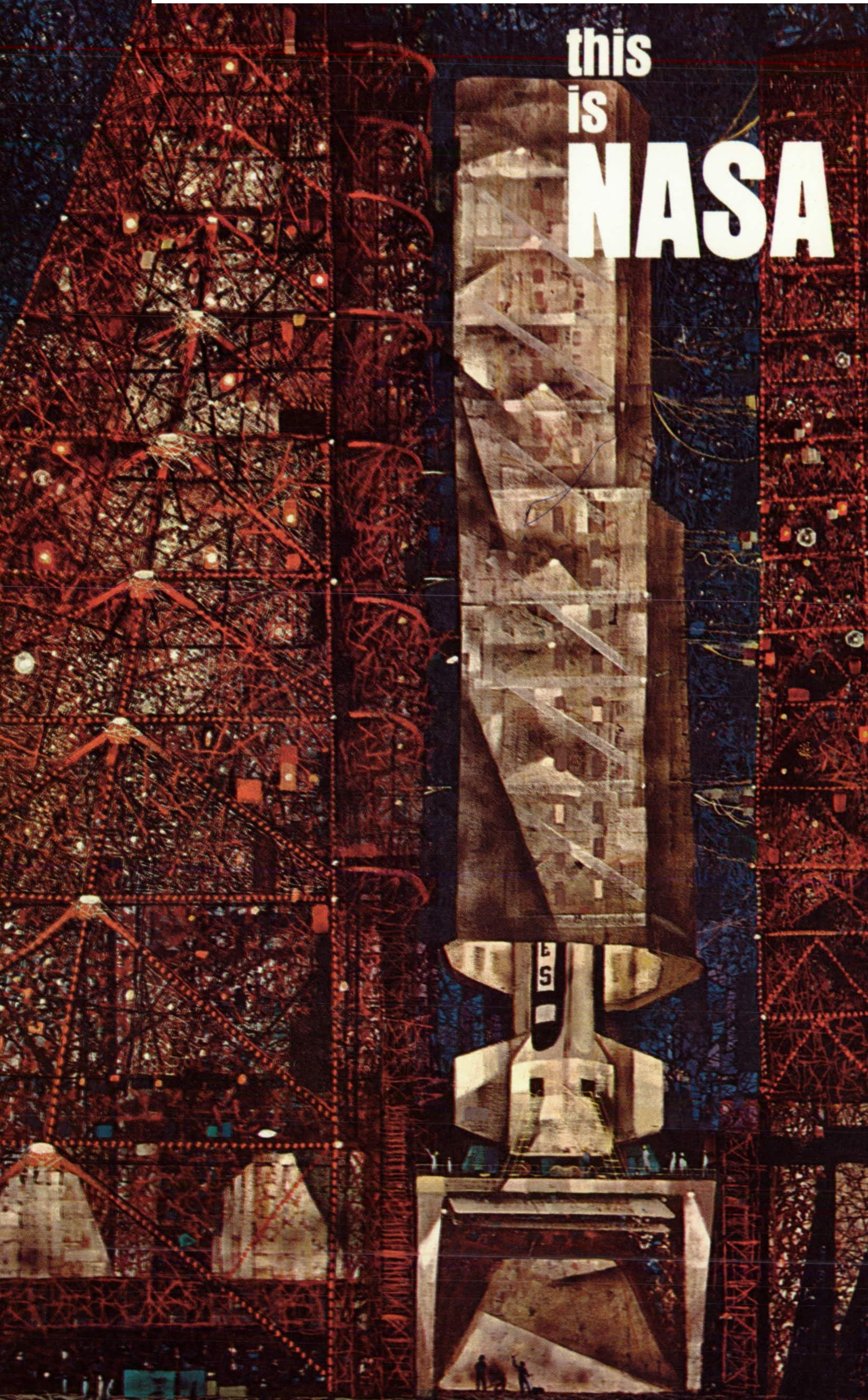
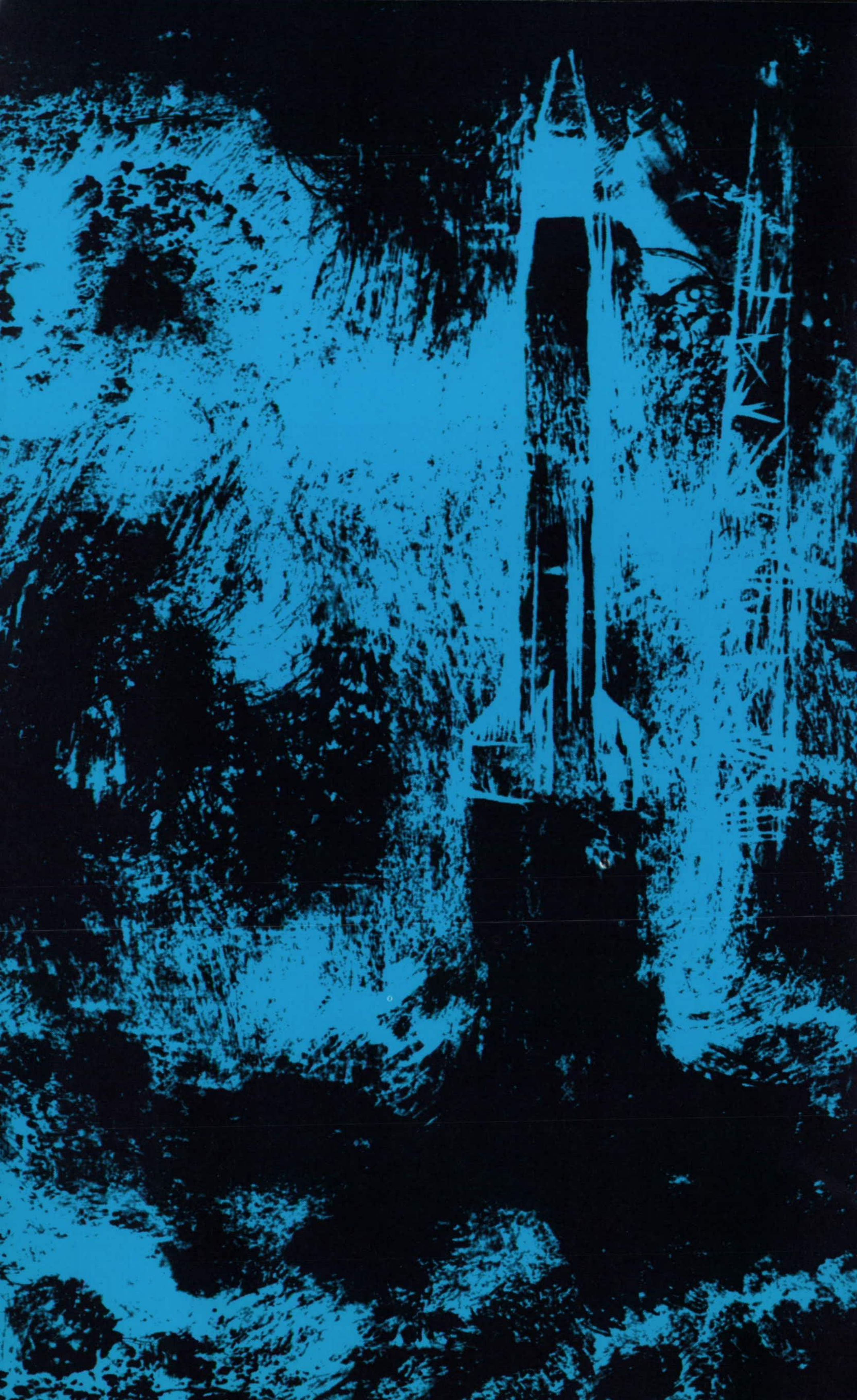
this is NASA





With the advent of the space age, the Congress adopted the National Aeronautics and Space Act of 1958 creating NASA. The Agency was directed to "provide for research into the problems of flight within and outside the Earth's atmosphere." The Congress further stipulated that "activities in space should be devoted to peaceful purposes for the benefit of all mankind."

The new Agency was built around a nucleus of existing facilities and experienced people. The personnel and the laboratories of the National Advisory Committee for Aeronautics (NACA) which had made vital contributions to aeronautical development were brought under NASA's roof. With NACA came its field installations: the Langley Research Center at Hampton, Virginia; Ames Research Center, Moffett Field, California; Lewis Research Center, Cleveland, Ohio; Flight Research Center, Edwards, California; and Wallops Station at Wallops Island, Virginia. The Naval Research Laboratory's Project Vanguard was shifted to NASA as was the Army's Jet Propulsion Laboratory contract operation, managed by the California Institute of Technology, and the Development Operations Divsion of the Army Ballistic Missile Agency at Huntsville, Alabama. The latter developed into the George C. Marshall Space Flight Center.

As the space effort broadened, new facilities were added. The Goddard Space Flight Center was built at Greenbelt, Maryland. A launch operations complex was constructed at Cape Canaveral, Florida, and was subsequently named the John F. Kennedy Space Center. A Manned Spacecraft Center was established at Houston, Texas, as was a component installation, the White Sands Test Facility at Las Cruces, New Mexico. Additionally, under the cognizance of Marshall Space Flight Center, the Michoud (La.) Assembly Facility and the Mississippi Test Facility at Bay St. Louis were put into operation. A Joint Atomic Energy Commission—NASA Space Nuclear Propulsion Office was established at Germantown, Maryland. The most recent addition is the Electronics Research Center being developed at Cambridge, Massachusetts.

Such is the physical plant—the wind tunnels, the laboratories, the assembly plants, the test stands and the launch complexes. With the addition of the communications net and a global tracking system, they constitute the instruments of the national effort in aeronautics and space. They are put to use by a staff of more than 33,000 people attached to NASA—more than a third of these scientists and engineers—and also by the specialists and craftsmen of the industries with which NASA contracts for design and feasibility studies, and for the fabrication and testing of flight hardware. Included as well are the many universities across the nation with which NASA has established a working relationship so as to bring the talents of their faculties to bear on space exploration.

Together NASA, industry and the universities comprise a team that has pushed the upper limit of atmospheric flight to 4250 miles per hour, and, at the other end of the speed spectrum, has developed fixed-wing prototypes that can rise vertically from the ground and hover at zero forward speed. This combine has increased payloads in low-Earth orbit from the 30 pound Vanguard to the 240,000 pounds put into space by the giant Saturn V. In its work, it has greatly improved existing structural materials as well as developing new ones. It has contributed substantially to major advances in new technologies, in work with extremes of cold and heat, microminiaturization, guidance and sensors. It has enhanced the state of the art of unconventional sources of energy, of telemetry, and of high energy fuels. It has set high levels of reliability and quality control, and has refined techniques for the management of big systems. In these processes, it has multiplied knowledge about the Sun, the planets, and the forces at work in the solar system. It has also contributed to new understandings of the terrestrial environment and of Earth itself. In sum, this organization has been a major factor in the scientific and technological revolution that is now in progress.

This is NASA.

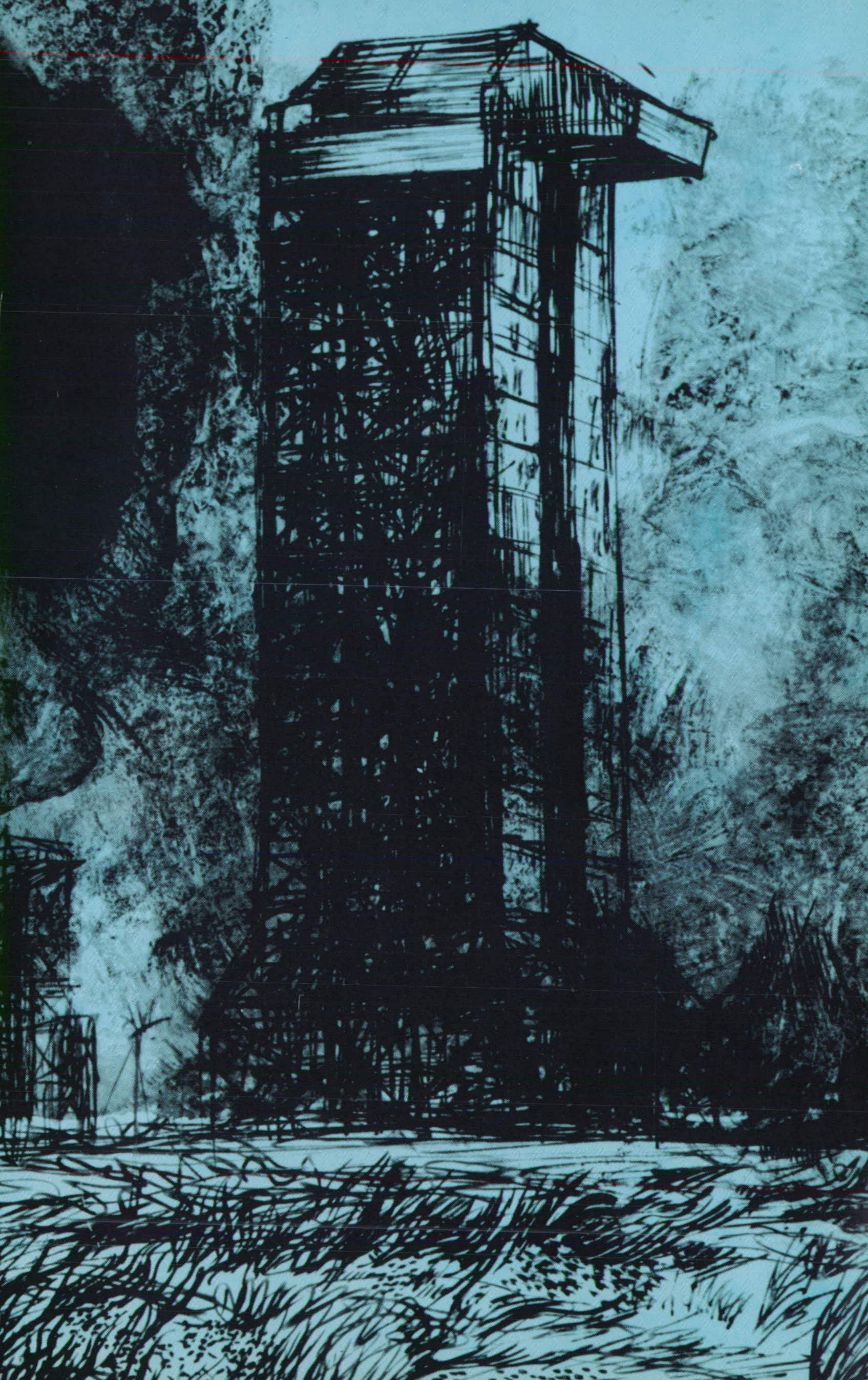
flight in the atmosphere

"Wilbur, having used his turn in the unsuccessful attempt on the 14th, the right to the first trial now belonged to me. Wilbur ran at the side, holding the wings to balance it on the track. The machine, facing a 27-mile wind, started very slowly. Wilbur was able to stay with it until it lifted from the track after a forty-foot run."

Orville Wright, December 17, 1903
Kitty Hawk, North Carolina

Even as NACA supplied the first and core organization of the Space Agency, the first "A" in NASA stands for aeronautics. The most dramatic aspect of the Agency's research in aeronautics has been in the regime of hypersonic flight. The experimental tool has been the stubby-winged X–15 aircraft, described by a prominent aeronautical scientist as perhaps the finest research tool ever built by man. Carried by a B–52 to 45,000 feet and released, the X–15 has achieved speeds in excess of six times the speed of sound and reached an altitude of over 300,000 feet. Typically, free flights of the X–15 last roughly eleven minutes, less than two minutes of which is powered flight. The instruments it carries provide data on structural heating—which can reach 2,000°F at certain points on the airframe, a temperature that exceeds the tolerance of the conventional alloys usually found in airframe construction. The instruments also provide important information on stress, stability and other flight characteristics. The X–15 flights have built a base of knowledge essential to the designing of tomorrow's high-performance aircraft, and the spacecraft of the future as well.

NASA is also assisting in the development of the Supersonic Transport (SST) and is pioneering with the "Lifting Body" design—a craft without wings that gets lift from its body shape. When this design is perfected, the Lifting Body can be placed in orbit and, at the end of its flight, reenter the atmosphere and be flown to an airstrip and landed. Thus it may be possible to eliminate the cumbersome



and costly technique of recovery at sea, and the craft will be available for reuse.

The Agency's inquiries explore the less exotic flight regimes—the Vertical Take-off and Landing (V/TOL), and the Vertical or Short Take-off and Landing (V/STOL) designs. As these reach operational status, they may provide a valuable supplement to the domestic air transport system. Short-haul inter-city transport will be easier and quicker, and rural areas will have high speed economical links with urban centers.

NASA specialists in aeronautics are investigating ways of dealing with sonic boom, and of reducing aircraft noise in the vicinity of airports. They are, further, making important contributions to flight safety in subsonic operations.

exploring space

NASA's space work is divided into four major program sectors: manned space flight, space science and applications, advanced research and technology, and tracking and data acquisition. These subdivisions describe areas of concentration but are, by no means, mutually exclusive. The supporting relationships are numerous and cross-feeding is continuous. Without the tracking network, manned flights would not be feasible. The findings of the unmanned scientific missions permit manned flight to proceed with greater assurance.

manned flight

On May 5, 1961, Astronaut Alan B. Shepard made a brief suborbital flight in a Mercury capsule followed by the late Virgil I. "Gus" Grissom on July 21, 1962. Early in 1962 John Glenn made his three-orbit flight. With the completion of Project Mercury, Scott Carpenter, Walter M. Schirra and L. Gordon Cooper joined the illustrious company of Americans who had penetrated the realm of space.

While Project Mercury, and the Gemini Program that followed, carried a number of scientific experiments, their purpose was primarily engineering and biological—a learning exercise with a multiple purpose. In addition to validating the spacecraft, the heat shield, and the onboard systems, it was essential to determine in detail the effect of the hostile spatial environment on the human metabolism and to discover the limitations space imposes on human capacities. It was also necessary to gain experience in performing the maneuvers that were required in the execution of advanced missions.

Thus, with the knowledge accumulated from the Mercury flights, NASA proceeded with the more ambitious and sophisticated Gemini program. Gemini III, the first manned mission of the program saw Gus Grissom and John Young experiment with the orbital maneuvering system and adjust the reentry flight path by means of the variable spacecraft lift. Gemini IV went 62 revolutions in a little more than four days. During this flight, Ed White walked in space while James McDivitt piloted the capsule. This Extra Vehicular Activity (EVA) was the first performed by an American. In the following flight, Cooper and Charles Conrad set an endurance record of 190 hours in orbit which demonstrated the feasibility of a round trip lunar mission. The next two Gemini flights performed rendezvous and flew formation for five hours. One of them, Gemini VII, carrying Frank Borman and James A. Lovell, remained in orbit for fourteen days. Subsequent Gemini missions performed rendezvous and docking maneuvers—essential elements in the lunar mission. Extended EVA was carried out and valuable information accumulated on an astronaut's ability to work in space outside the spacecraft.

The Gemini series also validated the fuel cell as an onboard power source.

As planned, the Gemini series set the stage for the next giant step in manned flight—Saturn/Apollo.

to the moon and back

In 1961, President John F. Kennedy set a goal for the manned flight program—the landing of men on the lunar surface and their safe return to Earth. Although of itself scientifically and technologically significant, the lunar mission had broader implications. It provided an easily identifiable target as a focus for the energies of hundreds of thousands of scientists, engineers, technicians, craftsmen and administrators in both government and private industry who were engaged in the program. Its achievement would demonstrate a U.S. capability to travel anywhere in space out to a radius of 250,000 miles in large and sophisticated spacecraft on flights of two weeks or longer.

The complexity of the lunar mission far exceeds any space mission ever attempted. The first and then the second stage of the Saturn drive the rocket to suborbital altitude and speed, and are separated when their fuel is exhausted. A two-minute burn of the third stage places the Apollo complex in a parking orbit for a final engineering checkout. Later, the third stage will re-ignite for another six-minute burn until escape velocity (24,900 MPH) has been achieved and the spacecraft has entered the lunar corridor. After mid-course trajectory corrections are made, the Apollo will continue its coast until it is time to slow the spacecraft enough to enter a lunar orbit. Two crewmen will then crawl into the Lunar Module (LM), separate from the mother ship and using the retro- and vernier rockets of the Lunar Module make a controlled descent to the surface of the Moon.

After completing their tasks on the lunar surface, the two astronauts will reenter the Lunar Module. At the right instant, relative to the orbital position of the mother ship, they will ignite the ascent engine of the Lunar Module, using the lower half of the vehicle as a launch platform. Then they will launch, rendezvous and dock with the Command and Service Module. They will then crawl back into the Command Module to rejoin the Command Module pilot and jettison the Lunar

Module, which will be left circling the Moon.

The Service Module's engine will be fired to boost the three astronauts out of lunar orbit and into the return corridor to Earth. Before re-entering the Earth's atmosphere, the Service Module will be separated and the Command Module, with its crew of three astronauts, will proced on the last leg of their historic journey.

sun, planets and stars

The ability to fly in space has offered the scientist unique experimental advantages. An instrumented capsule free of the opacity of the Earth's atmosphere and the Earth's electromagnetic shield can take readings of the solar system, the galaxy and the universe which are foreclosed to Earth-bound laboratories. From the beginning, since Explorer I, the experimenters have employed a rich variety of unmanned spacecraft to broaden their comprehension of phenomena about which little was known; and to open up whole new areas of knowledge. New understandings of the solar system, the stars and interplanetary and interstellar space are being reached.

Explorer I set a high standard when it discovered the Van Allen radiation belts—bands of intense radiation that encircle the Earth. Orbiting Solar Observatories (OSO) have trained their instruments on the Sun—the source of Earth's light and heat, without which there would be no life as we know it. OSOs have mapped the Sun's emissions of X-rays and ultraviolet light. They have plotted the direction and speed of the solar wind, studied the white light corona effect, reported on solar flares and many other aspects of solar activity through much of the eleven-year solar cycle.

The Orbiting Geophysical Observatories (OGO) and related spacecraft direct their attention to Earth itself and its environment. The OGOs measure the geophysical characteristics of the planet on which we live—its shape, consistency, density and gravitational fields. The magnetosphere and the ionosphere also come in for their attention as does the composition of the extreme upper atmosphere.

A series of Orbiting Astronomical Observatories (OAO) will make photometric and spectroscopic evaluations of individual stars, groups and clusters.

The Pioneers, the IMPs (for Interplanetary Monitoring Platform) the Ariels, the San Marcos, the Alouettes, the follow-on Explorers, and a multiplicity of probes (that investigate that band of the atmosphere too high for balloons and too low for satellites) are returning a flood of data on this planet's environment and the forces at work therein.

to explore the moon and the planets

Before plans for the manned lunar mission could be made final, extensive lunar reconnaissance was needed. A number of landing sites smooth enough for the Lunar Module touchdown had to be identified and the bearing strength of the Moon's surface established. In addition, there was keen interest in such lunar properties as its soil composition and the nature of lunar rocks that would provide evidence about the origin and history of this Earth satellite.

The Rangers were the first of a three-stage program. In the brief moments before its planned crash landing, a Ranger spacecraft snapped hundreds of useful pictures of the Moon's surface, the last taken but a fraction of a second before impact. A series of Lunar Orbiters circled the Moon at an altitude of between 25 and 30 miles. The Orbiters took thousands of excellent photos—both verticals and obliques—with the medium and high resolution cameras that they carried, and gathered data, with their sensors, on the lunar environment. The Surveyors landed softly on the Moon's surface—of itself an unprecedented technical feat— and took close-ups of surrounding features, dug into the lunar surface, and subjected the Moon's soil to chemical analysis.

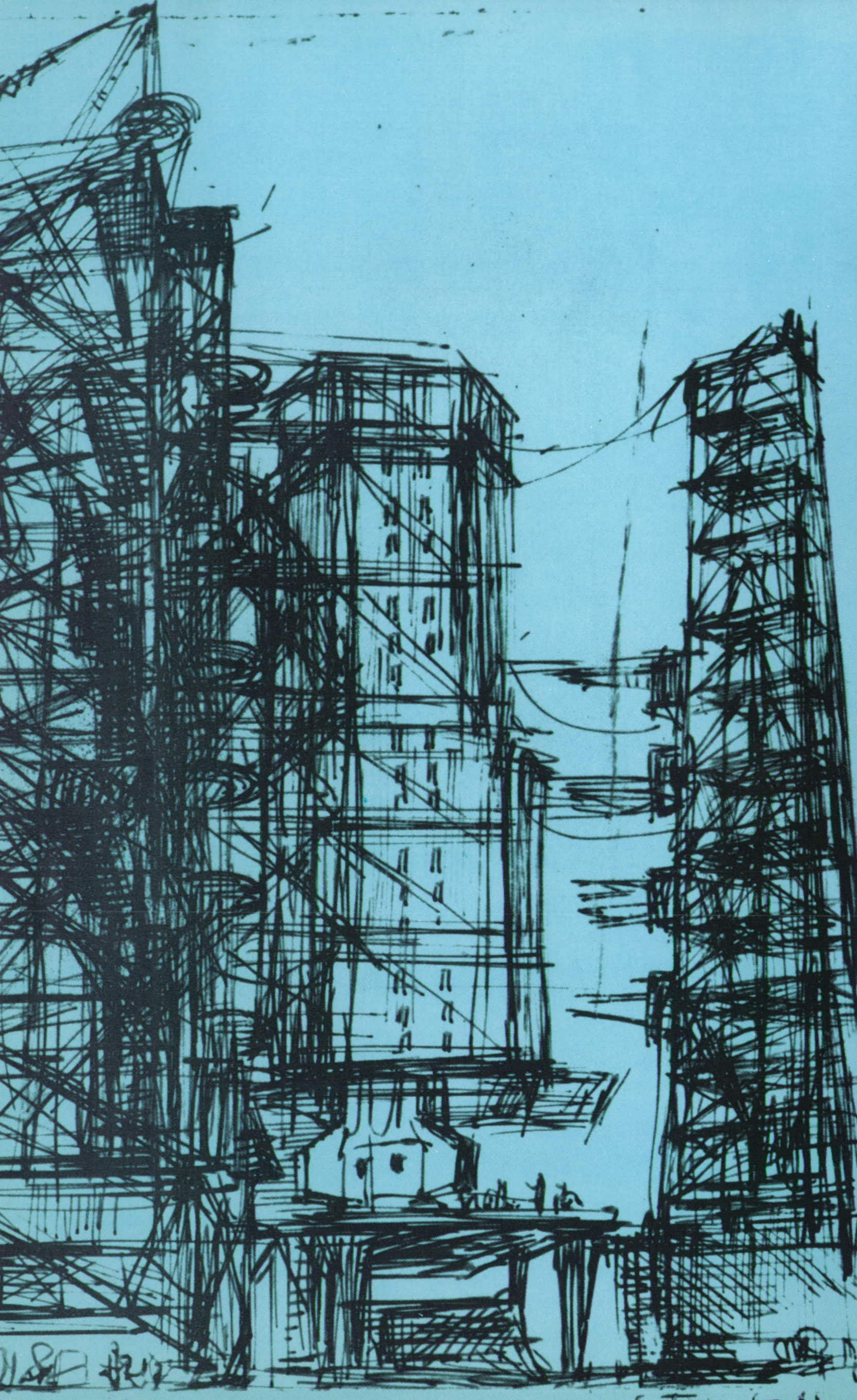
Until the Rangers flew, no one had ever seen a lunar rock. Until Surveyor, no one had ever dug one. Orbiter, while photo-mapping the Moon's surface, provided photographic studies of the side that is always hidden from Earth. Surprisingly, the relatively smooth maria that dominate the Moon's visible face are rare on the ruggedly structured dark side.

These flights located eight potential landing sites. They established that the bearing strength of the surface would support the LM and the astronauts. Lunar soil was revealed to be granular, with a thin fracturable crust overlaying darker soil beneath. A small sample, manipulated by Surveyor's surface sampler, crumbled like a clod of dirt while another appeared as hard as a terrestrial rock. The surface appeared to correspond to terrestrial basalt. No evidence of a magnetic field or radiation belt was found.

Ranger, Orbiter and Surveyor not only established that the lunar surface was suitable for manned landings and pin-pointed where; but added greatly to the scientific knowledge of Earth's only natural satellite.

In addition to the Moon, the neighboring planets of Venus and Mars were investigated by automated spacecraft. In the fall of 1962, Mariner II flew behind Venus coming to within roughly 20,000 miles of the planet. In September 1967, Mariner executed a Venus flyby coming within 6,000 miles of the planet. The data returned from these flights disclosed that although Venus resembles the Earth in size and mass, there are few other similarities. Venus' atmosphere is preponderantly carbon dioxide, much denser and more opaque than Earth's. The planet's surface is very hot—perhaps 800°F. The Venutian ionosphere on the day side is one-half as dense as Earth's and falls to ten percent or less on the night side. It is much lower in altitude and apparently compressed into a very thin layer. No magnetic field was detected.

In late 1964, Mariner IV made the long journey to Mars. After a flight of more than six months—during which its systems functioned without a significant failure of any component—the spacecraft came within 6,118 miles of the red planet and snapped 22 pictures of the Martian surface. To transmit these over a distance of more than



200 million miles was a slow process, some eight and a half hours a picture. The area photographed was a barren, moon-like surface heavily pocked with craters. The spacecraft reported that Mars had a very tenuous atmosphere with an atmospheric pressure only a small fraction of that of Earth.

In the service of man

The "Applications" class of satellite works directly for the benefit of man. Two types in this category—communications and weather spacecraft—are already operational; providing fast, economical and highly reliable long-distance communications and assisting the weather forecasters with photographs, taken from space, of the weather systems of the globe.

The development of the present satellite communications system was a sequence of experimental craft that validated the technology. Several passive satellites (very large aluminum-coated balloons named Echo), that simply reflected radio signals, were flown. These were followed with a series of active-repeater spacecraft that carried both receiving and transmitting equipment and were flown at medium altitude—up to 12,000 miles. Score, Telstar and Relay were among them. The last of the experimental group was SYNCOM, a spacecraft placed in synchronous orbit and remaining over a fixed point on the Earth's surface (much as a dent on the rim of a wheel stays opposite to the same point on the hub as it turns). A truly synchronous orbit offers a number of advantages. One advantage is that once the spacecraft position is precisely known, tracking is no longer needed.

With the basic concepts proved out, NASA launched a series of the Early Bird spacecraft (now officially designated Intelsat) for the Communications Satellite Corporation, a quasi-private entity formed to operate the satellite communications net. The 240-channel Intelsats are now at work handling the trans-Atlantic and trans-Pacific telephone, teletype and telegraph, radio and television traffic.

Weather eye in space

The operational weather satellites, which are basically TIROS (*T*elevision and *I*nfra-*R*ed *O*bservation *S*atellite) models, are designated ESSAs (*E*nvironmental *S*urvey *SA*tellite) when taken over by the Environmental Science Service Administration (also called ESSA). The Environmental Science Service Administration assumes responsibility for systems operation after NASA has launched and checked out the spacecraft. ESSAs are advanced, first-generation spacecraft in a cartwheel configuration. Typically they are placed in a near-polar, Sun-synchronous orbit that keeps them always in daylight. They roll along in their orbit with their advanced vidicon cameras, which are rim-mounted, snapping a photo of a 4,000,000 square mile area of weather every six minutes.

Linked with the TIROS system are relatively inexpensive ground based facilities capable of receiving pictures of cloud cover from the Automatic Picture Transmission system carried by some of these satellites. When the TIROS approaches within 2,100 miles of a ground station, it will transmit, on ground command, photos of the weather system within a 1,000 mile radius of the commanding station. Since the satellite weather system was instituted, 305 ground receivers have been placed in operation; 89 of them in foreign countries. Besides providing the weather forecaster with vital information on cloud systems, the TIROS spacecraft have spotted and tracked a number of violent storms enabling the broadcast of timely storm advisories to threatened areas.

NASA is now well along with the development of an improved and more versatile weather satellite. Experimental Nimbus spacecraft have been flown as well as Applications Technology Satellites (ATS). The former carry infra-red sensors that measure cloud temperatures in both daylight and dark, and report on the heat balance of the Earth. The latter are multi-purpose spacecraft; in addition to weather reporting equipment they carry communications and navigation facilities. They are also able to photograph the Earth in color—in the case of ATS III spectacular color pictures of the full disc of the Earth were returned. Positioning an ATS in synchronous orbit permits continuous observation of small, violent storms. It warns us of tornadoes and thunderstorms that can do much damage. Because they have a life of only a few hours, these storms might escape the notice of a non-synchronous satellite. As weather satellite technology advances, we move closer to realizing the capability for accurate, long-range weather forecasts. This capability will mean savings of hundreds of millions of dollars annually to the farmer, the resort industry, transportation and others, on whose operation weather exerts a significant influence.

the lifting force

It is the rocket that lifts the payload and places it in orbit. In its ten years of operation, NASA has developed an assortment of these launch vehicles carefully scaled to execute various classes of missions. They vary in size, volume of thrust, and propellant—solid or liquid. If liquid fueled, they may employ different types. They also differ in the size of the payload they can put into space.

The smallest of the major launch vehicles is the solid-fueled, four-stage Scout. This vehicle can orbit a 240-pound payload and is used for unmanned scientific flights. Next larger is the Delta, a work horse with a long list of successful launches to its credit. Delta can orbit 880 pounds. In its thrust-augmented version (TAD), wherein strap-on rockets increase its thrust from 170,000 to 332,000 pounds, its payload capacity is raised to 1,195 pounds.

The Thor-Agena, developed by the U.S. Air Force and adapted to civilian launches by NASA, is a two-stage vehicle with a payload capacity of 1,600 pounds. Its thrust-augmented version (TAT), with a trio of strap-on engines, can lift a 2,200 pound payload.

In the middleweight class are the Atlas—which has been flown alone or with one of several different upper stages—and the Air Force-developed Titan II. Technically, the Atlas D is regarded as a 1 1/2 stage vehicle with the outer two of three engines counted as a half stage. All three engines ignite at launch and the half-stage is jettisoned at the end of its burn time. The inner engine, the sustainer, continues firing until orbit is achieved. This vehicle can launch a payload of 3,000 pounds. With an Agena as an upper stage, payload weight can be increased to nearly 6,000 pounds. In combination with the Centaur, a high energy upper stage using liquid hydrogen and oxygen as a fuel, payload ceiling goes to 8,500 pounds in Earth orbit or 2,300 pounds for a lunar mission.

The Titan II generates a thrust of 430,000 pounds and can lift a payload of around 8,000 pounds into an Earth orbit. This vehicle employs a storable fuel that, unlike many other liquid fuels, does not need to be kept at extremely low temperatures. Therefore, Titan's tanks can be filled well ahead of launch, and need not be drained in the event of a postponement.

The heavyweight boosters are the Saturn IB, and its more muscular brother, the giant Saturn V. The Saturn IB has a first stage thrust of 1.6 million pounds and a second stage that develops 200,000 pounds. It can place 18 tons in Earth orbit. The mammoth Saturn V, which towers 363 feet and weighs—loaded—3,000 tons, generates 7.5 million pounds of thrust in its first stage. This is the energy equivalent of approximately 160,000,000 horsepower. Developed for the lunar mission, the Saturn V can orbit 140 tons or send 50 tons to the Moon. It has two upper stages that produce a million and 200,000 pounds of thrust respectively.

the sky watch

To track spacecraft, retrieve scientific and engineering data and support the manned missions, NASA has built three networks of stations that girdle the Earth:

STADAN (*S*pace *T*racking and *D*ata *A*cquisition *N*etwork) is a chain of stations using radio and optical equipment to track scientific payloads and probes, and acquire the data that the flights collect.

The Manned Space Flight Network supported the Mercury and Gemini missions and is equipped to support the Apollo program.

DSIF (*D*eep *S*pace *I*nstrumentation *F*acilities) is a series of major installations with great range and pointing accuracy. It was the DSIF that picked up the faint signals transmitted by Mariner IV over a distance of more than 200 million miles. Some stations on this network will combine with the Manned Space Network to handle Apollo missions.

widening the horizons

A vital component of the U.S. effort in aeronautics and space is the Office of Advanced Research and Technology. In this office, and in the university and industrial laboratories with which it has ties, the scientific and technological base for the nation's work in aeronautics and space is built. Scientific and technological horizons have been widened and the nation's capabilities in atmospheric and space flight vastly enhanced.

This forward movement is apparent throughout the spectrum of NASA activities. Sensor technology has advanced to a point where it is now possible to detect a temperature difference of two degrees at a distance of more than a hundred miles. Guidance systems and techniques of space navigation have reached a level of development that made it possible to put Surveyor VII on the lunar surface—a scant 1.2 miles from the aiming point—after a flight of more than 250,000 miles. The nature of fatigue and the behavior of stress corrosion in metals is now better understood and this understanding has pointed the way to corrective measures. The versatility and the capacity of computers has been greatly increased—even to the extent of improving the resolution of photographs and X-ray negatives. Research on the molecular structure of materials has produced fresh insights into the relationship between molecular structure and such characteristics as strength, resistance to heat, and conductivity. One result is the ability to increase or reduce the frictional coefficient of a metallic surface by altering the shape of the molecules that make up its surface. Fiber and plastic composites have been developed that are very light, very strong and easy to mold. Alloys have been tailored to withstand extremely high temperatures without deforming or losing strength. In one instance, a titanium nozzle with a coating—or cladding as it is called—of hafnium was exposed to 4,000°F for more than an hour without ill effect. New, tough and exceptionally heat resistant plastics—notably the pyrrone family, brought into being in the laboratories at the Langley Research Center—have been fabricated.

Constraints on weight and volume imposed on instruments designed for use in spacecraft have forced great advances in microminiaturization. More than 200 electric circuits can now be printed on a wafer thinner than a piece of cardboard and less than a quarter of an inch on a side. Efficient and unconventional sources of electric power, such as the fuel cell, are approaching operational status. Cryogenic technology—the use of extremely low temperatures—has come out of the laboratory and into more general use. Improved lubricants, long-life bearings, super insulation, tougher coatings and paints have been developed. This broad and balanced effort in basic and applied research has been a factor in many improvements, innovations and inventions, that will exert a strong influence on the future of the space program and on the nation's economy.

maximizing spin-off

The concept that invention is swiftly followed by application to general use is not borne out by experience. History is filled with instances where important developments have lain on the shelf, unused; sometimes for years. From its beginnings, NASA has been aware of this and has organized an aggressive effort to insure that the scientific and technological advances resulting from the space effort are promptly brought to the attention of industries not involved in space work; and made available to them.

Contractors and Agency facilities report specific innovations or inventions and improved technological processes to the Technology Utilization Division. These are carefullv screened and evaluated. Those adjudged worth processing are described in one or more publications—for example in Tech Briefs where the development is summarized in one sheet. This information is also stored in a computer bank. More than 700 innovations were announced during 1968.

Dissemination is the responsibility of six regional centers that have been set up for this purpose. Each of the Centers has a list of paying subscribers, more than 250 for all Centers, who have provided the Center with a profile of their interests. Where the development falls within the area of the subscriber's interest, he is so advised and may make a detailed investigation with the help of the Center. The Center facility also provides other services such as conducting a search of the computer bank for specific items at the request of a client.

Experiments are also being conducted with other transfer mechanisms. Three small, multidisciplinary Biomedical Application Teams are working with a number of research groups in medicine and biology to spot barriers to progress in this research discipline. They apply knowledge acquired in aerospace work to aid in the removal of these obstacles. Thus far, 240 specific medical problems have been identified. A dozen have already been solved using NASA generated technology.

work with the universities

From the first, NASA recognized that the universities of the nation, as centers of proven competence, would be the primary source of much of the fundamental knowledge required for scientific and technological advance. It was not enough that they provide immediate assistance in specified areas. There was need of them as participating members of a government-industry-university aerospace team. The plan aimed at giving universities throughout the nation a chance to participate in space research and to strengthen themselves in the process.

Project-oriented research grants and contracts arose directly from aerospace program needs. NASA also supported special training and research in space-related sectors that were supplemental to the work linked to specific NASA projects. NASA supported students doing predoctoral graduate work in areas of interest to the Agency. It also financed studies in space-related subjects of the universities' own choosing that abetted the institution in developing its academic and research strength.

The space program has significantly benefited from university participation. University scientists have conceived and developed satellite experiments productive of new knowledge. Research in university laboratories has supported manned flight operations. University scientists have served on advisory groups which plan and evaluate space activities. The universities are also collaborating with industrial and regional organizations to accelerate the application of space research results to other public problems. In the process, the institutions taking part have acquired new knowledge and experience essential to their continued scientific, technical and academic progress.

assistance to elementary and secondary schools

The National Aeronautics and Space Administration recognizes the importance of the nation's elementary and secondary schools in the fulfillment of its mission. NASA also has the responsibility to inform Americans of its activities and the results of those activities. To provide teachers and students with understanding of its progress, NASA has an active educational program with offices at the several NASA Centers and a headquarters in Washington, D.C.

Its purpose is to help teachers, supervisors, curriculum makers, and textbook writers update their work with information and understandings of the space program.

Each year it assists, by invitation, 400 to 500 teacher education courses and workshops enrolling 25,000 to 30,000 pre- and in-service teachers. Each year, through its Spacemobile lectures, it addresses two to three million pupils in assembly programs and classroom visits.

The educational programs also provide schools and other groups with films and publications of an informational/educational nature. Schools may write for information to the Educational Officer at any of the NASA Centers listed in the back of this publication.

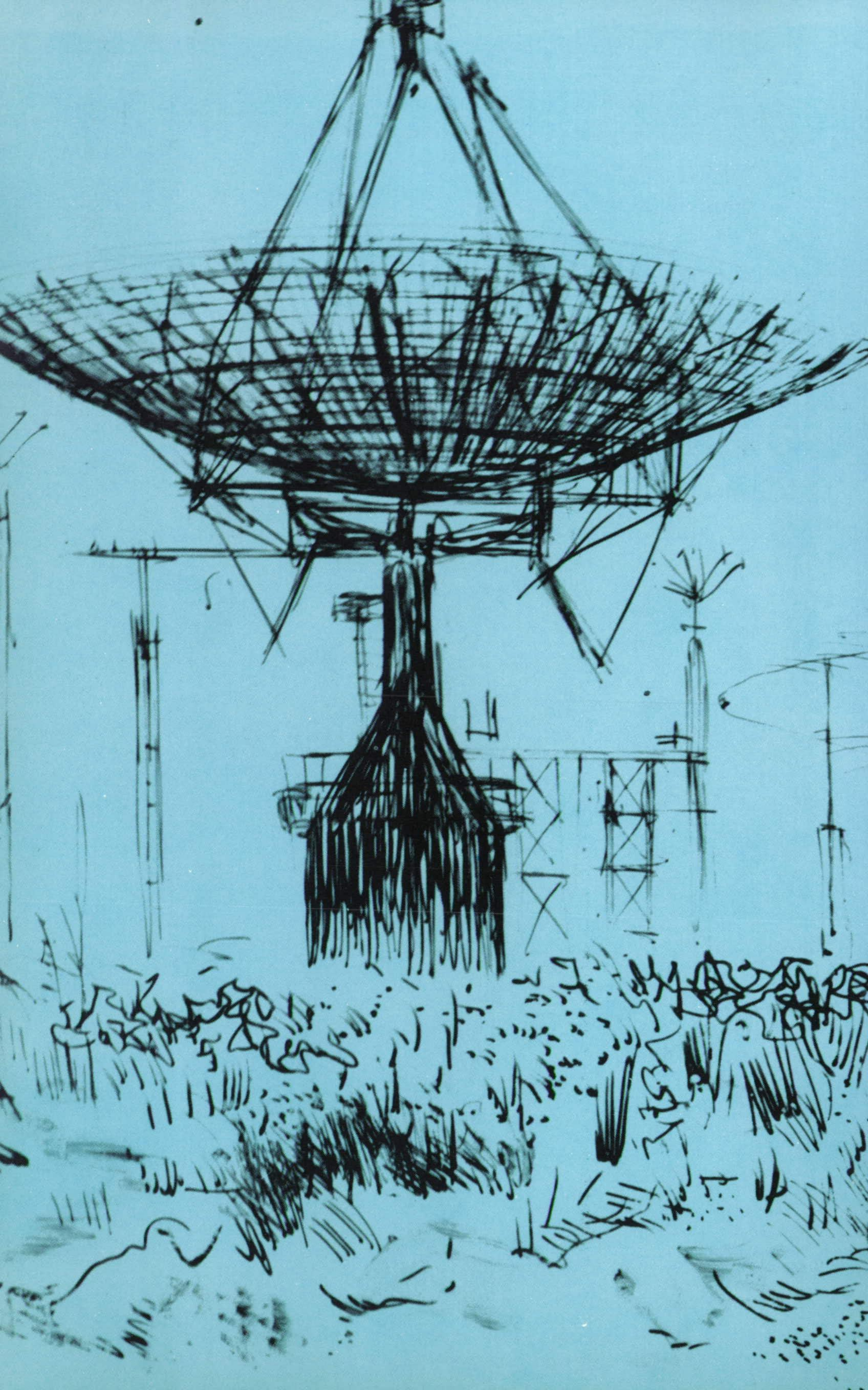
international cooperation in space

NASA initiatives have been fruitful in promoting cooperation between nations for the peaceful exploration of space. The broad and varied effort that has been mounted has involved scientists in 73 nations and jurisdictions, including a modest exchange with the Soviet Union. Three basic criteria have been applied to these joint ventures.

1. Scientific validity and mutual interest.
2. Open conduct, with scientific results freely available to the world's scientific community.
3. Significant contributions and independent funding by each participant.

Sixteen international satellites have been agreed upon. Of these, ten have since been placed in orbit: three for the United Kingdom, two for Canada, two for Italy, one for France and two for ESRO. These spacecraft were equipped to investigate the ionosphere, energetic particles and atmospheric structure.

NASA has agreements with 19 countries for a variety of cooperative sound-



ing rocket projects. Over a six year period, there have been more than 400 launches in this category. Of particular interest is EXAMETNET—a north-south meteorological sounding rocket network—with Brazil, Argentina, and prospectively Canada and Mexico participating with the United States. Many foreign countries have built their own ground receiving stations so that they can take advantage of the weather read-outs from the TIROS APT system. Forty-two nations supply the U.S. with conventional weather observations that help with the interpretation of cloud cover photographs. A number of foreign countries are assisting in the communications experiments being conducted with the Applications Technology Satellites.

The 1962 agreement with the Soviet Union has produced limited results. There were one-way communications demonstrations using Echo II; an exchange of ground-based magnetic field data looking toward an agreed exchange of satellite data; and an exchange of conventional and some satellite weather data over a special Washington-Moscow communications channel. A 1965 agreement provides for the preparation and publication of a joint review of research in space biology and medicine in the two countries.

International cooperation in space has produced scientific achievements of consequence. In addition, it has opened up a new area in which this kind of cooperation can go forward to insure that space retains its essentially international character and makes its contribution to the reduction of tension between nations.

the prospect

As NASA moves into its second decade, the potential seems almost without limit. To a great degree, the experimental phase is past and the chief constraints on the operational future are the decisions as to which of the many desirable options available shall be undertaken and the resources allocated to carry out the selected missions. The aphorism "What is past is prologue" speaks for the nation's future in space.

NASA facilities

NASA HEADQUARTERS, WASHINGTON, D.C.

NASA Headquarters formulates policy and coordinates the activities of the space flight centers, research centers, and other installations which comprise the National Aeronautics and Space Administration.

AMES RESEARCH CENTER, MOFFETT FIELD, CALIFORNIA

The work of the Ames Research Center is concerned with laboratory and flight research in unmanned space flight projects and in aeronautics. The fields of interest include atmosphere entry research, fundamental physics, materials, guidance and control, chemistry and life sciences. Ames aeronautical projects include the supersonic transport, V/STOL aircraft and operations research. The space flight projects involve management of scientific probes and satellites, and payloads for flight experiments. Projects Pioneer and Biosatellite are managed by Ames.

ELECTRONICS RESEARCH CENTER, CAMBRIDGE, MASSACHUSETTS

This Center was established to stimulate research and advanced development in electronics and related fields for application in space and aeronautics. The Center organizes, sponsors and conducts programs in the basic disciplines of guidance, control, navigation, communications, data processing, electronic components, micro-wave and electromagnetic technology, and reliability.

FLIGHT RESEARCH CENTER, EDWARDS, CALIFORNIA

The Flight Research Center is concerned with manned flight within and outside the atmosphere, including low-speed, supersonic, hypersonic and reentry flight, and air operations and safety problems. Major programs include aeronautics projects such as the X–15 and supersonic transport. Space vehicle programs are typified by studies such as flight behavior of lifting bodies. In biotechnology, man-machine integration problems are studied.

GODDARD SPACE FLIGHT CENTER, GREENBELT, MARYLAND

The Goddard Space Flight Center, named for the rocket pioneer, Dr. Robert H. Goddard, is responsible for the development and management of a broad variety of unmanned Earth-orbiting satellite and sounding rocket projects. Scientific, communications and meteorological satellites are included. (Orbiting Observatories, Explorers, TIROS, Nimbus, Relay, Syncom, and others). Goddard also is the nerve center for the world-wide tracking and communications network for both manned and unmanned satellites.

JET PROPULSION LABORATORY, PASADENA, CALIFORNIA

The Jet Propulsion Laboratory is operated under contract to NASA by the California Institute of Technology. Its primary missions are the development of spacecraft for unmanned lunar and planetary exploration (Ranger, Mariner, Surveyor) and the operation of a world-wide deep space tracking and control network. There is a broad scale program of supporting research.

JOHN F. KENNEDY SPACE CENTER, FLORIDA

The Nation's First Spaceport, the John F. Kennedy Space Center, makes preflight tests, prepares, and launches manned and unmanned space vehicles for NASA. New Kennedy Space Center facilities have been readied for the Apollo-Saturn V space vehicle in the U.S. program to land astronauts on the lunar surface in this decade. Manned Apollo missions, unmanned lunar, planetary, interplanetary missions, and scientific, meteorological, and communications satellites are launched by Kennedy Space Center.

LANGLEY RESEARCH CENTER, HAMPTON, VIRGINIA

Oldest of the NASA Centers, Langley has the task of providing technology for manned and unmanned exploration of space and for improvement and extension of performance and utility of aircraft. The major technical areas of Langley are theoretical and experimental dynamics of flight through the entire speed range, flight mechanics, materials and structures, space mechanics, instrumentation, solid rocket technology, and advanced ramjet engine research. The Center conceives, develops and operates simulators for the supersonic transport and lunar landing projects, and conducts an extensive program of V/STOL flight research projects.

LEWIS RESEARCH CENTER, CLEVELAND, OHIO

The mission of this Center is propulsion and space power generation. Fields of investigation are materials and metallurgy, problems concerned with the use of extremely high and low temperature materials, combustion and direct energy conversion, chemical, nuclear and electric rocket propulsion systems, advanced turbojet power plants, fuels and lubricants, plasmas and magnetohydrodynamics. Lewis has technical management of a number of chemical, solid and liquid rocket projects including the Agena and Centaur.

Plum Brook Station at Sandusky, Ohio, with facilities for propulsion research and development, is operated as an arm of Lewis.

MANNED SPACECRAFT CENTER, HOUSTON, TEXAS

The Manned Spacecraft Center is a new NASA facility located 20 miles southeast of Houston, Tex. on the edge of Clear Lake. It has the responsibility for the design, development, and testing of manned spacecraft and associated systems, for the selection and training of astronauts, and for operation of manned space flights. Mission Control for manned space flights, formerly at Cape Kennedy, now is

Cover painting and drawings by Mitchell Jamieson

based at the Manned Spacecraft Center.

The scientists and engineers who make up the technical staff of the Manned Spacecraft Center were responsible for placing the first American astronauts in space. Experience gained in Projects Mercury and Gemini is now being utilized in the Apollo Program.

GEORGE C. MARSHALL SPACE FLIGHT CENTER, HUNTSVILLE, ALABAMA

Launch vehicles essential to Apollo and other major missions are designed and developed by the scientists and engineers of the General George C. Marshall Space Flight Center. The Center is presently concerned with launch vehicles of the Saturn class, as well as payloads, related research and studies of advanced space transportation systems.

The Michoud Assembly Facility at New Orleans, Louisiana has been established to manufacture Saturn and other large launch vehicle stages.

The Mississippi Test Facility, located in a sparsely settled area about 40 miles east of New Orleans, is a facility for static tests of launch vehicle stages by contractors under the direction of the Marshall Space Flight Center.

NUCLEAR ROCKET DEVELOPMENT STATION, JACKSON FLATS, NEV.

This facility, located near Las Vegas, Nev., is managed by the Space Nuclear Propulsion Office, a joint operation of NASA and the Atomic Energy Commission. This major facility contains the laboratories, test stands and equipment for development of reactor technology and the nuclear engine and rocket stage for the nuclear rocket. The Station is the scene of many tests for the nuclear rocket program, which is in the advanced phases of research for missions to follow after the Apollo lunar landing project.

PACIFIC LAUNCH OPERATIONS OFFICE, LOMPOC, CALIF.

The NASA Pacific Launch Operations Office provides administrative, logistic, and technical support for NASA programs and projects at the Western Test Range.

WALLOPS STATION, WALLOPS ISLAND, VA.

The rocket-borne experiments flown from the Wallops Island Range are conceived, designed and built, by scientists and engineers in laboratories and research centers throughout the U.S. and in many of the countries of the world. Functions of Wallops Station are payload checkout, vehicle preparation and launching, instrumentation and data acquisition, processing and reduction of data, and tracking of vehicles.

NASA PASADENA OFFICE, PASADENA, CALIF.

The NASA Pasadena Office is a branch of NASA Headquarters. Primary mission of the Office is to administer the Jet Propulsion Laboratory contract and the procurement of pressurants, propellants and Delta launch vehicles.

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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

A request for career information should be sent to the Personnel Officer at the NASA Center listed below, which is designated to serve your area.

A request for NASA educational publications should be sent to the Educational Officer, Division of Public Affairs, at the NASA Center listed below, which is designated to serve your area.

If you live in:	Write to:
Alaska Idaho Montana Northern California (Monterey, Fresno and Mono counties, and North) Oregon Washington Wyoming	NASA Ames Research Center Moffett Field, California 94035
Connecticut Maine Massachusetts New Hampshire New York Rhode Island Vermont	NASA Electronics Research Center 575 Technology Square Cambridge, Massachusetts 02139
Alabama Arkansas Louisiana Mississippi Missouri Tennessee	NASA George C. Marshall Space Flight Center Huntsville, Alabama 35812
Delaware District of Columbia Maryland New Jersey Pennsylvania West Virginia	NASA Goddard Space Flight Center Greenbelt, Maryland 20771
Florida Georgia Puerto Rico Virgin Islands	NASA John F. Kennedy Space Center Kennedy Space Center, Florida 32899
Kentucky North Carolina South Carolina Virginia	NASA Langley Research Center Langley Station Hampton, Virginia 23365
Illinois Indiana Iowa Michigan Minnesota Ohio Wisconsin	NASA Lewis Research Center 2100 Brookpark Road Cleveland, Ohio 44135
Colorado Kansas Nebraska New Mexico North Dakota Oklahoma South Dakota Texas	NASA Manned Spacecraft Center Houston, Texas 77058
Arizona Hawaii Nevada Southern California (San Luis Obispo, Kings, Kern, Tulare, Inyo Counties, and South) Utah	NASA Pasadena Office 4800 Oak Grove Drive Pasadena, California 91103

Information concerning other educational publications of the National Aeronautics and Space Administration may be obtained from the Educational Programs Division, Code FE, Office of Public Affairs, NASA, Washington, D.C., 20546.

December, 1968

For sale by the Superintendent of Documents, U.S. Government Printing Office
Washington, D.C. 20402 - Price 45 cents

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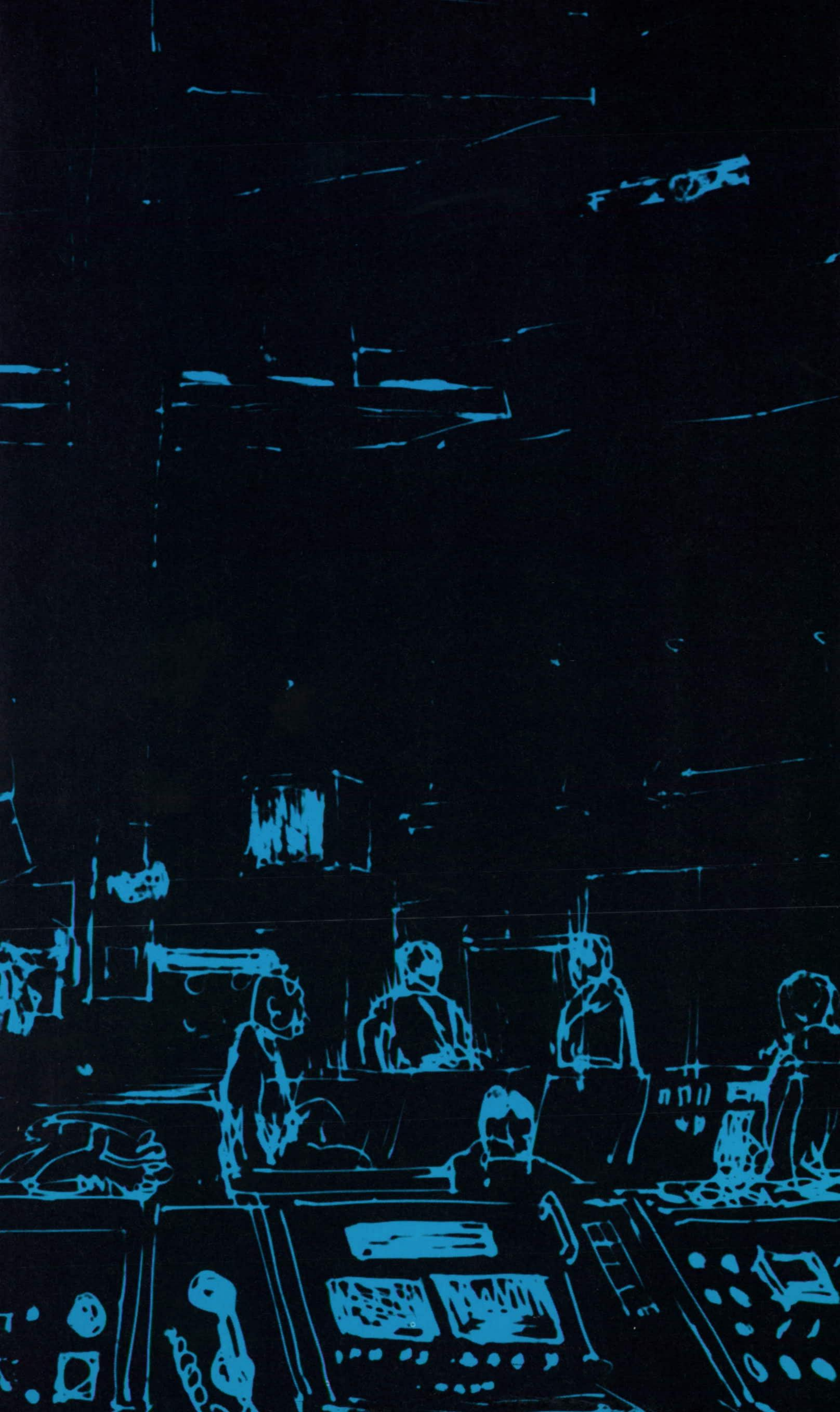

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