increase of more than $1.5 billion over 1978, the previous record year. Aerospace imports increased some $500 million to $1.5 billion. Thus, the aerospace balance of trade was $10.1 billion, once again the major positive factor in U.S. foreign trade.



EMPLOYMENT

Total aerospace industry employment at year-end 1979 was 1,120,000, the highest level since 1970. The industry's payroll, at $24.9 billion, was the largest in history.





COMMERCIAL SALES

Sales of commercial transport aircraft in 1979 reached a record $8.2 billion, up $3.9 billion over 1978. Aerospace Industries Association forecasts a further increase to $9.5 billion in 1980. Estimate of the world market for new transports in the decade of the 1980s is more than $100 billion.

The steady growth of civil helicopter deliveries continued in 1979, with sales of $436 million, an increase of $110 million or about 33 percent. Sales forecast for 1980 is $580 million and the civil helicopter market for the 1980s is estimated at $10 million.