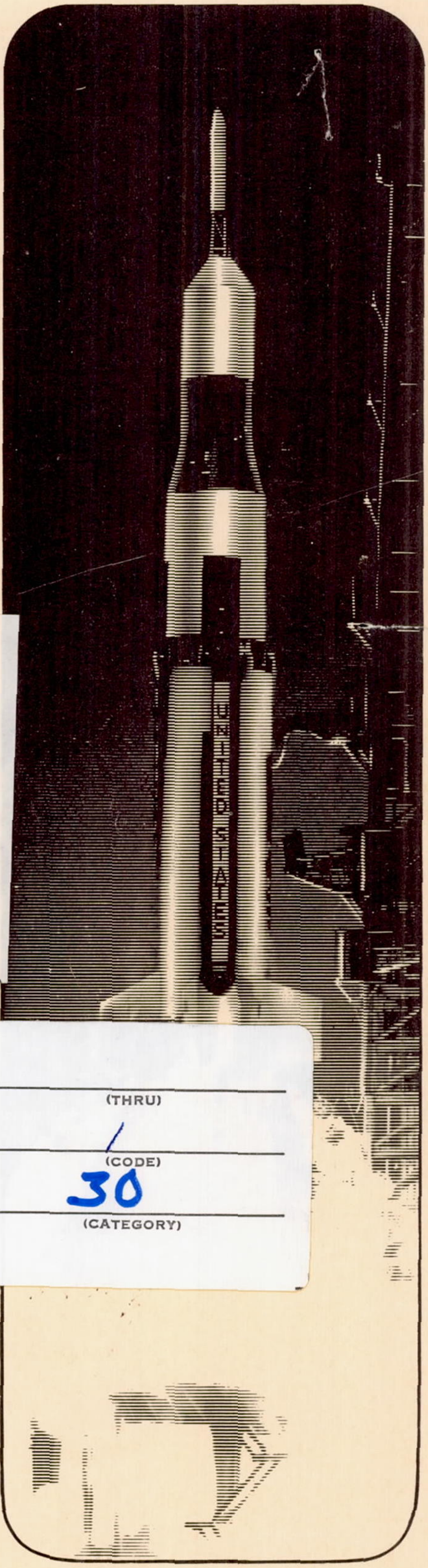
HISTORICAL SKETCH OF NASA



PRESIDENTS ON SPACE EXPLORATION

"All that we have already accomplished, and all in the future that we shall achieve, is the outgrowth not of a soulless, barren technology, nor of a grasping state imperialism. Rather, it is the product of unrestrained human talent and energy restlessly probing for the betterment of humanity."

President Dwight D. Eisenhower, speech at dedication of NASA Marshall Space Flight Center, Huntsville, Ala., September 8, 1960.

"Those who came before us made certain that this country rode the first waves of the industrial revolution, the first waves of modern invention and the first wave of nuclear power. And this generation does not intend to founder in the backwash of the coming age of space. We mean to be a part of it—we mean to lead it."

President John F. Kennedy, speech at Rice University, Houston, Tex., September 12, 1962.

"The fate of the free society—and the human values it upholds—is unalterably tied to what happens in outer space, as humankind's ultimate dimension."

President Lyndon B. Johnson, in Saturday Evening Post, *February 29, 1964.*

HISTORICAL SKETCH OF NASA

Prepared by the
NASA Historical Staff

National Aeronautics and Space Administration
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1965

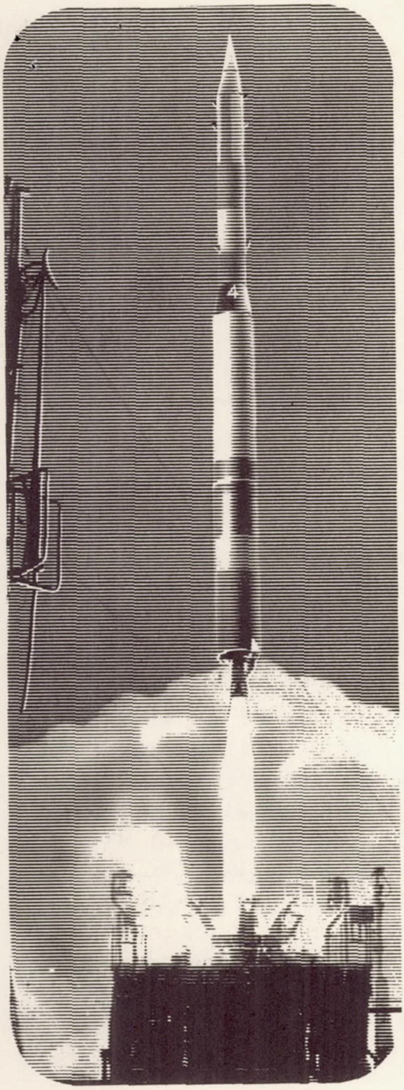
Foreword

This historical sketch has been compiled to supply the numerous demands for a brief accounting of the origins and early history of the National Aeronautics and Space Administration. It is neither complete nor pretends explanation of the full significance of the exciting scientific, technological, and related events of the recent past. The accelerated velocity of changes in our knowledge concerning nature beyond man's age-old planetary homeland, as well as in our growing space mobility, demands we remain mindful of what has already transpired.

Readers are invited to examine other NASA historical products for additional information, particularly our annual chronologies. Full-fledged histories of major space activities are also in process of preparation. The select bibliography at the end of this pamphlet will assist the curious reader in delving deeper into the interlocking governmental, academic, and industrial background of what has become a complex undertaking to explore and to exploit space science and technology. It has already been an endeavor of considerable national and international impact while new knowledge and techniques also portend alterations in human affairs on earth.

It has only been 50 years since the National Advisory Committee for Aeronautics, NASA's institutional ancestor, was created. This was a dozen years after the Wright brothers first achieved practical manned flight. It was only 350 some years ago that Galileo first pointed a telescope at the moon and the rise of modern science began. Americans now realize, too, that the first successful liquid-fuel rocket flight was achieved by Robert H. Goddard in 1926, and the first man-made moon, SPUTNIK I, orbited the earth thirty-one years later. As space-goals are achieved and the unpredictable unknowns of tomorrow's space exploration and exploitation unfold, the meaning provided by a historical perspective should prove even more helpful.

Eugene M. Emme
NASA Historian



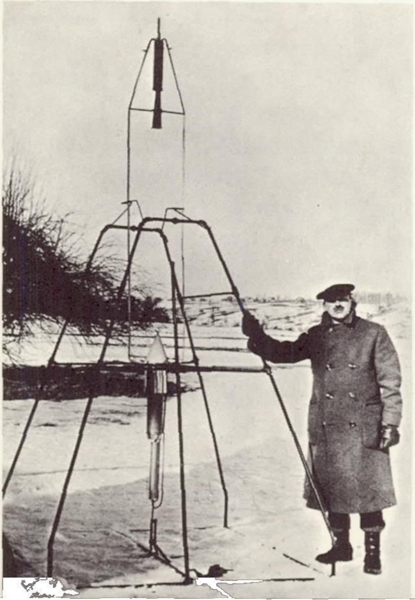
The Founding of NASA

The rise of space science and technology as a major activity in human affairs has been both unprecedented and swift. Over 400 earth satellites and space probes have already been launched including flights by man himself as well as the first scientific reconnaissance of the Moon and the nearby planets of Venus and Mars. Communication and weather satellites are already of daily service to earthbound activities. The vast mobilization of scientists and engineers, facilities, and resources for the exploration of our readily accessible solar system has come about within a few breathless years. It will not be many months until man himself will have set foot upon the surface of the moon. Then the next phase of man seeking his destiny in his universe will begin.

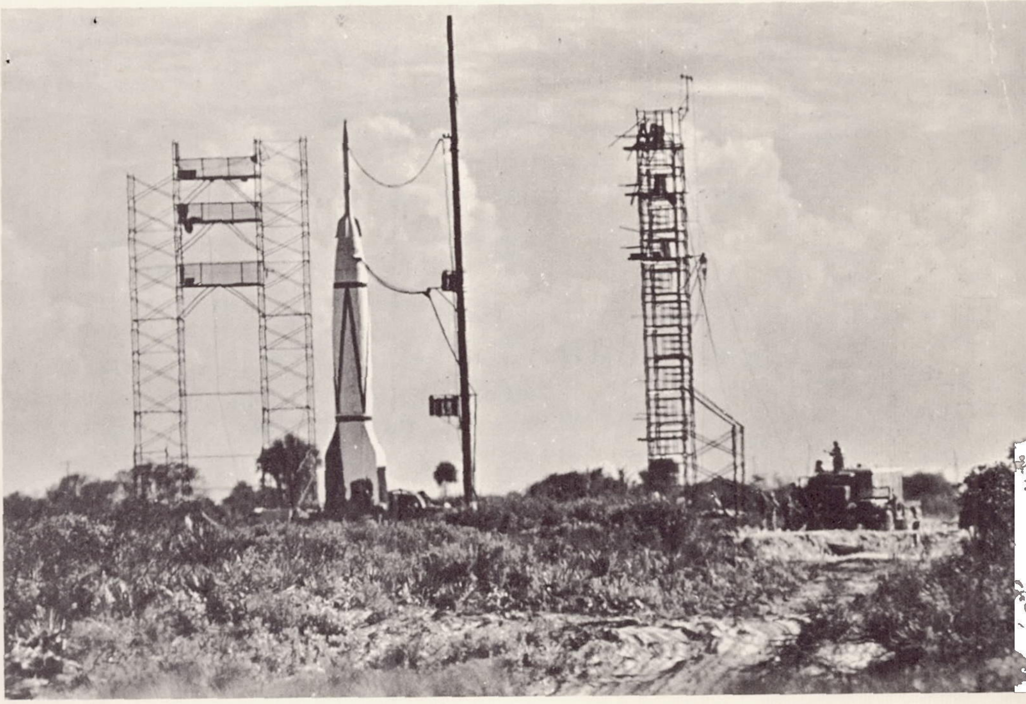
When the first manmade moon was orbited, something new had been added to world history. Headlines of newspapers around the world publicized the launching of SPUTNIK I on October 4, 1957. It was the beginning of what is called the "space age," the dramatic, difficult, and challenging quest by man to explore nature beyond the planet earth.

Space flight had become possible because of the thrust of large liquid-fuel rockets which had been developed as military missiles. Begun in 1954, the race for the first generation of intercontinental ballistic missiles tipped with thermonuclear warheads came to a climax at the same historical moment that the Space Age began. The revolutionary implications of flight into the newly accessible environment of outer space, however, obviously was of profound future significance. Indeed, the challenging idea that man was not forever destined to be confined to his planet became evident almost overnight after the first Sputniks in 1957.

The first U.S. earth satellite program, initiated in 1955 as a part of the International Geophysical Year (IGY) and called Project Vanguard, was judged after the Sputniks by many Americans as a propaganda failure. Actually Vanguard proved to be a scientific and technological success. Yet many concerned Americans heaved a sigh of relief when EXPLORER I, the first U.S. satellite, was successfully launched into orbit from Cape Canaveral by the Army Ballistics Missile Agency (ABMA) on January 31, 1958. It carried an IGY experiment, provided by Professor James A. Van Allen of the University of Iowa, which made the most important discovery of the IGY—the radiation belts which carry his name. VANGUARD I, first with solar-powered batteries, was launched on March 17, 1958, and made numerous scientific contributions on solar pressure and the shape of the earth because of its concentric orbit. Both EXPLORER I and VANGUARD I are yet in orbit today.



World's First Liquid-Fuel Rocket: Robert H. Goddard (1882–1945) stands beside his rocket which successfully flew 184 feet on March 16, 1926, at Worcester, Mass. This primitive flight was for astronautics what the Wright Brothers' flights at Kitty Hawk in 1903 were for aeronautics.



First launching from USAF Long Range Proving Ground, Cocoa, Fla., Bumper-Wac No. 8 on July 12, 1950 (V–2 first stage; Corporal second stage). LRPG was later the Atlantic Missile Range of the Department of Defense and known as Cape Canaveral, and more recently as Cape Kennedy.

After Sputnik in 1957, most Americans first learned that it had been an American in 1926 who had first successfully launched a liquid-fuel rocket, a device leading to the technology that would make space mobility possible. The pioneering work of Dr. Robert H. Goddard of Clark University had antedated the spectacular 5½-ton German V–2 rockets of World War II fame. After the war, the U.S. began scientific probing of the upper atmosphere with V–2 rockets, later the Aerobee and Viking sounding rockets. Rocket technology making space exploration practical derived directly from the accelerated military missile programs growing out of the "cold war" of the 1950's. Until SPUTNIK I, however, military security requirements for operational intercontinental ballistic missiles with nuclear warheads received highest priorities and support in the United States. After SPUTNIK I, it was clear that the United States must place a sound and long-range space program on a coherent and purposeful basis for its own sake, that space exploration had vital scientific and technical implications of far-reaching future significance.

The national space program of the U.S. was created as a result of the National Aeronautics and Space Act of 1958. This was, in effect, a national process of decision involving the White House, the Congress, and the American people to engage in an organized and an accelerated program of space exploration and exploitation. The Space Act created a new civilian agency, the National Aeronautics and Space Administration. Known as NASA, it began functioning a year after SPUTNIK I on October 1, 1958.

The National Aeronautics and Space Act:

On November 7, 1957, President Dwight D. Eisenhower announced that Dr. James R. Killian, President of the Massachusetts Institute of Technology, would serve as White House scientific advisor. The committees of the Congress also began their detailed investigation of the U.S. missile and space program late in November 1957, ultimately creating special committees responsible for space affairs. After hearing more than seventy military and civilian witnesses, the Preparedness Investigating Subcommittee, chaired by Lyndon B. Johnson of the Senate Committee on Armed Services, submitted a unanimous report on January 23, 1958. This report called for the creation of an independent space agency and for a reorganization of missile and space activities in the Department of Defense. In the meantime, the American Rocket Society and the Rocket and Satellite Research Panel of the National Academy of Sciences joined in calling for a National Space Establishment, one which would be responsible for the "broad cultural, scientific, and commercial objectives of American space objectives." In his State of the Union message to the Congress on January 9, 1958, President Eisenhower announced the creation of an Advanced Research Projects Agency (ARPA) "to concentrate into one organization all anti-missile and satellite activities undertaken within the Department of Defense." Satellite and space probe projects were initiated by ARPA. Shortly thereafter, the President directed his science advisor, Dr. Killian, to formulate recommendations on the overall organization of the U.S. space effort.

On March 5, 1958, the President approved the recommendation of his Advisory Committee on Government Organization that a civilian space agency be created upon the structure of the National Advisory Committee for Aeronautics (NACA), into which all nonmilitary space activities would be integrated. On March 26, President Eisenhower released the classic report of his Science Advisory Committee entitled "Introduction to Outer Space." In his prefatorial statement, the President said:

> This statement of the Science Advisory Committee makes clear the opportunities which a developing space technology can provide to extend man's knowledge of the earth, the solar system, and the universe. These opportunities reinforce my conviction that we and other nations have great responsibility to promote the peaceful uses of space and to utilize the new knowledge obtainable from space science and technology for the benefit of all mankind.

In outlining the principal reasons for undertaking a national space program, the President's Science Advisory Committee listed four factors which gave importance, urgency, and inevitability to the advancement of space technology:

> The first of these four factors is the compelling urge of man to explore and to discover, the thrust of curiosity that leads men to try to go where no one has gone before . . .
>
> Second, there is the defense objective for the development of space technology. We wish to be sure that space is not used to endanger our security. If space is to be used for military purposes, we must be prepared to use space to defend ourselves.
>
> Third, there is the factor of national prestige. To be strong and bold in space technology will enhance the prestige of the United States among the peoples of the world and create added confidence in our scientific, technological, industrial, and military strength.
>
> Fourth, space technology affords new opportunities for scientific observation and experiment which will add to our knowledge and understanding of the earth, the solar system, and the universe.

On April 2, 1958, the President sent his recommended bill for the establishment of a civilian "National Aeronautics and Space Agency" to the Congress for consideration. After further deliberations between April 2 and July 16, 1958, the Congress, through its committees and as a body, worked out what became the National Aeronautics and Space Act of 1958. President Eisenhower signed it on July 29, 1958.

The Space Act laid down the basic objectives or goals of the United States in the conquest of space. It said that American aeronautical and space objectives shall be conducted so as to contribute to one or more of the following national goals:

> (1) The expansion of human knowledge of phenomena in the atmosphere and space;
>
> (2) The improvement of the usefulness, performance, speed, safety, and efficiency of aeronautical and space vehicles;
>
> (3) The development and operation of vehicles capable of carrying instruments, equipment, supplies, and living organisms through space;
>
> (4) The establishment of long-range studies of the potential benefits to be gained from, the opportunities for, and the problems involved in the utilization of aeronautical and space activities for peaceful and scientific purposes;
>
> (5) The preservation of the role of the United States as a leader in aeronautical and space science and technology and in the application thereof to the conduct of peaceful activities within and outside the atmosphere;
>
> (6) The making available to agencies directly concerned with national defense of discoveries that have military value

The First Administrators of NASA: Dr. T. Keith Glennan (center), first NASA Administrator (1958–60); Dr. Hugh L. Dryden (left), Deputy Administrator (1958–); and Mr. Richard E. Horner (right), Associate Administrator (1959–60). NASA Headquarters was located first in the Dolley Madison House on Lafayette Square.

or significance, and the furnishing by such agencies, to the civilian agency established to direct and control nonmilitary aeronautical and space activities, of information as to discoveries which have value or significance to that agency;

(7) Cooperation by the United States with other nations and groups of nations in work done pursuant to this Act and in the peaceful application of the results thereof; and

(8) The most effective utilization of the scientific and engineering resources of the United States, with close cooperation among all interested agencies of the United States in order to avoid unnecessary duplication of effort, facilities, and equipment.

These goals were to stand up well as the U.S. space effort gathered direction and momentum in the years to follow.

While the Department of Defense was to remain responsible for potential military application of space technology, the National Aeronautics and Space Administration was charged with the task of getting on with the exploration of space for its own sake and to ensure the widest possible benefits would thereby be obtained.

NASA thus came into being on October 1, 1958. Dr. T. Keith Glennan, president of Case Institute of Technology, and former AEC Commissioner, was named the first Administrator. Dr. Hugh L. Dryden, Director of the NACA, became the first Deputy Administrator, a position he still holds. The early history of NASA was largely that of consolidating a national program out of projects, facilities, and personnel of Government agencies, the scientific community, and the aerospace industries. No other new agency of the Executive Branch of the Federal Government had been created by the transfer of as many units and programs of other departments and agencies as was NASA. No other agency was to undergo as rapid a growth in personnel and budget in peacetime as NASA during its first five years.

The NACA Nucleus:

The organizational nucleus of NASA was the National Advisory Committee for Aeronautics (NACA). In April 1958, Dr. Abe Silverstein was called by Dr. Dryden to Washington from NACA's Lewis Propulsion Laboratory to help organize the new civilian space agency. Before NASA's first day of business, Silverstein pulled together a small, select group of space-oriented people to accelerate the transition of NACA into NASA.

For forty-three years the NACA helped ensure American technical excellence in military and civilian aviation. Founded just before the U.S. entrance into World War I, the NACA had been created to focus nationwide competence upon the then relative technical backwardness of American aviation. In 1914, the United States was the only major nation in the world without a

Three Well-Known Members of the NACA: Shown here at a NACA luncheon on April 18, 1940, are Orville Wright, Maj. Gen. Henry H. "Hap" Arnold (Chief of the Army Air Forces), and Jerome C. Hunsaker. Orville Wright was an active member of the NACA from 1920 until his death in 1948. General Arnold was an active member of the NACA from 1938 until his retirement in 1946, and was instrumental in pushing the rocket research airplane and other programs during and after World War II. Dr. Hunsaker of MIT was one of the designers of the historic U.S. Navy flying boat (NC–4) which first flew the Atlantic in 1919, was a long-standing member of the NACA (1922–23, 1938–58), and served as Chairman of the NACA from 1941 to 1956. Dr. Hunsaker was succeeded as Chairman of the NACA by Dr. James H. Doolittle, who served until NASA was created in 1958.

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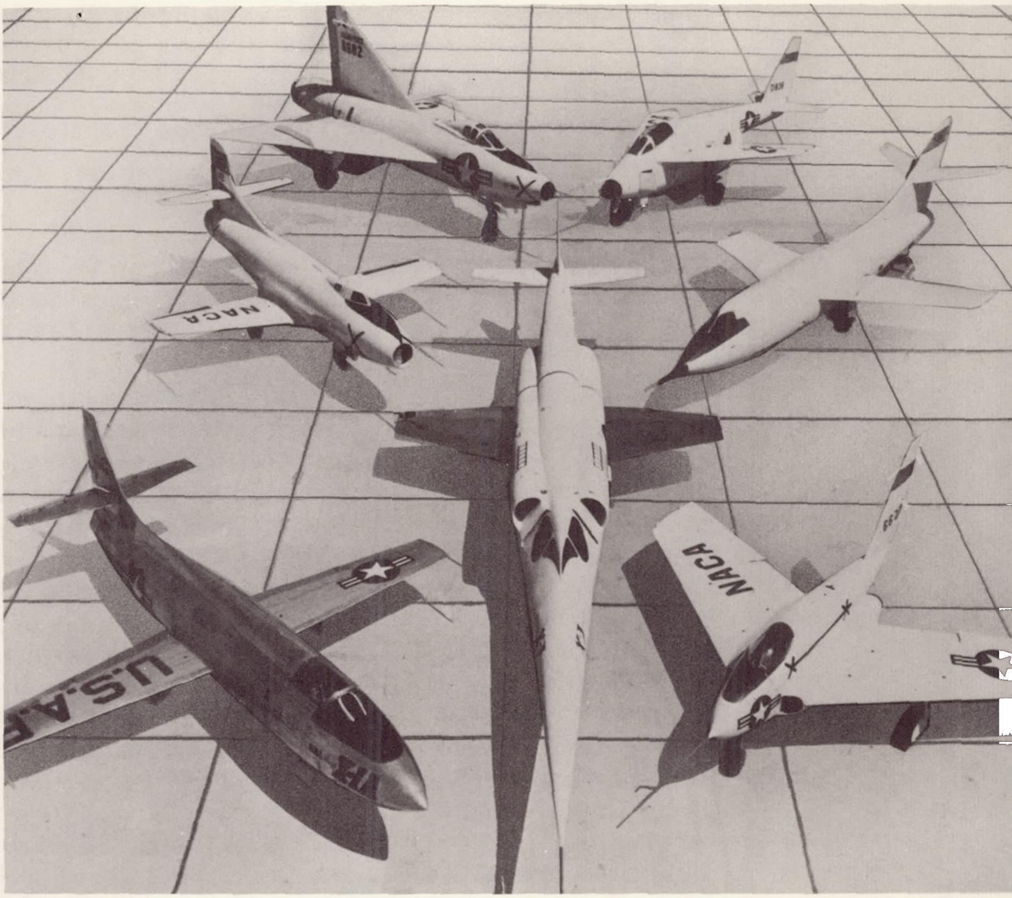
governmental laboratory devoted to the science of flight. Created on March 3, 1915, the NACA was ". . . to supervise and direct the scientific study of the problems of flight, with a view of their practical solution." The members of the National Advisory Committee were representatives of the military and naval air services, the Weather Bureau, the Smithsonian Institution, and the scientific community. They served without compensation. "The sum of $5,000 a year, or so much thereof as may be necessary, for five years" was appropriated by the Congress for the NACA. The first meeting of the NACA was held on April 23, 1915, called at the direction of President Woodrow Wilson by the Secretary of War.

The NACA served as a focal point for defining and solving crucial policy problems and assigning research tasks during the war. It made important recommendations on cross-licensing of patents, on air mail, and on aircraft production. No aircraft of American design was to reach combat in World War I, which illustrates the backwardness of U.S. aviation at the time NACA was created. The NACA did not begin its own historic wind-tunnel and research contributions until after the war, when Congress authorized the establishment of its first laboratory at Langley Field, Virginia. It was the only NACA laboratory until 1940. Basic aircraft design was to be revolutionized time and again by NACA's technical reports in the 1920's and 1930's. The famous NACA cowling, for which it received the Collier Trophy for 1929, led to the low-wing, multi-engined air transports (e.g., Boeing 247, Douglas DC–3) and bombers (e.g., B–17) of the 1930's. NACA's fundamental research and its direct application into industrial, military, and civil aviation helped create for the United States the world's greatest commercal air transportation network before World War II, as well as the world's greatest air power during that conflict. The P–51 "Mustang," the best single-engine fighter aircraft of the war, was designed in 90 days in 1940 to British specifications and was based on NACA's famous laminar-flow wing. The Germans were later unable to discover in their own wind tunnels why the P–51 was so fast and maneuverable.

NACA's fundamental aeronautical research led to rocket propulsion and the threshold of space by the end of World War II. The historical X–series of rocket research aircraft began in 1944. In 1947, the NACA–USAF X–1 made the first flight faster than the speed of sound. NACA made important contributions to the supersonic military aircraft of the 1950's as well as the variable-sweep aircraft of the mid-1960's. Headline achievements of the recordbreaking X–15 rocket research program are but the latter-day offspring of the NACA tradition of fundamental research in the technical problems of manned flight. Contributing to Project Mercury technology, the USAF–USN–NACA/NASA X–15 program spanned almost a decade from its initial conception in 1952 until it achieved its designed altitude and speed objectives in 1963.



Research Airplanes—1956: Flying regularly at transonic and supersonic speeds, the research airplanes explored new fields for data required to design military and civil airplanes. In center is the Douglas X–3; at lower left, the Bell X–1A flown late in 1953 at a record 1,650 mph, or 2.5 times the speed of sound. Continuing clockwise from the X–1A are the Douglas D–558–I "Skystreak"; Convair XF–92A; Bell X–5 with variable sweepback wings; Douglas D–558–II "Skyrocket," first piloted airplane to fly at twice the speed of sound; and the Northrop X–4. The National Advisory Committee for Aeronautics, the U.S. Air Force, the U.S. Navy, and the aircraft manufacturing industry joined to design, build, and fly these and other advanced airplanes in the high-speed flight research program which led to the X–15 and space. This program began in 1944.

NACA had learned to work closely with the military services, the aerospace industry, and university laboratories and scientists.

Immediately transferred to NASA in October 1958 were 8,040 NACA scientists, engineers, technicians, and other personnel. NACA's excellent laboratories became NASA research centers:

Langley Research Center, Hampton, Virginia
(established in 1917)

Ames Research Center, Moffett Field, California
(established in 1940)

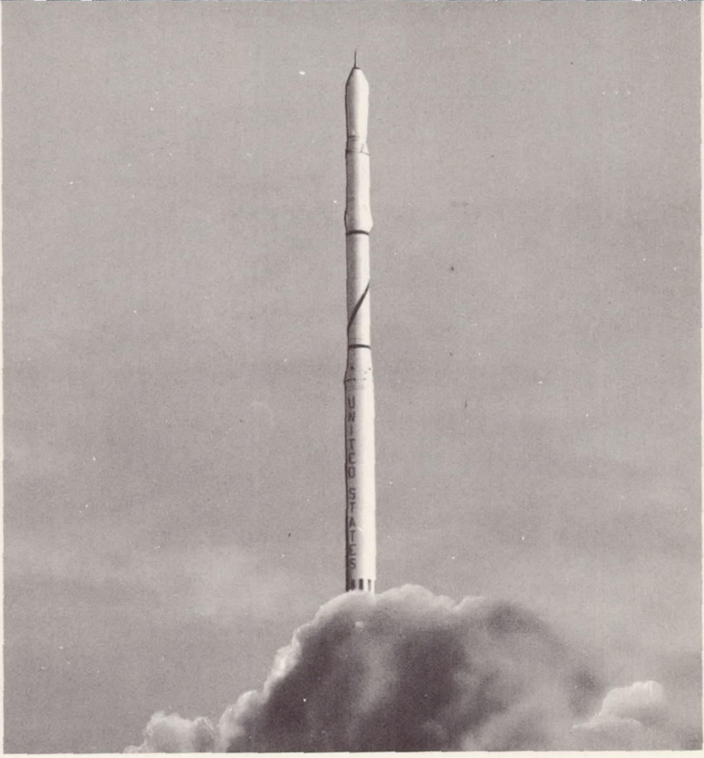
Lewis Research Center, Cleveland, Ohio
(established in 1941), and its Plumb Brook facility at Sandusky

Flight Research Center, Edwards AFB, California
(established in 1945)

The NACA rocket launching facility at Wallops Island, Virginia, used extensively as a "flying wind tunnel" for ballistic missile and aeronautical research at supersonic speeds since 1945, also came to NASA.

The NACA tradition of fundamental aeronautical research was to serve well as the aegis of advanced research and technology activities in the new NASA. Each of these former NACA facilities contributed much to American civilian and military aeronautics over the years, and also had been more recently engaged in work on rocket propulsion and missile problems. The year 1953, for example, was the first year that as much as a million dollars had been spent on American ballistic missile developments. The breadth and interdisciplinary nature of space science and technology required a wide variety of special skills and a vast integration of related programs, facilities, and equipment. There were to be many important additions to the NACA nucleus of NASA instituting a national program for the conquest of space.

X–15 Research Airplane Landing: Designed from its beginning in 1952 to fly to speeds of 4,000 mph and at altitudes between 50 and 100 miles, the X–15 is shown landing after launch from a B–52 "mother aircraft," a rocket-powered research flight, and a glide to landing on a dry lake bed near Edwards, Calif. The X–15 is now in its new phase of research contributions.



Launching of EXPLORER XIII: By NASA-developed four-stage Scout launch vehicle from Wallops Station, Va., November 6, 1964.

Integration and Early Growth of the NASA Organization:

Also transferred to NASA immediately, by Executive Order of the President in October 1958, were various space projects from DOD's Advanced Research Projects Agency (ARPA) and from the military services. This mass transfer, authorized by the Space Act, included five space probes, three satellite projects, and several rocket engine programs. NASA thus became responsible for ongoing space projects begun under Air Force and Army direction. The Saturn launch vehicle later came from ARPA, the Centaur from the Air Force, and the Tiros meteorological satellite from the Army Signal Corps. These initial and early transfers to NASA were illustrative of actions consolidating America's talent, resources, and programs into a single nonmilitary management structure for the scientific exploration of space and peaceful application of the newly developed space technology.

The IGY Project Vanguard scientific satellite program was immediately transferred to NASA along with some 200 highly qualified scientific and technical personnel from the Naval Research Laboratory (NRL). This included 157 members of the Project Vanguard team under Dr. John P. Hagen and 46 members of the NRL Upper Atmosphere Sounding Rocket group under Dr. John W. Townsend, Jr. Key members of these naval groups are today

Dedication of Goddard Space Flight Center: Mrs. Robert H. Goddard and NASA Administrator James E. Webb are admiring the bust of Dr. Robert H. Goddard following the dedication ceremonies of the Goddard Space Flight Center, Greenbelt, Md., on March 16, 1961, 35 years to the day after the launching of the world's first liquid-fuel rocket. Bust of Dr. Goddard was done by Joseph Anthony Atchison.

found in NASA Headquarters and the Goddard Space Flight Center at Greenbelt, Md. The Goddard Center operated from its NRL quarters for almost two years before moving to its new facilities at Greenbelt, opened officially in March 1961.

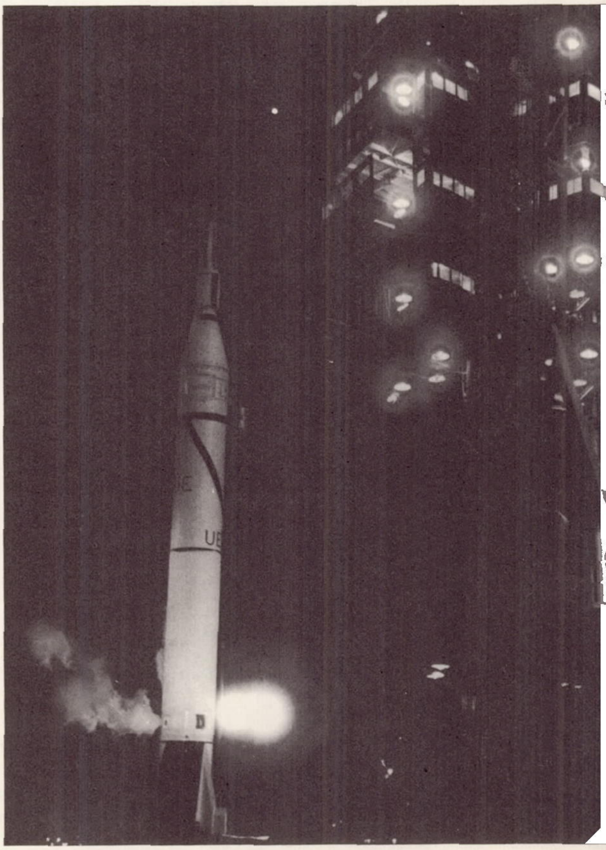
In December 1958, the Jet Propulsion Laboratory (JPL) of the California Institute of Technology, a contract Federal facility with 3,800 employees, was brought under NASA's direction. Founded in 1936 by Dr. Theodore von Kármán and a small group of dedicated colleagues who began a series of rocket development studies, the Cal Tech Laboratory had received the first Federal contract of $10,000 for rocket studies from the National Academy of Sciences in 1938. In JPL Memorandum No. 1 of November 20, 1943, the possibilities of long-range rocket projectiles were summarized. Jet Propulsion Laboratory developed liquid-fuel rockets to assist

Dedication of Marshall Space Flight Center: Mrs. George C. Marshall and President Dwight D. Eisenhower unveil the bust of General Marshall at Huntsville, Ala., on September 8, 1960. Marshall had been the only professional soldier ever awarded the Nobel Peace Prize. This bust was done by the Finnish sculptor, Kalervo Kallio.

airplane take-offs and the Corporal rocket, as well as various solid-fuel rockets such as the Loki during World War II. Pioneering in space work, JPL contributed the upper rocket stages, payloads, and telemetry of the early Explorer satellites and Pioneer probes launched by the Army.

At the same time that JPL became a major contractor of NASA the Army Ballistic Missile Agency (ABMA) in Huntsville, Alabama, was made responsive to NASA's space requirements. Eighteen months later, on July 1, 1960, the NASA George C. Marshall Space Flight Center (MSFC) came into being at Huntsville and was dedicated by President Eisenhower in September. MSFC at first consisted of ABMA's Development Operations Division, under Dr. Wernher von Braun, many of whose 4,600 people had been active in pioneering rocket development for over two decades (V–2, Redstone, Jupiter, Pershing). In the history of rocket technology, the German V–2 had been a major step beyond Dr. Goddard in the development of large liquid-fuel rockets. Development of the Redstone rocket had begun in 1950. EXPLORER I had been launched by ABMA with a Jupiter–C, a modified Redstone with upper stages. The Saturn I development began in 1958.

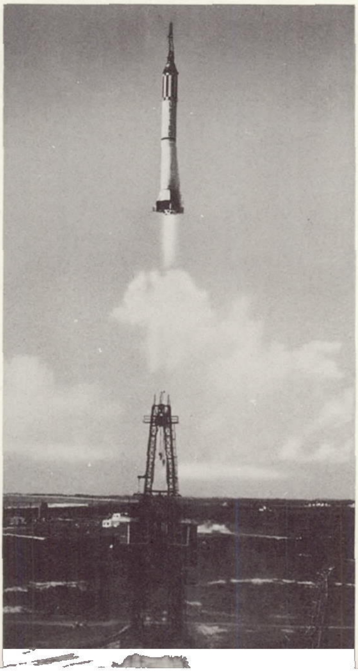
EXPLORER I Countdown: First U.S. satellite, EXPLORER I, was launched by modified ABMA–JPL Jupiter-C booster, with United States-IGY scientific experiment of James A. Van Allen, on January 31, 1958.



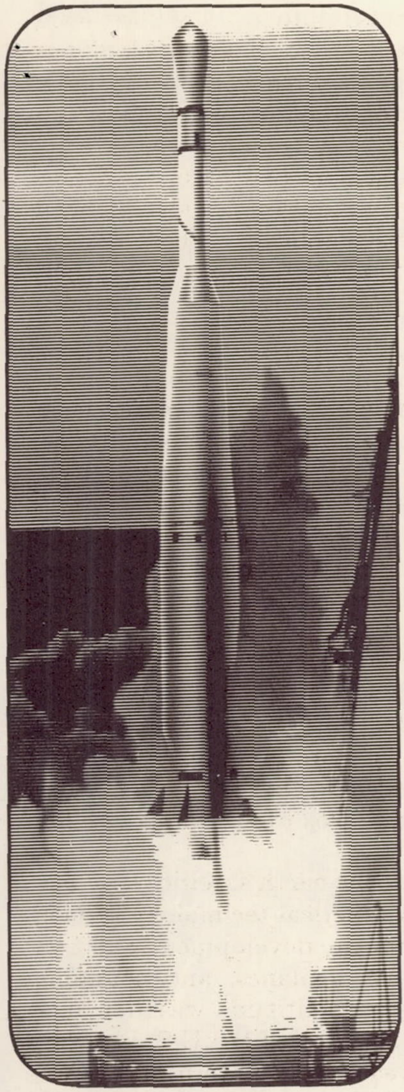
The first U.S. manned space flight of Commander Alan B. Shepard (USN) on Mercury-Redstone 3 on May 5, 1961, the flight of Capt. Virgil I. Grissom on July 21, 1961, as well as the first successful development flight of the giant Saturn I on October 27, 1961—these were early milestones in the U.S. space effort growing out of the contribution of MSFC rocketry to the rapidly evolving space exploration program under NASA.

The NASA Launch Operations Center (LOC) at Cape Canaveral also grew out of MSFC. It was established on July 1, 1960, to handle NASA affairs at the Atlantic Missile Range, which had been launching military rockets since 1950. LOC became an independent NASA Center under Dr. Kurt Debus on July 1, 1962. It was renamed the John F. Kennedy Space Center, NASA, when President Johnson named Cape Kennedy in honor of the late President on November 29, 1963. NASA created the Pacific Launch Operations Office at the Pacific Missile Range (PMR) on March 7, 1962, to provide support for the launching of its polar-orbiting satellites from what is now called the Western Test Range.

The early history of NASA between 1958 and the end of 1960 was a difficult period. Problems of organization, facilities, long-range goals, and funding for the exploration of space involved the urgent response to the Russian challenge, the high interest of Congress and the general public in space affairs, and the gearing-up of a new Federal agency with highly qualified people and on-going programs inherited from diverse parentage. NASA grew from 8,000 to 16,000 persons in its first 28 months, excluding the 3,500 contractor employees of NASA's JPL. It acquired major facilties from the Army and the Navy including worldwide tracking facilities. The greatest period of rapid expansion and accomplishment, however, was to come after December 1960.



First American Into Space: Launching of Comdr. Alan B. Shepard, Jr., as pilot of FREEDOM 7 by Mercury-Redstone from Cape Canaveral, May 5, 1961. Flight to an altitude of 115.7 miles and a distance down range of 302 miles demonstrated integrity of Mercury spacecraft and feasibility of spaceflight by man.



Early Milestones and Progress

NASA began with inherited rocket boosters and space flight programs from ARPA and the military services, and advanced technological research from NACA, and the scientific goals of space exploration derived from the momentum established by the International Geophysical Year (IGY). An early task was to establish intimate working relationships with all Federal agencies contributing to the U.S. space competence, notably the Department of Defense and the military services, the AEC, the Weather Bureau, as well as relevant important industrial and academic activities. NASA's evolving program was to focus upon the space sciences, manned space flight, and utilitarian weather and communications satellites as well as the advanced technology under-

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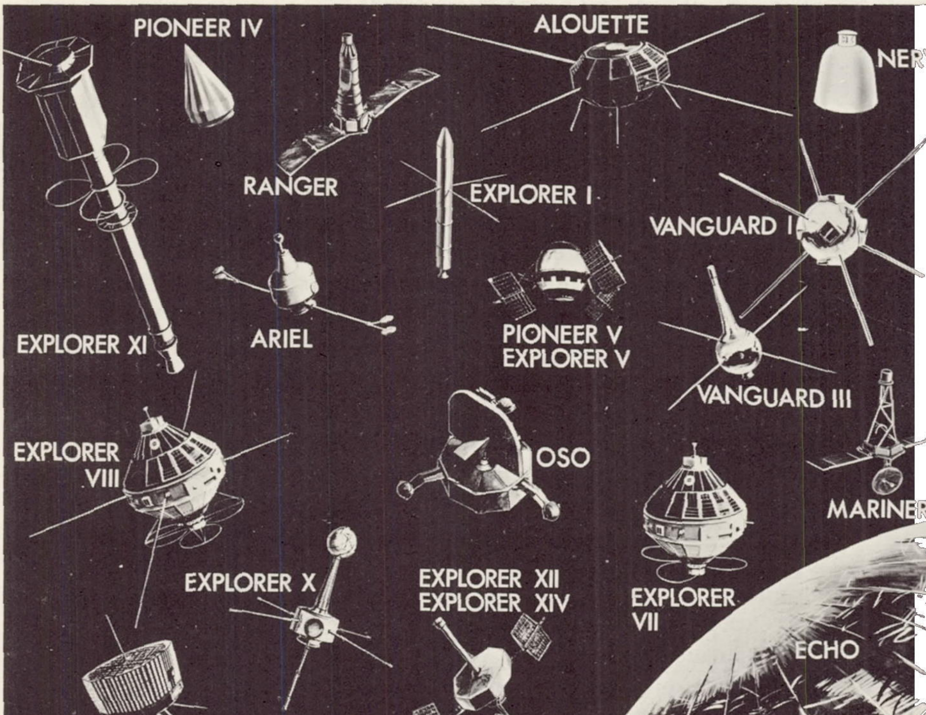
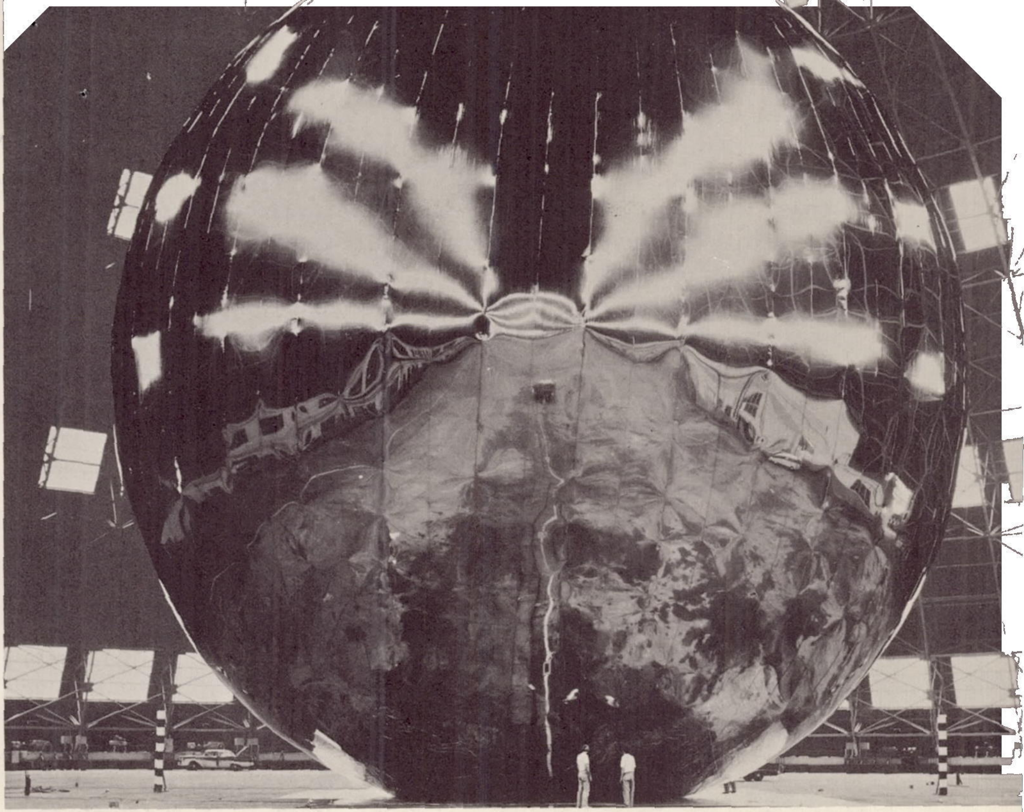
writing such space missions. It also continued the aeronautical research in the NACA tradition.

Space Sciences:

Before NASA had come into being, the National Academy of Sciences had created the 16-man Space Science Board (SSB) in June 1958, chaired by Dr. Lloyd V. Berkner, to fulfill both "national and international research interests." Eleven ad hoc subcommittees of the SSB met frequently during the early years of NASA to help organize the space sciences program of NASA as well as to further scientific interest internationally in space exploration. NASA scientific satellite, sounding rocket, and space probe programs thus were to evolve from the basic needs of geophysics, astronomy, and the other science disciplines interested in the newly accessible space environment. American scientific accomplishments in space had begun with the discovery of the earth's radiation belts by the IGY experiment of Dr. James A. Van Allen flown on EXPLORER I, the first U.S. satellite. VANGUARD I



Historic Scientific Spacecraft: Portrayed here are representative early U.S. unmanned spacecraft. (Not shown: Department of Defense satellites).



ECHO I

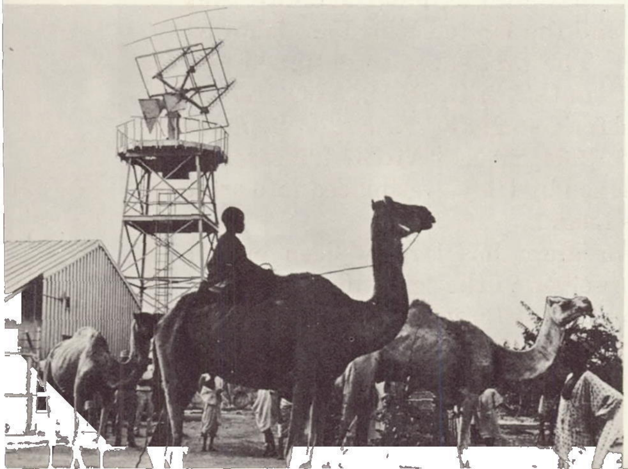
likewise compiled a distinguished scientific record by providing data on solar pressure, and the slightly pear-shape of the earth. As early NASA Explorer satellites, space probes, and satellite observatories were to be defined in 1959, enthusiasm caught hold of scientists in many disciplines as they came to see the startling new opportunities for new knowledge promised by projecting their instruments and experiments into the previously inaccessible reaches of the extraterrestrial environment.

It was to be a characteristic of scientific activities in space in the early phase of the Space Age and later, that they ceased to be front-page news as soon as satellites were launched. The press corps noted the launchings, added them to the "box score" of comparative U.S. and U.S.S.R. launchings, and that was that. But once in orbit, a scientific satellite or space probe merely begins the process of acquiring experimental data, which then require time-consuming and exacting analysis and validation of the evidence. The difficult task of piecing together what Dr. Harry Goett, first Director of NASA's Goddard Space Flight Center, has called "the cosmic jigsaw puzzle" of the space environment only rarely merits newspaper attention. EXPLORER XI was to disprove the matter-antimatter theory of steady-state cosmology, while the discovery of the helium layer by EXPLORER VIII and the P–21 probe revised existing concepts of the composition profile of the earth's upper atmosphere.

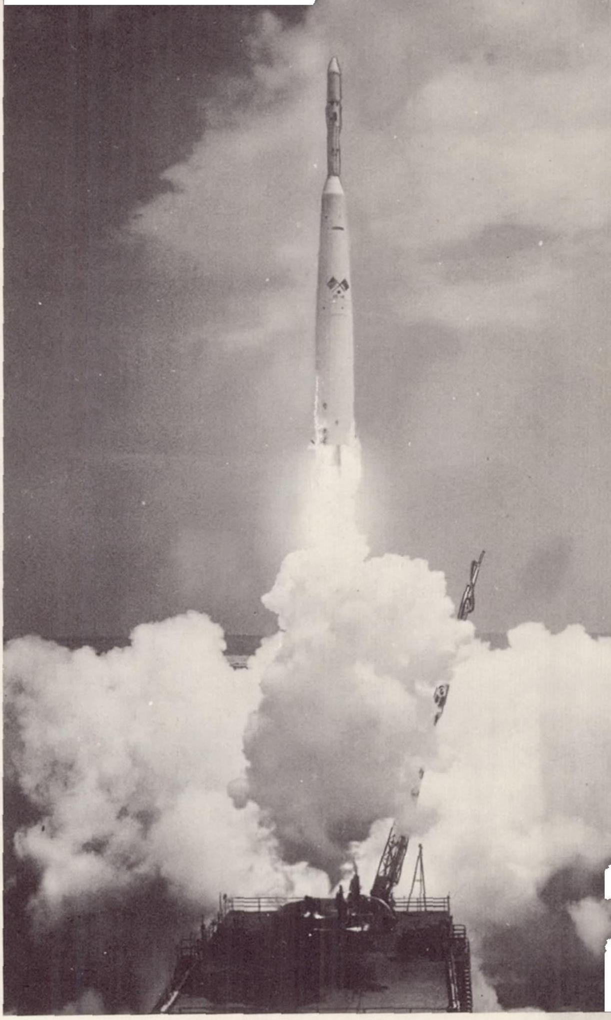
Under the Space Act, NASA began at once to work out a coherent variety of space science projects. The basic nature of our solar system, no less, dictated early attention to earth-sun relationships, the structure of the atmosphere, the shape and the physical history of the earth, the solar system, and the universe. The close-by moon was of particular scientific interest because, lacking an atmosphere, it is little eroded and could be a Rosetta Stone for 100 million years of the geological history of our solar system. Knowledge of micrometeroids, temperatures, and solar radiation was likewise basic for the design of reliable scientific spacecraft as well as for safe manned space flight operations.

Progress in the space sciences (i.e., science in space) proved a chain-reaction process as previously unknown information was acquired by the early NASA satellites. VANGUARD I, for example, had made accurate tracking possible because of its concentric orbit but posed new problems for the astrophysicist interested in the radiation pressure from the sun as well as for the geophysicist studying the temperature and composition of the earth's upper atmosphere. The flight of ECHO I, the 100-foot diameter balloon-satellite launched on August 12, 1960, confirmed the solar pressure data produced by VANGUARD I as well as providing a man-made satellite visible around the world to the naked eye, and also proved to be a very successful reflector for communications experiments. Other pieces of the space environment began to fit new patterns of understanding as the hundreds of miles of telemetry tape were assessed by the experimenting scientists. Where the early satellites contained six to eight experiments, later satellite observatories such as OGO I and OSO I were to include twenty or more, an indication of how swiftly the dimensions of space science activities were to expand.

Many of NASA's scientific programs have been logical outgrowths of the international scientific cooperation established by the International Geophysical Year (June 1957–December 1958) which had opened the Space Age. From 1960 on, more than 60 nations were to join with NASA in the peaceful exploration of outer space. This included various arrangements of mutual



NASA Tracking Station at Kano, Nigeria: One station of the globe-circling tracking and communication system required for manned and scientific satellites, pictured here with a more time-honored form of transportation.



First International Satellite—ARIEL I: Thor-Delta booster launches joint United Kingdom-United States ARIEL I satellite (S–51) into orbit from Cape Canaveral on April 26, 1962. First satellite other than United States or U.S.S.R. was ALOUETTE (S–27), launched from the Pacific Missile Range into polar orbit for Canada by NASA on September 28, 1962.

interest, no transfer of NASA funds being involved. Global tracking and data acquisition was required by NASA while foreign scientists pressed for inclusion in the experimentation on the new frontier of science in space. Coordinated international sounding rocket launching programs begun in the IGY were continued, particularly during the International Year of the Quiet Sun. On April 26, 1962, ARIEL I, the first international satellite, was launched by the United States and the United Kingdom, followed by ARIEL II in March 1964. The first satellite designed and constructed by a country other than U.S. or U.S.S.R., ALOUETTE I, was launched into polar orbit for Canada by NASA on September 28, 1962. On December 15, 1964, SAN MARCO I, a satellite designed, constructed, and launched by Italy, was placed into orbit by a NASA Scout from Wallops Island.

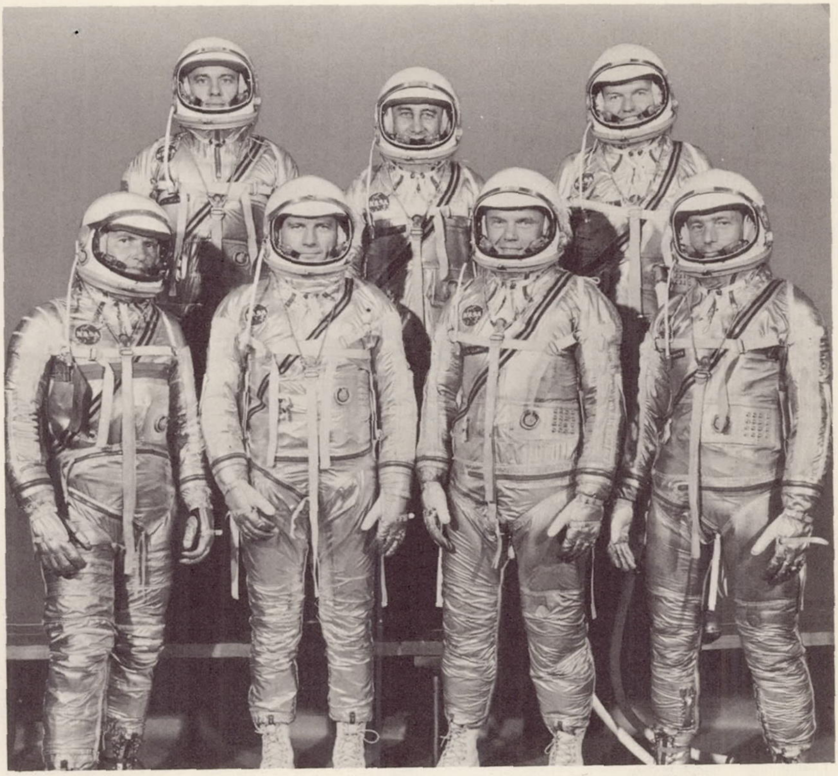
NASA's space cooperation program has largely been one of helping other nations help themselves to the scientific benefits of space exploration; enabling competent foreign scientists thus to participate in the advancement of man's knowledge concerning extraterrestrial nature. Beyond NASA-sponsored joint efforts.

NASA international program maintains close working relations with the International Committee on Space Research (COSPAR), the European Space Research Organization (ESRO), and the deliberations of the United Nations Committee on the Peaceful Uses of Outer Space. Space-acquired data, such as the 400,000 Tiros cloud-cover photographs, were to be widely made available. Since 1961, Tiros data have been coordinated with ground station weather information provided by 28 nations.

First International Meteorological Satellite Workshop: Representatives of 28 nations spent 10 days at NASA–U.S. Weather Bureau workshop called to give meteorologists from other countries increased understanding of techniques for using satellite information. Workshop was held in Washington, D.C., November 13–21, 1961.

Project Mercury

In August 1958, President Eisenhower had assigned responsibility for the first American manned space flight program to NASA. During its first week, NASA created a new organization to be responsible for Project Mercury and for planning follow-on manned flight programs. This was the Space Task Group (STG) under Dr. Robert R. Gilruth, which was created at Langley AFB, Virginia, and originally consisted of 45 specialists drawn from Langley and Lewis Research Centers. Technology and related studies sponsored by the Air Force and others were geared into this first manned satellite program. STG included many key NACA people who had been working on the design of manned spacecraft for some years as well as select military personnel assigned to support this American effort. The latter included the seven Mercury astronauts screened out of the Nation's best-qualified engineer test-pilots.



Project Mercury Astronauts: First official photo of the seven engineer-test pilots selected for the first U.S. manned space flight program in their Mercury space suits. Front row (left to right), Walter M. Schirra, Jr. (Lt. Comdr., USN), Donald K. Slayton (Capt., USAF), John H. Glenn, Jr. (Lt. Col., USMC), and M. Scott Carpenter (Lt., USN). Back row (left to right), Alan B. Shepard, Jr. (Lt. Comdr., USN), Virgil I. Grissom (Capt., USAF), and Leroy G. Cooper, Jr. (Capt., USAF).

NASA Mercury Control Center: Monitoring and control of Project Mercury manned orbital flights was performed at the NASA Mercury Control Center at Cape Canaveral, now called Cape Kennedy. Center plot board pictures the planned six-orbit MA–8 flight of Astronaut Schirra, which took place on October 3, 1962.

Over two million persons were ultimately to participate in Project Mercury. In addition to a host of contractors, support to Mercury was provided NASA by the military services for tracking and telemetry, astronaut recovery forces, operation of the Atlantic Missile Range, and specialized requirements such as aerospace medicine. The "Little Joe" test rocket as well as the worldwide communication system was developed by Langley Research Center, while Goddard operated the communications and orbital computations. ABMA-MSFC man-rated the Redstone for suborbital test flights, and the Air Force provided the man-rated Atlas booster so successfully utilized in the manned orbital flights. Project Mercury became truly a national effort.

Because of open press and live television coverage of the launching of all the Mercury astronauts, the American public and the rest of the world were able also to witness and appreciate the complexity and drama of man's early ventures into the hostile space medium. The suborbital flights of Commander Alan B. Shepard (USN) on May 5, 1961, and Captain Virgil I. Grissom (USAF) on July 21, 1961; the three-orbit flights of Lt. Colonel John H. Glenn, Jr. (USMC) on February 20, 1962, and Commander M. Scott Carpenter (USN) on May 24, 1962; the six-orbit flight of Commander Walter M. Schirra, Jr. (USN) on October 2, 1962; and the 22-orbit flight of Major Gordon Cooper (USAF) on May

John Glenn Reports to the Congress: First American to orbit around the earth in Mercury spacecraft gave a 20-minute address to a joint session of the Congress on February 26, 1962. After paying tribute to the Project Mercury team, Astronaut Glenn said: "We are just probing the surface of the greatest advancement in man's knowledge of his surroundings that has ever been made. . . . There are benefits to science across the board. Any major effort such as this results in research by so many different specialties that it's hard to even envision the benefits that will accrue in many fields."

X–15 Honors: X–15 Awards Ceremony in NASA Headquarters on July 18, 1962, NASA Outstanding Leadership Awards and Distinguished Service Awards were presented by Vice President Lyndon B. Johnson, Chairman of the National Aeronautics and Space Council. Shown (left to right) are Maj. Robert M. White (USAF), Hartley A. Soule (X–15 Project Manager), NASA Administrator James E. Webb, Vice President Johnson, Paul F. Bikle (Director of NASA Flight Research Center), Joseph A. Walker (NASA), and Comdr. Forrest Petersen (USN). Test pilots White, Walker, and Petersen had earlier in the day, along with A. Scott Crossfield, received the Robert J. Collier Trophy from President Kennedy at the White House.

15–16, 1963—these are the milestones in manned space flight known to all Americans. The technological roots of Project Mercury, of course, extend back into the pre-NASA history of NACA aerospace research leading to the X–15 rocket research airplane as well as to military weapons systems and rocket development. Begun as the first U.S. manned space flight program during the first week of NASA's existence, Mercury comprised a step-by-step

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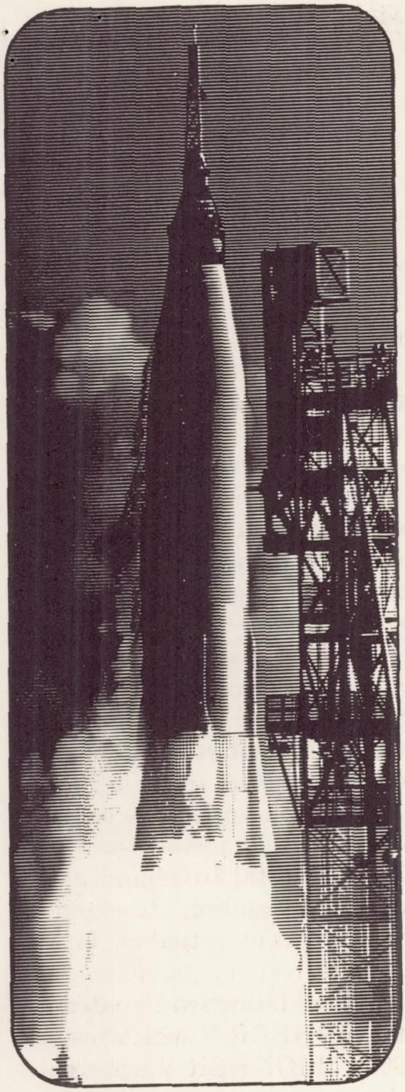
series of 25 space flights involving six astronauts and four primates, none of whom was lost. Before Mercury was completed, the follow-on manned space flight Apollo and Gemini programs were initiated and well into development.

NASA's Long-Range Planning:

While Project Mercury was underway, NASA's consolidated program was gaining direction and momentum. Early in 1960, the first NASA "Ten-Year Plan" was presented to the Congress. It pointed to the future goal of manned exploration of the moon and the nearby planets. A series of technological developments including the eight-engine Saturn booster with 1.5 million pounds of thrust, scientific satellites and probes, and practical weather and communication satellites were specified. While asking for less than a billion dollars for Fiscal Year 1961, Administrator Glennan indicated that NASA's long-range plan could cost "at least $12 to $15 billion during the next decade." The base of the Ten-Year Plan was for the development of a family of standardized space booster rockets, defined as the National Launch Vehicle Program. Rather than utilize adapted military missiles, the National Launch Vehicle Program was a NASA–DOD outline of classes of boosters capable of performing specific space missions by payload weights and flight parameters. The Saturn, later called "Saturn I," was indicated as the space workhorse of the future. The importance of NASA's Ten-Year Plan was that for the first time the entire complex of inherited facilities and personnel under NASA—NACA, JPL, ABMA, Vanguard, etc.—could be programed for the future with augmenting contractual arrangements with industry, other agencies, and university participants.

By the end of 1960, the United States had launched two deep-space probes, the most successful being PIONEER V which made its historic flight in the summer of 1960. PIONEER V acquired the first data on the nature of interplanetary space to a distance of 18 million miles and established a communications distance record of 22.5 million miles which was not to be broken until the flight of MARINER II in 1962. The U.S. had also launched 31 earth satellites by the end of 1960 as compared to 7 Russian satellites. This included TIROS I and II, ECHO I, and DISCOVERER XIII, the USAF data capsule of the latter being the first man-made object recovered from orbital flight. Russia's LUNIK II impacted the moon. LUNIK III made a crude photograph of the back side of the moon, a feat yet to be matched by the American space effort. As history would have it, however, the first dramatic space flights by man himself were to spark an expansion of the American space effort and an acceleration of goal accomplishment far beyond what had been instituted in the exciting kindergarten era of the Space Age.



The Expanded Space Program

A chain-reaction of events in 1961 increased greatly the level of the American space effort. The goals of space exploration by the United States remained as originally stated in the Space Act. Election of President John F. Kennedy, however, brought about a detailed review of where the United States was in its space effort and at what pace it was proceeding. Many of NASA's major programs such as Mercury were reaching operational status in 1961, while planning for future space missions and follow-on programs had been undertaken. Decisions on large and expensive space booster development for future space missions had to be made soon by the new Administration. In the same time period, the Soviet Union began the launching and recovery from orbit of spacecraft containing living payloads. On August 19, 1960, the U.S.S.R. successfully recovered the first biological payload after a 17-orbit flight: two dogs, rats, mice, flies, plants, and seeds. On March 9, 1961, the U.S.S.R. repeated this feat. On April 12, 1961, Soviet Cosmonaut Yuri Gagarin in VOSTOK I became the first man to orbit the earth. The Space Age was to now enter its second phase.

Review and Decision:

During 1959 and 1960, NASA made detailed studies of manned and unmanned programs for future space missions in support of the Ten-Year Plan. On July 5, 1960, the House Committee on Science and Astronautics recommended NASA revise its Ten-Year Plan time-table for a manned lunar expedition from "after 1970" to a "high priority program . . . in this decade." On July 29, 1960, NASA announced Project Apollo as the successor to Project Mercury, with the objective of carrying three astronauts in sustained orbital flight or circumlunar flight. Industry studies were initiated shortly thereafter. On October 17, 1960, George Low, Chief of Manned Space Flight in NASA Headquarters, formed an Ad Hoc Manned Lunar Landing Program Working Group "to prepare an integrated development plan" of a program for manned lunar landings. By January 5–6, 1961, detailed presentations by Space Task Group, Langley, Marshall, and Headquarters personnel covered all lunar-landing mission modes and general program requirements. It was clear that a White House decision would be required before a program of such magnitude could be undertaken. NASA created a Manned Lunar Landing Working Task Group on January 6, 1961, however, to proceed with detailed planning for a lunar landing mission.

President-elect John F. Kennedy in the meantime had created a task force, chaired by Dr. Jerome B. Wiesner of MIT—who shortly would become the President's science advisor—to examine the national space program. On January 10, 1961, this task force submitted what became known as the Wiesner Report to the President-elect. Released to the public two days later, this report called for a sweeping reorganization of the U.S. space effort, including utilization of the National Aeronautics and Space Council, single direction of military space efforts in DOD, stronger technical management in NASA, and closer Government partnership with industry. This report was critical of Project Mercury.

On January 16, 1961, President Eisenhower's FY 1962 budget for NASA was submitted to the Congress. It contained limited post-Mercury funding, saying: "Further test and experimentation will be necessary to establish if there are any valid scientific reasons for extending manned space flight beyond the Mercury program." These were dark and uncertain days for NASA. Until man successfully flew in the weightless environment and stresses of space flight longer than the seconds that could be simulated on the ground or in aircraft, the scientific validity of future manned space flight could be questioned.

From a "pieced together" new agency in October 1958, NASA had grown in orderly fashion by January 1961 into a well-knit program and space-dedicated team. NASA planning proceeded. NASA's drive to proceed with the Ten-Year Plan thus coincided with the early days of the new Kennedy Administration. On January 24, 1961, the first draft of "A Plan for Manned Lunar Landing" was submitted by the Working Task Group to NASA's Associate Administrator Robert C. Seamans, Jr. On January 31, 1961, a Mercury-Redstone (MR-2) launched the space chimp "Ham" in a successful suborbital flight from Cape Canaveral. That same day, the President nominated James E. Webb to be the new Administrator of NASA. He had been Director of the Bureau of the Budget and Under Secretary of State during the Truman Administration. Subsequent events were to shift the American space program into high gear.

Administrator James E. Webb of NASA and Secretary of Defense Robert S. McNamara were directed by President Kennedy to review the overall U.S. space program during February. Approval was first given by the new President for advancing the pace of large rocket booster development on March 23, 1961. The one-orbit flight of Cosmonaut Yuri Gagarin in VOSTOK I on April 12, prompted President Kennedy to say that "no one is more tired than I am" of seeing the United States second in space. VOSTOK I was, in its impact, a second-verse Sputnik. NASA spokesmen testifying before the House Committee on Science and Astronautics after the Gagarin flight were pressed to admit that NASA's planning to date had indicated that a manned lunar landing could be accomplished by the United States before 1970 with additional funding.

The President directed Vice President Lyndon B. Johnson, new Chairman of the National Aeronautics and Space Council, to make a thorough examination of what should be done. The first space flight by an American, the suborbital flight of Alan B. Shepard in FREEDOM 7 on May 5, 1961, brought to a climax the NASA recommendation for undertaking a lunar landing mission within this decade. The integrity of Project Mercury was confirmed and the worldwide reaction to the open launching of an American astronaut gave Space Age credence to the virtues of the open society.

On May 25, 1961, President Kennedy stated in his second State of the Union message to the Congress:

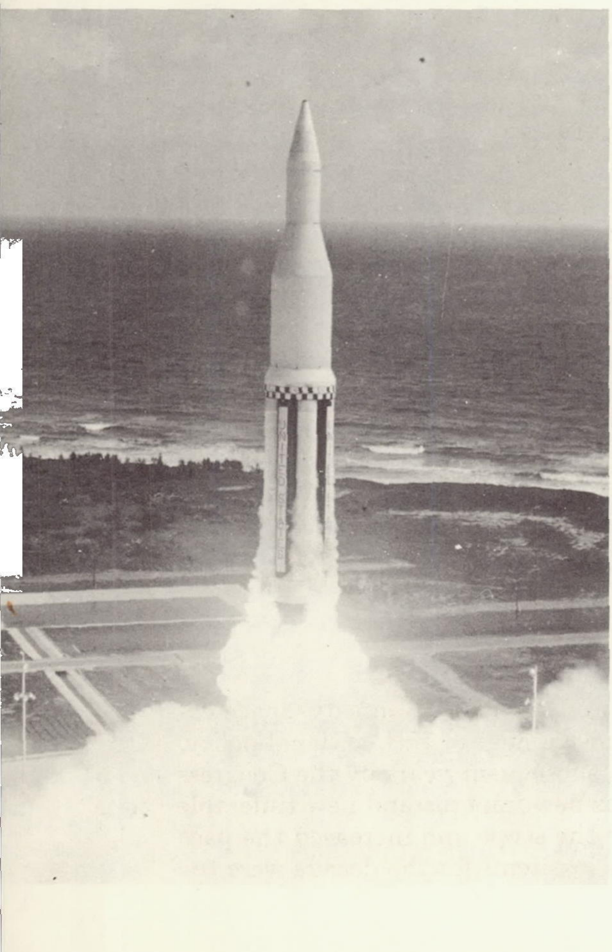
> With the advice of the Vice President, who is Chairman of the National Space Council, we have examined where we [the U.S.] are strong and where we are not, where we may succeed and where we may not. . . .
>
> Now is the time to take longer strides—time for a great new American enterprise—time for this Nation to take a

clearly leading role in space achievement which in many ways may hold the key to our future on Earth. . . .

Recognizing the head start obtained by the Soviets with their large rocket engines . . . we nevertheless are required to make new efforts on our own. . . . This is not merely a race. Space is open to us now; and our eagerness to share its meaning is not governed by the effort of others. We go into space because whatever mankind must undertake, free men must fully share. . . .

First, I believe that this Nation should commit itself to achieving the goal, before this decade is out, of landing a man on the moon and returning him safely to earth. No single space project in this period will be more impressive to mankind, or more important for the long-range exploration of space; and none will be so difficult or expensive to accomplish. . . . It will not be one man going to the moon—if we make this judgment affirmatively, it will be an entire nation. . . .

In laying out an expanded NASA program to include also additional funding for development of nuclear rockets as well as



First Saturn I Launching: Saturn I (SA–1) makes first test flight from Cape Canaveral on October 27, 1961. First ten test flights of this eight-engine clustered first-stage generating 1.5 million pounds of thrust were successful. Saturn development began in 1958, based on Juno V design.

communications and weather satellites, President Kennedy stated that this was a "choice, which this country must make." The historic decision to take longer strides" with Project Apollo was fully endorsed by subsequent Congressional action and public opinion. With the 17-orbit flight of Soviet Cosmonaut Gherman Titov on August 6–7, 1961, the basis for the American decision to land an American on the moon before 1970—a decision taken before the first orbital flight by a Mercury astronaut—was confirmed. On October 27, 1961, the first Saturn I, generating 1.3 million pounds of thrust, made a successful maiden flight. The opening of the second phase of the Space Age in 1961 continued the drama and expansion which had begun with Sputnik in 1957.

President Kennedy Inspects Apollo Model: President John F. Kennedy and Dr. R. Gilruth, Director of NASA Manned Spacecraft Center at Houston, Tex., inspect small model of Apollo lunar spacecraft on September 12, 1962. Speaking at Rice University later in the day, President Kennedy stated that the United States means "to become the world's leading spacefaring nation. We sail on this new sea because there is new knowledge to be gained, and new rights to be won, and they must be won and used for the progress of all people."

Expansion of NASA:

With the May 25 declaration of President Kennedy, space exploration thus became a major instrument of U.S. national policy, one which has been sustained in subsequent years by the Congress and the American people. This new impetus and new timetable for the space venture expanded the scope and increased the pace of NASA's program. Major pacing items for the decade were the facilities required to support the accelerated program. Basic implementation decisions were made in 1961, including the following:

- To expand and move the Space Task Group to Houston, Tex., where would be located the Manned Spacecraft Center for Projects Gemini and Apollo, including the manned lunar missions.

- To expand fivefold the launching facilities nearby Cape Canaveral on Merritt Island to accommodate the enormous new Saturn V-class launch vehicles coming into the U.S. space program.

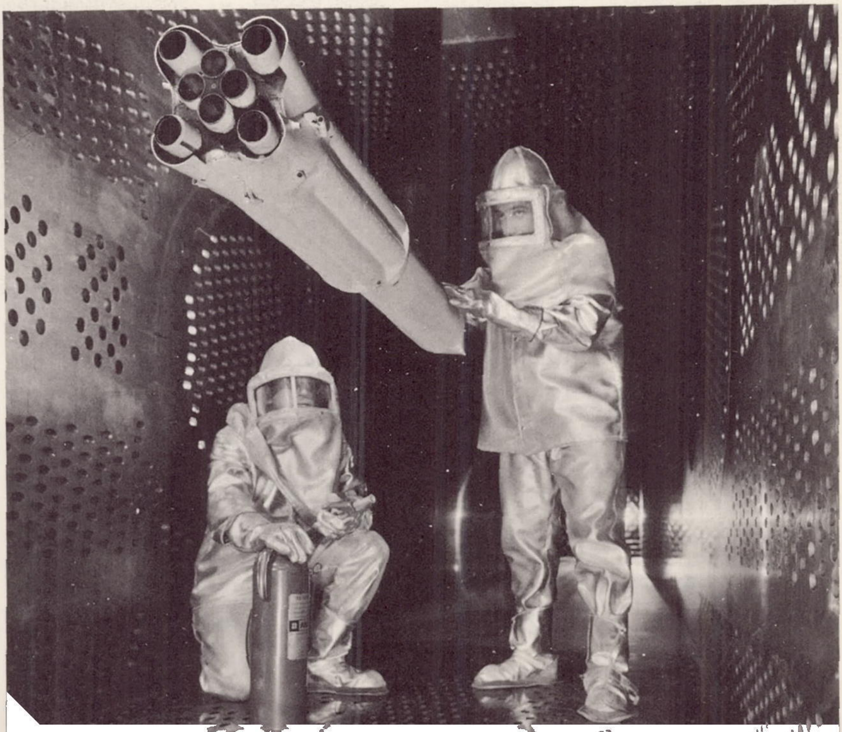
- To create a spacecraft fabrication facility at the Michoud Ordnance Plant near New Orleans for the construction by contractors of the Saturn family of large boosters which could then be water-transported to Florida for launching.

- To acquire and develop a site in southwestern Mississippi for the static testing of Saturn-class vehicles.

NASA Managers—1962: Seventh Management Conference of NASA was held at Langley Research Center on October 4–5, 1962. Seated in front row (left to right) are James E. Webb, NASA Administrator; Robert C. Seamans, Jr., Associate NASA Administrator; and Hugh L. Dryden, Deputy NASA Administrator. Back row (left to right) Floyd L. Thompson, Director of Langley Research Center; Eugene J. Manganiello, Associate Director of Lewis Research Center; Brian Sparks, Jet Propulsion Laboratory; Wernher von Braun, Director of Marshall Space Flight Center; Harry J. Goett, Director of Goddard Space Flight Center; Smith J. DeFrance, Director of Ames Research Center; Robert R. Gilruth, Director of Manned Spacecraft Center; Paul F. Bikle, Director of Flight Research Center; Kurt Debus, Director of Launch Operations Center; and Robert L. Krieger, Director of Wallops Station.

NASA Headquarters was given a new organizational structure effective November 1, 1961, to realign its management for the expanded U.S. civilian space program. From an administrative point of view, 1961 was perhaps NASA's most eventful year. Major program offices were created, with project management clearly identified, the respective roles of the field centers and supporting activities defined. Revised Program Evaluation and Review Techniques (NASA's PERT) and agency-wide reliability and quality assurance systems were instituted. Basic contracts were let with industry as soon as they could be precisely defined under the expanded program. Through grants and contracts NASA extended working relationships with the academic and scientific institutions which have much to contribute to the national space exploration effort over the long haul. The Army Engineers were asked to undertake the massive and timely construction of new facilities. Through the NASA–DOD Aeronautics and Astronautics Coordinating Board efforts were implemented to ensure effective working relationships on all aspects of NASA's program with the vital interests of the Department of Defense. When NASA obtained Congressional sanction in 1964 to establish an Electronics Research Center in Cambridge, Massachusetts, the overall structure of major NASA facilities as presently constituted had largely been laid out.

Lewis Tests Saturn I: Technicians at NASA's Lewis Research Center check out a model of the 1½-million-pound-thrust Saturn I booster before studying base heating problems in a supersonic wind tunnel run.



With endorsement of manned exploration of the moon as a priority goal NASA established task groups to determine the phasing of the unmanned Ranger and Surveyor probes with the Apollo schedule as well as the development of large space booster requirements. In July, NASA and DOD jointly undertook a study of the National Launch Vehicle Program (Golovin-Kavanau Committee) which, by December 1961, had completed among its recomendations that which became the Saturn IB and Saturn V space boosters. The major decision of 1962 was that of the "lunar

NASA Astronauts: By 1964, a total of 30 engineer-test pilots had been selected as NASA astronauts and put in training for manned space flight. Above, seated, is the original Project Mercury group (left to right): L. Gordon Cooper, Jr.; Virgil I. Grissom; M. Scott Carpenter; Walter M. Schirra, Jr.; John H. Glenn, Jr.; Alan B. Shepard, Jr.; and Donald K. Slayton. In the rear, standing, is the second group of astronauts, selected in September 1962 to join the Mercury astronauts in the larger Gemini and Apollo programs (left to right): Edward H. White II; James A. McDivitt; John W. Young; Elliot M. See, Jr.; Charles Conrad, Jr.; Frank Borman; Neil A. Armstrong; Thomas P. Stafford; and James A. Lovell, Jr. The photograph below shows the third group of astronauts. They were selected in October 1963. Seated (left to right): Edwin E. Aldrin, Jr.; William A. Anders; Charles A. Bassett II; Alan L. Bean; Eugene A. Cernan; and Roger B. Chaffee. Standing (left to right): Michael Collins; R. Walter Cunningham; Donn F. Eisele; Theodore C. Freeman; Richard F. Gordon, Jr.; Russell L. Schweikart; David R. Scott; and Clifton C. Williams, Jr. (John Glenn resigned from the program in January 1964; Theodore Freeman lost his life in an aircraft accident in October 1964).

orbital mode" for the Apollo lunar landing mission. This was a concept first proposed by Dr. John Houbolt of Langley Research Center as an alternative to the direct ascent or an earth-orbital-rendezvous method of achieving the lunar landing mission. New astronauts were named. In January 1962, Project Gemini was announced as a two-man earth-orbital extension of fundamental manned space flight technology beyond Mercury. It was also phased to contribute to Project Apollo as well as development of fundamental knowledge concerning extended manned flight. Its Titan II booster and progressive development of earth-orbital flight techniques made Gemini of increased DOD interest in the manned space flight effort. The highly successful Mercury orbital flights of John Glenn, Scott Carpenter, Walter Schirra, and Gordon Cooper during 1962 and 1963 provided both insights and confidence in manned space flight operations targeting for the future. As NASA spokesmen have often explained, selection of the difficult manned lunar landing mission had the important purpose of instilling urgency and purpose in the entire space program.

Growth and Progress:

The expanded national commitment of resources for space exploration was characterized by both internal growth and management realignments within NASA. In January 1961, President Eisenhower had requested $1.1 billion for NASA in Fiscal Year 1962. Two years later, $5.7 billion was requested by NASA for FY 1964, a 500 per cent increase, most of which was provided by the Congress. In December 1960, NASA had a total of 16,042 employees. Two years later it had 30,069 employees, and 34,000 by 1965. In a very real sense, NASA was to make a capital investment in facilities, skilled scientific and management personnel, and the resources to make the United States a "space-faring nation" as the late President Kennedy once called for.

Inevitably, perhaps, a "space dialogue" was manifested during 1963 as various segments of the American public questioned the increased cost of the space commitment relative to other major programs. When all was said and done, however, the national decision to undertake an aggressive and vigorous space program was reconfirmed.

The Soviet space challenge was further demonstrated by the twin Vostok flights of 1962 and 1963, Cosmonaut V. F. Bykovsky making as many as 81-orbits. VOSTOK VI featured the 48-orbits of the first woman to make a space flight. The 24-hour three-man flight by a physician, scientist, and cosmonaut in VOSKHOD I in October 1964, and the spectacular flight of VOSKHOD II in March 1965, continued to confirm the intent and competence of the Soviet competition. Such exploits also helped dissolve many of the arguments of those who were inclined to stretch out over a longer period of time the cost of the accelerated U.S. space program.

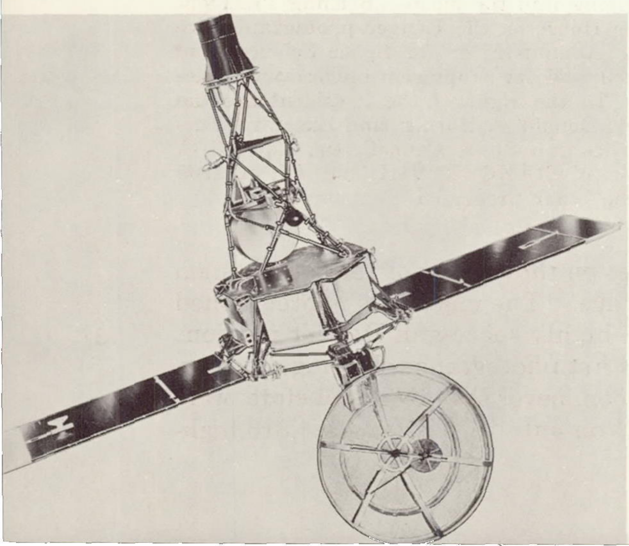
The first two-man Gemini flight (GT–3), by Astronauts Virgil Grissom and John W. Young on March 23, 1965, came after a 22-month lapse was bridged since the final Mercury flight by Gordon Cooper. It demonstrated that the overall manned space flight portion of NASA's program was much more than the lunar landing Apollo mission. The eighth successful launching of the 1.5-million-pound-thrust Saturn I, used to orbit PEGASUS I on February 16, 1965, was followed by the first static firing of the giant 8.5-million-pound-thrust Saturn V in April 1965. As the booster for Apollo and future missions, the Saturn V test signalled that the long Russian lead in rocket thrust central to manned space flight missions might one day be ended. A payload equal in weight to ninety Mercury spacecraft, for example, could be placed into earth orbit by a Saturn V booster.

As the massive new NASA launch facilities at Cape Kennedy neared completion and the Mission Control Center at the Manned Spacecraft Center operated on the GEMINI IV mission in June 1965, the emergence of basic American space potentials stemming from the 1961 decision for acceleration became well apparent by 1965. The spectacular space "walk" of Astronaut Edward White during the GEMINI IV mission, as well as the record 120-revolution flight of GEMINI V, clearly indicated that the U.S. manned space effort was second to none.

Beyond the drama and scientific interest in landing a crew on the moon and the milestones for extended manned orbital flight in Project Gemini were the spectacular scientific and practical accomplishments of other NASA missions. They confirmed the broad-based nature of the U.S. space program directed towards the peaceful uses of outer space for the benefit of all mankind.

Mariners, Rangers, and Orbiting Observatories:

Unmanned exploration of cislunar and interplanetary space and of the surface of the moon, as well as the first successful scientific



MARINER II Spacecraft: Historic spacecraft which flew past the planet Venus on December 14, 1962.

reconnaissance of the planets Venus and Mars, placed the names of "Mariner" and "Ranger" prominently in the history of the Space Age. Launched by an Atlas-Agena on August 2, 1962, MARINER II intercepted the planet Venus 109 days later. Passing Venus within 21,594 miles on December 14, MARINER II made a 42-minute scan indicating that Venus has little or no magnetic field and that the surface of Venus may be considerably hotter than the 600° F previously assumed. The first successful planetary probe by man was an exciting scientific event. On November 28, 1964, MARINER IV was launched successfully, which was to make a similar flypast of the mysterious planet Mars on July 14, 1965. The disclosure of moon-like craters on the surface of Mars was a startling scientific discovery. Increased knowledge of the space environment is important to the continued advancement of man's efforts to understand and control his environment.

The legendary moon has been a priority target of NASA unmanned space exploration: it is near to the earth and also offers

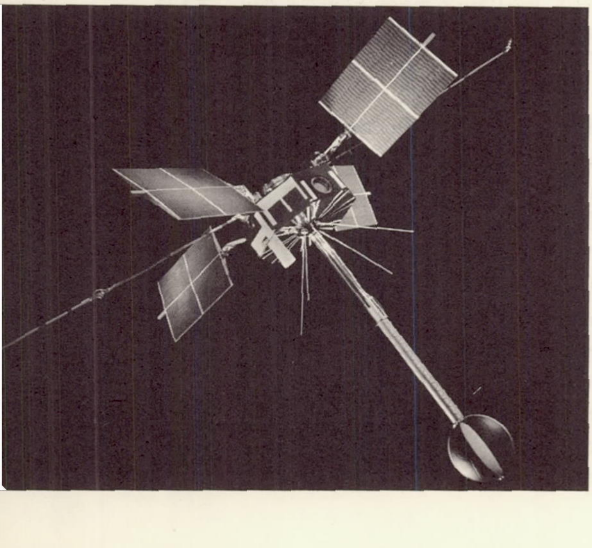
President Johnson Views RANGER VII Photos of the Moon: One of the highlights of the space program came on July 31, 1964, when RANGER VII photographed and returned to earth more than 4,000 closeup photographs of the lunar surface before crashing into the moon. Briefing President Lyndon B. Johnson at the White House on the Ranger photographs are (left to right) NASA Associate Administrator for Space Sciences and Applications, Dr. Homer E. Newell, and Jet Propulsion Laboratory Director, Dr. William H. Pickering. To the right of the President are the President's Scientific Adviser, Dr. Donald F. Hornig, and Executive Secretary of the National Aeronautics and Space Council, Dr. Edward C. Welsh. The successful missions of RANGER VIII and IX in 1965 concluded one of the most exciting lunar programs.

the possibility of scientific clues on the history of the solar system because of its erosion-free surface. The moon was photographed in spectacular detail by three highly successful Ranger missions in late 1964 and early 1965. First photographs showing detail on the pockmarked face of the moon, never seen by man before, were made by JPL's RANGER VII on July 28, 1964. Its 4,316 high-quality photographs transmitted before it crashed were duplicated for two other possible Apollo landing sites by RANGER VIII and IX in early 1965. Photographs of rills and small craters of the moon have stimulated all scientists holding various theories concerning the unknown nature of the structure and surface of the earth's natural satellite. The Surveyor program to soft-land an instrumented spacecraft on the moon in 1967 will offer new scientific evidence, perhaps raise more questions, as the physical nature of the moon is further documented before man sets foot on its surface.

What was not generally appreciated, as in the case of the Ranger program, that behind the dramatic newspaper headlines and TV coverage of a spectacular space mission success, was much painstaking toil, technical complexity, and often disappointment. RANGER I was launched in August 1961. While RANGERS III and V in 1962 missed the moon, RANGER IV on April 26, 1962, achieved the first U.S. lunar impact. How frustrating it must have been for the Jet Propulsion Laboratory team when RANGER VI made a "textbook flight" to a lunar impact on January 30, 1964, only to have its TV cameras not function in the last crucial 15 minutes of flight. One of the spectacular features of the last RANGER IX mission was that live TV coverage of the photographic mission until impact was observed by millions of Americans.

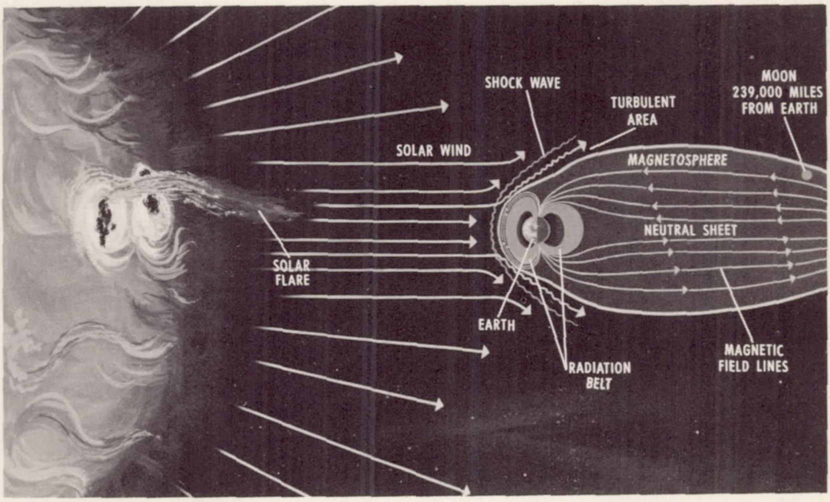
As planning proceeds for determining future planetary and lunar explorations, both manned and unmanned, it is significant to look back and realize how quickly some of the early promises of space exploration have been fulfilled by the pioneering missions of the Mariners and the Rangers.

The greatest amount of scientific data acquired in the NASA program has come from the Explorer class of satellites. Smaller spacecraft than the new generation of orbiting observatories, the Explorers were launched into a variety of orbits by the relatively



EXPLORER XVIII: Launched on November 26, 1963, this interplanetary monitoring platform (IMP), was essentially a compact physics laboratory measuring magnetic fields, cosmic rays, and solar winds in interplanetary space.

inexpensive Scout and Delta vehicles for specific scientific investigations. Most NASA Explorers have flown experiments developed by NASA laboratories, universities, industry, or cooperating countries. They have provided information on the environment of the earth, including its solar, terrestrial, and interplanetary relationships, as well as for astronomical and geodetic investigations. EXPLORERS XII and XIV observed properties of the solar wind and its interaction with the geomagnetic field, while EXPLORERS XVIII and XXI helped determine that the magnetosphere is swept out behind the earth by the solar wind. Indications are that this tail extends well beyond the moon and resembles in many respects the tail of a comet. Numerous sounding



Earth-Sun Phenomena Showing Comet-tail Magnetosphere.

rocket experiments, as many as a hundred in 1964, were launched to support NASA's space science program. These were launched from sites in the United States, Canada, Pakistan, India, Norway, Sweden, and ships at sea. For the International Quiet Sun Year during 1965, a worldwide series of launchings was undertaken.

The new observatory class of scientific satellites placed larger payloads of longer lifetime into earth orbit. The Orbiting Solar Observatory (OSO) opened a new era in solar astronomy. OSO I, launched on March 7, 1962, provided 2,000 hours of observation of the solar spectrum in the ultraviolet and x-ray regions. Scheduled for launching were seven additional OSO's, each carrying different instrumentation, which would be of increasing advanced design. The Orbiting Astronomical Observatory (OAO), initiated in 1960, would carry reflecting telescopes above the earth's filtering atmosphere in addition to photometers. The Orbiting Geophysical Observatory (OGO) provides higher data rates and a wider range of related experiments than Explorers. OGO I was launched in September 1964, while OGO II would carry 20 experiments in a survey of the earth's magnetic field.

The unmanned lunar and interplanetary programs of the future include the Surveyor spacecraft which would make soft landings on the surface of the moon and make lunar orbiter surveys. While the Ranger and Mariner programs are concluded, unmanned missions to the planet Mars by Voyager spacecraft are programed for NASA by the Jet Propulsion Laboratory. A new series of interplanetary probes, called "Pioneers," is also planned to obtain simultaneous data with earth satellites. These Pioneer probes will fill the time gaps between flights of the spacecraft sent on planetary missions.

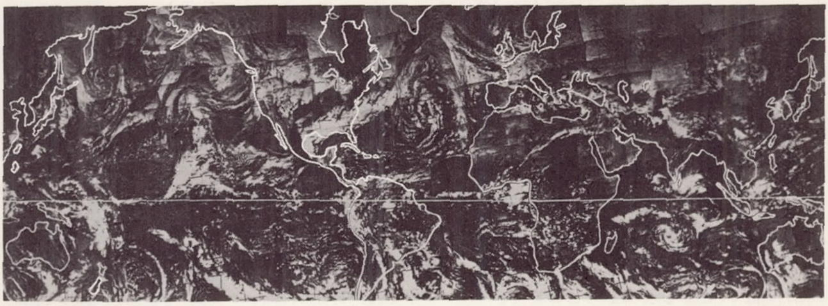
Weather and Communications Satellites:

While scientific and manned missions have provided the most exciting or spectacular events of the second phase of the Space Age, direct benefits to man's life on earth have been realized by new space-derived technologies for weather analysis and observation and for worldwide communications. Operational weather satellites and communications satellite systems became a practical reality within a brief span of time.

The ten Tiros satellites launched between April 1960 and July 1965 opened a new era in the history of meteorology. TIROS IX was the earth-oriented "wheel" prototype for an operational weather satellite system and provided photographs of the cloud cover of the entire world for each 24-hour time period. Once NASA had completed research and development, the U.S. Weather Bureau would fund and manage the Tiros operational satellite (called TOS) system.

NASA's role in the development of the earth satellite as a new tool of meteorology was notable. A practical technology serving all of mankind on earth resulted from the development phase of the Tiros program. Kites, balloons, airplanes, and sounding rockets had been used in gathering high altitude weather data before satellites. The late Dr. Harry Wexler of the U.S. Weather Bureau championed the idea of a weather satellite for the IGY. When NASA was created in 1958, responsibility for development of a weather satellite was transferred to NASA from DOD. The name of Tiros represented the acronym for Television Infrared Observation Satellite. Since the launching of TIROS I on April 1, 1960, the flood of cloud-cover photographs from above has been of direct and sometimes profound influence upon weather prognosis. Spectacular was the satellite's warning of the approach of Hurricane Carla in September 1961, which made possible the largest mass evacuation ever to take place in the United States. More than 350,000 persons fled the path of Hurricane Carla, thus minimizing its death-dealing effects. The economic value and lives saved because of numerous severe storm warnings by Tiros satellites is difficult to measure. As Chairman of the National Aeronautics and Space Council while Vice President, Lyndon B. Johnson estimated that a five-day advanced weather prediction represented national cost savings of $2.5 billion to agriculture, $4 billion to water resources management, $100 million to surface transportation, $75 million to retail marketing, and $45 million to the lumber industry.

To the general public, the Tiros photographs of the historic landscape of the surface of the earth provided a visual perspective only previously imagined by cartographers. NASA attempted to keep one operational Tiros satellite in orbit during each hurricane season. Already in August 1961, NASA and the Weather Bureau had begun the training of more than one hundred foreign weather observers on the use of Tiros photographs in weather prognosis. On April 15, 1962, the Weather Bureau began daily international transmission of cloud cover maps based on TIROS IV photographs. With the launching of TIROS VIII on December 31, 1963, the APT (automatic picture transmission) experimental camera system was orbited. With inexpensive equipment, weather



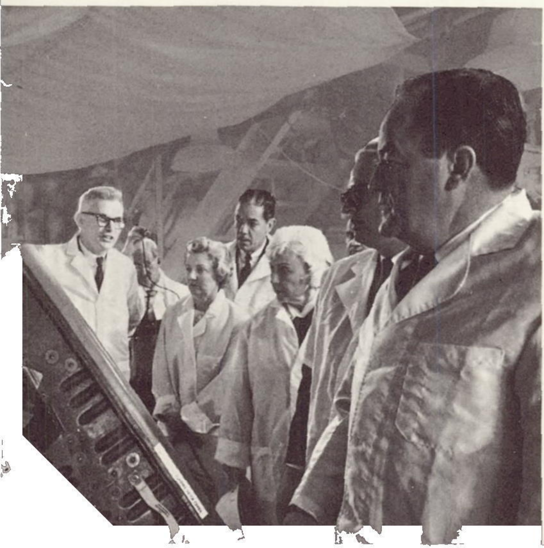
First Complete View of the World's Weather: Taken by cameras of TIROS IX on February 13, 1965.

observers around the world could read-out TIROS data immediately. Over 60 of these stations became operational, fifteeen of them in foreign nations. One of the spectacular consequences of TIROS IX operations in 1965 was the capability to have a map of the cloud cover over the entire surface of the world during any single day. The United States thus successfully pioneered and achieved the practical value of weather satellites for the benefit of mankind on earth. Little wonder that one of the first Tiros payloads was given an honored place in the Smithsonian's Air and Space Museum on the fifth anniversary of TIROS I on April 1, 1965.

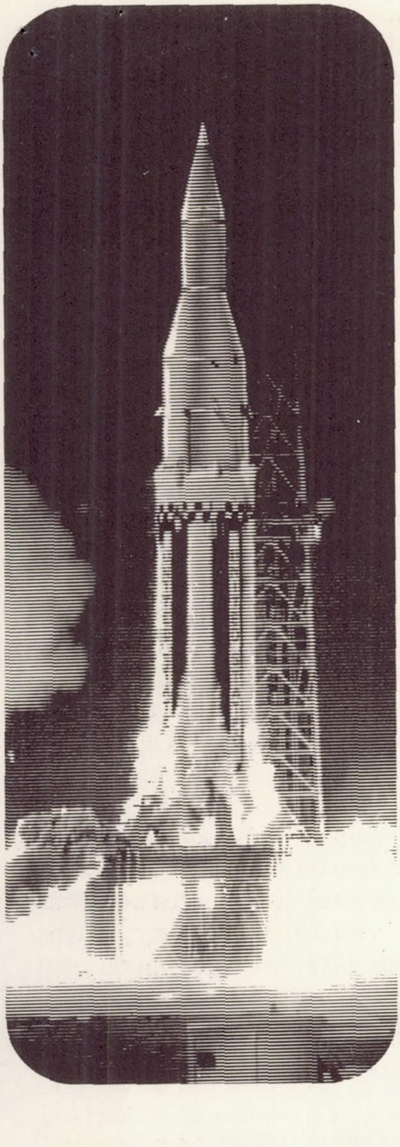
The economic and cultural significance of communication satellites was also demonstrated as a result of NASA's R & D program by mid-1965. The concept of a communications relay station in space was an old idea discussed by Edward Everett Hale in 1869, Hermann Oberth in 1923, and Arthur C. Clarke in 1945. In December 1958, Project Score had orbited an Army transmitter on an Atlas rocket. Its Christmas message from President Eisenhower was the first voice transmission from space. In October 1960, the Army Signal Corps' COURIER I-B demonstrated the role of active repeaters for both real-time and delayed transmission of high data rate messages.

NASA's experimental communications satellite program began in 1959. ECHO I, launched by NASA in August 1960, demonstrated that radio signals could be bounced off a 100-foot balloon-like reflector satellite. On July 10, 1962, NASA launched TELSTAR I for the American Telephone and Telegraph Company, and first experimental transmissions to and from Europe were achieved. NASA's RELAY I, launched in December 1962, provided first TV demonstrations between North and South America and operated twice its designed lifetime. TELSTAR II, RELAY II, and ECHO II in 1963 and 1964 provided further tests. The first U.S.-U.S.S.R. communications test was achieved with ECHO II in 1964.

On Valentine's Day 1963, NASA launched SYNCOM I, followed by SYNCOM II on July 26, 1963. A series of communications milestones were achieved involving live intercontinental TV transmissions. It was SYNCOM II which piled up 4,800 hours of experiments and tests, more than all other communications satellites combined. SYNCOM III, launched on August 19, 1964, was the first communications satellite to be successfully maneuvered into a synchronous orbit stationary above a preselected spot of the earth. It successfully relayed transmissions from the Olympic Games in Tokyo to the United States in October 1964. SYNCOM III demonstrated fully the value of the geostationary orbit and provided multichannel voice communications, teletype, and TV, with and without simultaneous voice. When NASA completed its R&D tests with SYNCOM III, operational control was transferred to the U.S. Army in April 1965. On April 6, 1965, EARLY BIRD I of the Communications Satellite Corporation was launched by NASA, the first commercial comsat. The international impact of reliable intercontinental communications was immediately evident. Plans for a consortium of twenty nations with the Comsat Corporation for an international operational system were animated. No one can fully predict the social and economic influences of communications satellites but it would appear to be considerable.



Vice President Humphrey Visits Kennedy Space Center, NASA: Vice President Hubert H. Humphrey, Chairman of the National Aeronautics and Space Council, visited Cape Kennedy, February 22, 1965. He received a first hand briefing on the launch complexes, related space hardware and looked over the 88,000 acre National Aeronautics and Space Administration's Merritt Island launching center. The visit included a stop at Complex 19 white room the launching site for Gemini-Titan II three orbital mission. (Left to right) Dr. R. C. Seamans, Jr., NASA Associate Administrator; Mrs. Burns, Governor Burns, Florida; Mrs. H. H. Humphrey; John Williams, NASA Gemini Launch Director; and Vice President H. H. Humphrey.



Impact and Implications

In a statement accompanying his annual report to the Congress on American aeronautical and space activities during the year 1964, President Lyndon B. Johnson said:

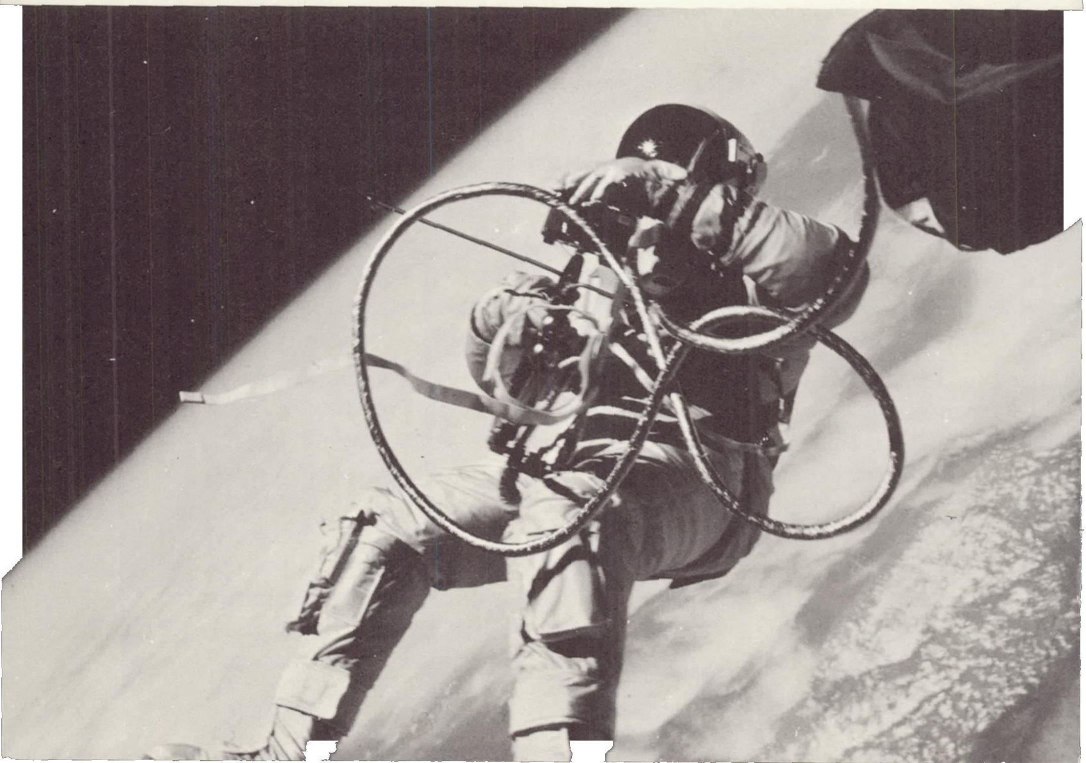
> The advances of 1964 were gratifying and heartening omens of the gains and good to come from our determined national undertaking in exploring the frontiers of space. While this great enterprise is still young, we began during the year past to realize its potential in our life on earth. As this report notes, practical uses of the benefits of space technology were almost commonplace around the globe—warning us of gathering storms, guiding our ships at sea, assisting our map-makers and serving, most valuably of all, to bring the peoples of many nations closer together in joint peaceful endeavors.

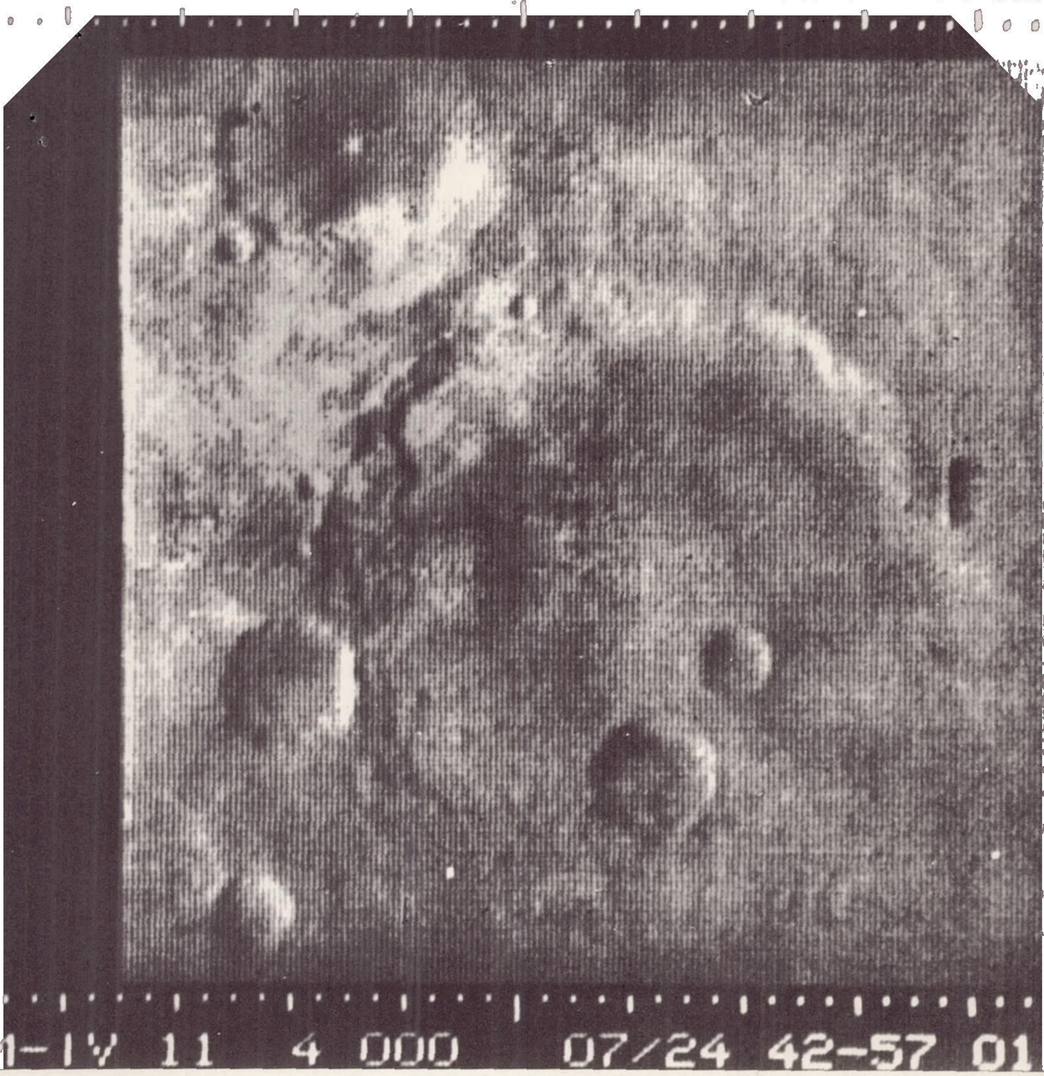
Substantial strides have been made in a very brief span of time—and more are to come. We expect to explore the moon, not just visit it or photograph it. We plan to explore and chart planets as well. We shall expand our earth laboratories into space laboratories and extend our national strength into the space dimension.

The purpose of the American people—expressed in the earliest days of the Space Age—remains unchanged and unwavering. We are determined that space shall be an avenue toward peace and we both invite and welcome all men to join with us in this great opportunity.

On February 15, 1965, NASA submitted a detailed report to the White House on future space programs for the 1970's. In April, a *Summary Report* of NASA's Future Programs Task Group was released. It contained an outline of long-range concepts which the fast-paced space effort might make feasible beyond NASA's present goals including the manned lunar landing mission. In aeronautics, lifting vehicles which could orbit as satellites and enter the atmosphere were forseen. Direct-broadcast satellites appeared possible once high power sources could be orbited. Beyond 1975, unmanned space probes "will probably be used initially to explore most of the more distant bodies in the solar system." Earth satellites will monitor the sun in detail while Voyager class spacecraft will be flown regularly to Mars and Venus. Unmanned

Astronaut Edward White's "Walk" in Space, June 3, 1965.





MARINER IV's scientifically startling closeup picture (No. 11) showing craters on the surface of the planet Mars, taken on July 14, 1965.

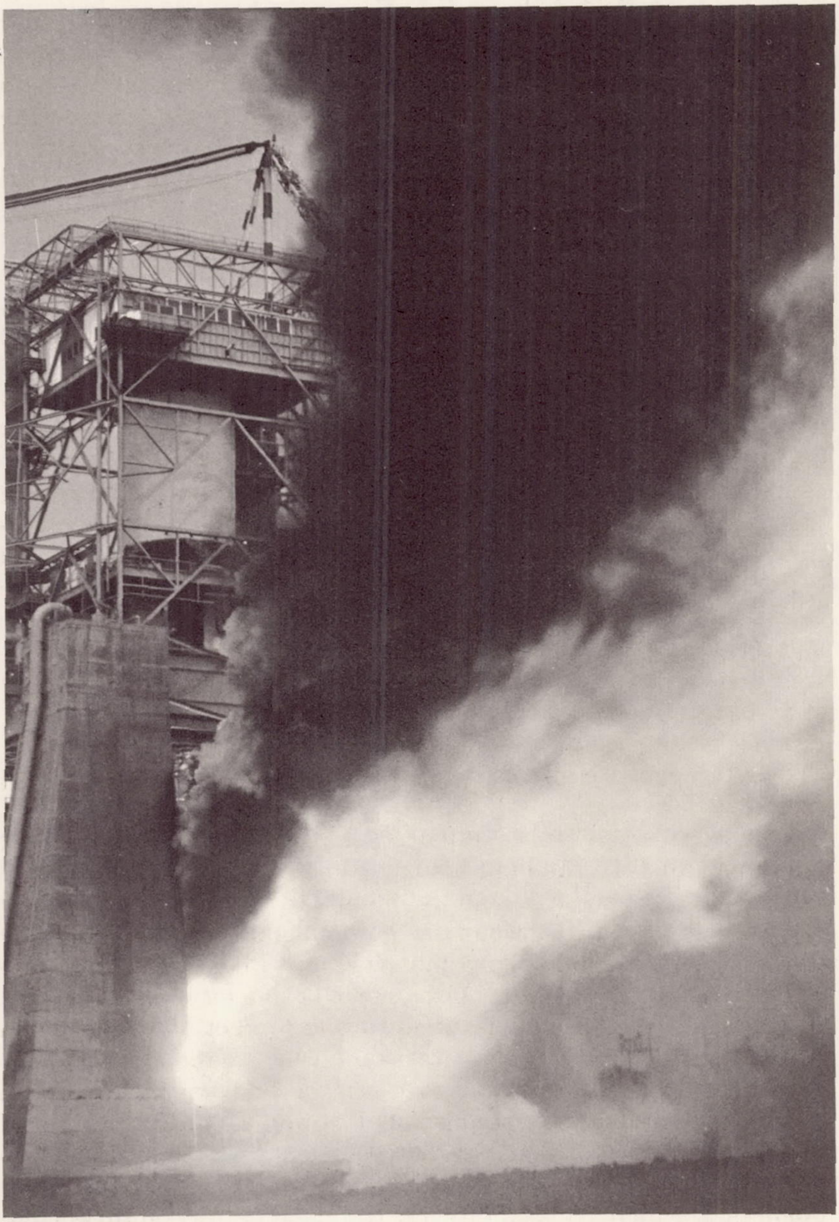
spacecraft will first explore the more distant planets, the asteroids, and comets.

In manned spacecraft missions, a series of practical possibilities were cited in NASA's look at the 1970's. An outgrowth of Apollo would lead to a six- to nine-man orbital laboratory, which could remain in orbit for possibly five years. As rendezvous and re-supply vehicles are developed for crew rotation, a host of practical tasks for an orbiting laboratory are feasible, including high-resolution telescopes above the earth's atmosphere, weather observation, and other useful work. Direct ascent to the moon will provide logistics for extended manned exploration of the moon including lunar-based observatories. Manned missions to Mars, both orbital and landing missions, appeared feasible. All such missions were structured upon a sound base of launch vehicle and associated advanced technological development. NASA's long-range outline clearly specified the difficulty of predicting the precise future programs deserving priority as a result of yet-to-be-achieved progress and possible other requirements directly affecting the national interest in space exploration. The breadth and challenge of the future possibilities in space affairs dictated to NASA planners "that a continued balanced program, steadily pursuing continued advancement in aeronautics, space sciences, manned space flight, and lunar and planetary exploration, adequately supported by a broad basic research and technical development program, still represents the wisest course." The basic future goal for NASA, as it was in the beginning, was a pre-eminent role for the United States in all aspects of aeronautics and space.

From a historical point of view, the future of space exploration and the adaptation to earth-bound activities of new knowledge and technology derived from space activities is difficult to ascertain. What has been most evident in this brief historical sketch has been the velocity of progress and change. All of the assumptions underwriting the U.S. space effort as legislated in the National Aeronautics and Space Act of 1958, which created NASA, have been documented and confirmed by the milestones of space science and technology. The challenges presented mankind by the opportunities in space remain crucial in spite of the crowded chronology of accomplishments already in our past. The bibliography of additional readings at the end of this publication will enable the reader to deepen his knowledge about that which could only be highlighted here.

When the era of space exploration began in 1957, something new was added to the long history of mankind. In spite of the events of the Space Age to date, no one can actually forsee fully the scientific, strategic, economic, political, miltary, or intellectual influences of this challenging undertaking. Man's insatiable curiosity about his accessible environment, both as a scientist and an adventurer, seem clearly destined to find projection tomorrow in space exploration and exploitation. The technological consequences of the demands of space science and engineering seem inevitably to contribute to national power as well as to broad social benefits. International cooperation and competition are both provided impetus by today's space effort, the future consequences of which are also difficult to foretell. The endless frontiers presented by the conquest of the solar system clearly impose no constraint upon either the scientific challenge or the possible destiny of mankind beyond its age-old planetary homeland.

The implications of space science and technology, as with the ultimate influences of NASA's program upon American history, have no discernable horizons. Few serious thoughts, whether associated with the physical or social sciences or the humanities, can ignore some aspect of the American space venture. Charged with the research and development task of space exploration for its own sake, NASA has continued to fulfill its mission in close

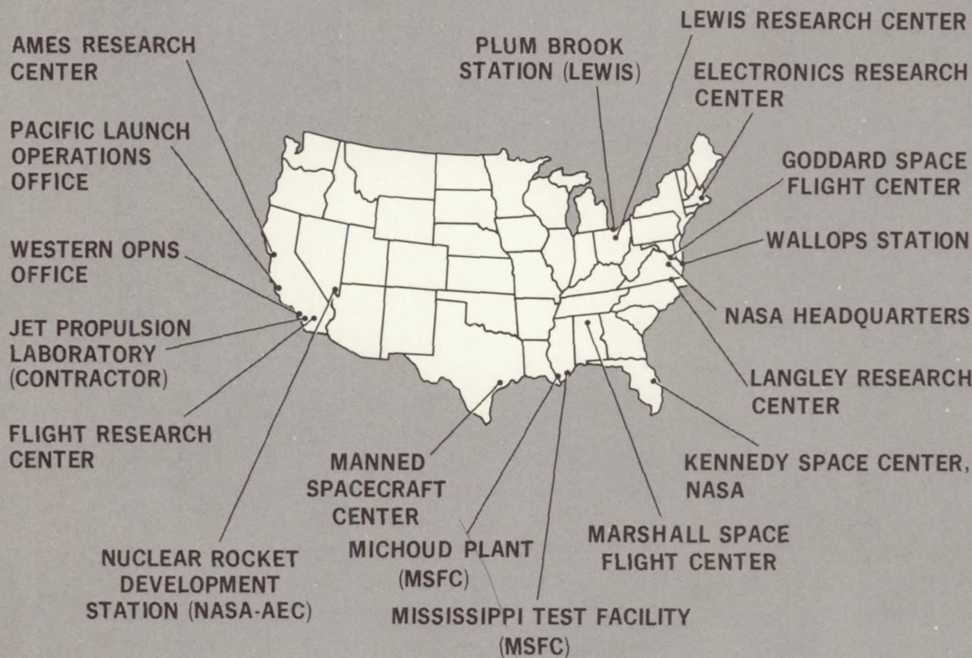


First full-duration firing of Saturn V first stage at Marshall Space Flight Center, August 5, 1965.

concert with other Federal agencies, the American aerospace industry, and the academic community. Research and development related to aeronautics also remains a vital part of NASA's program as VTOL-STOL and supersonic transport aircraft appear significant for the future.

Over 90% of NASA's monies is spent outside of NASA-proper in the broad-based program for the long-term achievement of gain

NASA INSTALLATIONS



for the peaceful pursuits of mankind. The complexities of space flight and its high challenge for unprecedented technology and equipment reliability portend advances of wider social and economic utilization than mere aerospace hardware. The capital space investment in NASA flight programs, laboratory and test facilities, skilled manpower, and knowledge are building American space power capabilities for any future needs. Our future histories will recount this story in more detail than can be adequately covered here.

The unknowns in space awaiting discovery and evaluation, as well as application of our new knowledge and new space technology, seem to foretell profound innovations in the affairs of mankind. Christopher Columbus was not looking for rich farm land, oil, coking coal, or other natural resources which were to make the United States what it is today. He found a new continent instead of an easier trade route to the continent of Eurasia. So also today, it would be absurd to predict precisely what is going to result from NASA's challenging and exciting effort now underway. The present era of astronautics, with its tender philosophy, also offers the germ for a new renaissance in the mind and spirit of mankind. It could well be a renaissance for mankind such as was sparked with the new geography of Columbus and Magellan and the new astronomy of Copernicus and Galileo which helped loosen Europe from the Dark Ages.

Less than four years hence, an astronaut will probably have stood on the moon while programs are underway to voyage to nearby planets in our solar system. Radio telescopes and orbiting laboratories and space station observatories will have already chartered much more of the new geography of space. Our present primitive level of understanding of the true nature of the dynamic universe will have been grossly expanded as the cosmic jigsaw puzzle of the space environment is pieced together. Then man's outermost horizons may truly be infinity.

It may also be exciting to more than the exobiologists to discover other forms of life elsewhere in our solar system. Perhaps there is even intelligent life elsewhere in our universe. These questions seem inevitably to help prod curious men into space so long as they have the capability to find partial answers. However swift and full the early history of the Space Age has been to date, its greatest history is yet to come.

Select Historical References

Akens, David S., *Historical Origins of Marshall Space Flight Center*. Huntsville, Ala.: NASA MSFC, 1960.

Ambrose, Mary S., *The National Space Program*, 2 vols. Washington: American Univ. Thesis, 1961.

Benecke, Th., and A. W. Quick (eds.), *History of German Guided Missiles Development* (Agardograph 20). Brunswick, Germany: Verlag E. Appelhans & Co., 1957.

Bergaust, Erik, *Reaching for the Stars*. New York: Doubleday, 1961.

Berkner, Lloyd V. (ed.), *The Challenges of Space*. Chicago: Univ. of Chicago, 1962.

Berkner, Lloyd V., *The Scientific Age*. New Haven: Yale Univ., 1964.

Berkner, Lloyd V., and Hugh Odishaw (eds.), *Science in Space*. New York: McGraw-Hill, 1961.

Bernardo, James V., *Aviation in the Modern World*. New York: E. P. Dutton, 1960.

Bonney, Walter T., *The Heritage of Kitty Hawk*. New York: Norton, 1962.

Bonney, Walter T., "High-Speed Research Airplanes," *Scientific American* (October 1953), pp. 36–41.

Chapman, Sidney, *IGY: Year of Discovery*. Ann Arbor: Univ. of Michigan, 1959.

Clarke, Arthur C., *Man and Space*. New York: Life-Time, 1964.

Cohen, Maxwell (ed.), *Law and Politics in Space: Specific and Urgent Problems in the Law of Outer Space*. Montreal: McGill Univ., 1964.

Crossfield, A. Scott, *Always Another Dawn*. Cleveland: World, 1961.

Davy, M. J. B., *Interpretative History of Flight*. London: H.M.S.O., 1948.

Dembling, Paul G., "National Coordination for Space Exploration," *The Judge Advocate Journal* (February 1959), pp. 11–19.

Dembling, Paul G., "Aspects of the Law of Space Activities," *Federal Bar Journal* (Spring 1961), pp. 235–244.

Department of State, *International Negotiations Regarding the Use of Outer Space, 1957–60*. Washington: 87th Cong., Senate Doc. No. 26, March 1961.

Department of State, *Documents on International Aspects of the Exploration and Use of Outer Space, 1954–1962*. Washington: 88th Cong., Senate Doc. No. 18, May 1963.

Doolittle, James H., "The Following Years, 1955–58," *Annual Report of the NACA—1958,* pp. 29–31. Washington: GPO, 1959.

Dornberger, Walter, *V–2.* New York: Viking, 1954.

Dreyer, J. L. E., *A History of Astronomy.* New York: Dover Press, 1953.

Dryden, Hugh L., "The Aeronautical Research Scene—Goals, Methods, and Accomplishments," *Journal of the Royal Aeronautical Society* (July 1949), pp. 623–666.

Dryden, Hugh L., "Frontiers of Aeronautical Science and Technology." *Proceedings . . . American Philosophical Society* (February 1953), pp. 56–60.

Dryden, Hugh L., "A Half Century of Aeronautical Research," *American Physical Science Proceedings* (Apr. 15, 1954), pp. 115–120.

Dryden, Hugh L., "IGY—Man's Most Ambitious Study of His Environment," *National Geographic* (February 1956), pp. 285–298.

Dryden, Hugh L., "Future Exploration and Utilization of Outer Space," *Technology and Culture* (Spring 1961), pp. 112–126.

Dryden, Hugh L., "National Significance of the Augmented Program of Space Exploration," *Airpower Historian* (January 1962), pp. 52–59.

Dryden, Hugh L., "The Lunar Exploration Program," *Vital Speeches* (Mar. 15, 1962), pp. 336–340.

Dryden, Hugh L., "Footprints on the Moon," *National Geographic* (March 1964), pp. 357–401.

Dupree, A. Hunter, *Science in the Federal Government: A History of Policies and Activities to 1940.* Cambridge: Harvard Univ., 1957.

Emme, E. M. (ed.), *The Impact of Air Power.* Princeton: D. Van Nostrand, 1959.

Emme, E. M., *Aeronautics and Astronautics: An American Chronology of Science and Technology in the Exploration of Space, 1915–60.* Washington: NASA, 1961.

Emme, E. M. (ed.), *History of Rocket Technology,* special issue of *Technology and Culture* (Fall 1963); revised and augmented edition, Detroit: Wayne State Univ., 1964.

Emme, E. M., *A History of Space Flight.* New York: Holt, Rinehart, and Winston, 1965.

Emme, E. M., and F. W. Anderson, *Aeronautical and Astronautical Events of 1961.* Washington: NASA HHR–5, 1962; printed by the House Committee on Science and Astronautics, 1962.

Faget, Max, *Manned Space Flight.* New York: Holt, Rinehart, and Winston, 1965.

Frutkin, Arnold, *International Cooperation in Space.* New York: Prentice-Hall, 1965.

Gavin, James M., *War and Peace in the Space Age.* New York: Harper, 1958.

Gatland, Kenneth W. (ed.), *Telecommunications Satellites.* New York: Prentice-Hall, 1964.

Gibbs-Smith, Charles H., *The Aeroplane: An Historical Survey . . . .* London: H.M.S.O., 1960.

Gilruth, Robert R., "Manned Space Flight," *Space Flight Report to Nation* (J. and V. Gray, eds.). New York: Basic Books, 1962, pp. 31–33.

Glasstone, Samuel, *Source Book on Space Science.* Princeton: D. Van Nostrand, 1965.

Glennan, T. Keith, "What's Next in Space," *U.S. News and World Report* (Feb. 6, 1959), pp. 102–103.

Glennan, T. Keith, "Our National Space Program," address before the Institute of World Affairs, Pasadena, Calif., Dec. 7, 1959.

Glennan, T. Keith, "A New Order of Technological Challenge in the Nation's Space Program," address at AAAS, Chicago, Ill., Dec. 27, 1959.

Glennan, T. Keith, "Opportunities for International Cooperation in Space Exploration," *U.S. Department of State Bulletin* (Jan. 11, 1960), pp. 58–63.

Glennan, T. Keith, "Space Exploration," *Vital Speeches* (Apr. 16, 1960), pp. 401–404.

Goddard, Robert H., *Rockets*. New York: American Rocket Society, 1946. Facsimile reprint of his 1919 and 1935 Smithsonian Reports.

Goddard, Robert H., *Rocket Development: Liquid Fuel Rocket Research 1921–1941*, ed. E. C. Goddard and G. Edward Pendray. New York: Prentice-Hall, 1948; reprinted 1961.

Goett, Harry J., *Scientific Exploration of Space*. Greenbelt, Md.: NASA GSFC (X–100–62–56), 1962.

Goodwin, Harold, *The Science Book of Space Travel*. New York: Watts, 1954.

Goodwin, Harold, *The Images of Space*. New York: Holt, Rinehart, and Winston, 1965.

Gray, George C., *Frontiers of Flight: The Story of NACA Research*. New York: A. Knopf, 1948.

Griffith, E. Alison, *The Genesis of the National Aeronautics and Space Act of 1958*. Washington: Public Affairs, 1962.

Grimwood, James M., *Project Mercury: A Chronology* (SP–4001). Washington: NASA, 1963.

Haley, Andrew G., *Rockets and Space Exploration*. Princeton: D. Van Nostrand, 1958.

Haley, Andrew G., *Space Law and Government*. New York: Appleton-Century-Crofts, 1963.

Hall, R. Cargill, "Origins and Development of the Vanguard and Explorer Satellite Programs," *Airpower Historian* (October 1964).

Hayes, E. Nelson, *The Smithsonian's Satellite-Tracking Program: Its History and Organization*. Washington: Smithsonian Institution (Pub. 4482), 1962.

Henry, James P., *Biomedical Aspects of Space Flight*. New York: Holt, Rinehart, and Winston, 1965.

Heron, S. D., *History of the Aircraft Piston Engine: A Brief Outline*. Detroit: Ethyl Corporation Research and Development Dept., 1961.

Holley, I. B., Jr., *Ideas and Weapons*. New Haven: Yale Univ., 1956.

Holley, I. B., Jr., *Buying Aircraft: Materiel Procurement for the Army Air Forces*. Washington: GPO, 1964.

Holmes, Jay, *America on the Moon: The Enterprise of the '60's*. Philadelphia: Lippincott, 1962.

Hoyle, Fred, *Astronomy: A History of Man's Investigation of the Universe*. New York: Doubleday, 1962.

Hunsaker, Jerome C., *Aeronautics at Mid-Century*. New Haven: Yale Univ., 1952.

Hunsaker, Jerome C., "Forty Years of Aeronautical Research, 1915–1955," *Smithsonian Report for 1955*, pp. 241–271. Washington: Smithsonian Institution, 1956.

Hunter, Maxwell W., *Thrust Into Space*. New York: Holt, Rinehart, and Winston, 1965.

Jaffe, Leonard, *Communications in Space*. New York: Holt, Rinehart, and Winston, 1965.

Jastrow, Robert (ed.), *The Exploration of Space*. New York: Macmillian, 1960.

Jastrow, Robert, "Results of Experiments in Space," 25th Wright Brothers Lecture (IAS), Washington, Dec. 18, 1961.

Jastrow, Robert, and A. G. W. Cameron (eds.), *Origin of the Solar System*. New York: Academic Press, 1963.

Jastrow, Robert, and A. G. W. Cameron, "Space: Highlights of Recent Research," *Science* (Sept. 11, 1964).

Jet Propulsion Laboratory, *Mariner: Mission to Venus.* New York: McGraw-Hill Paperbacks, 1963.

Jones, Bessie Z., *Lighthouse in the Sky: History of the S.A.O.* Washington: Smithsonian Institution, 1965.

Lear, John, "The Moon that Refused to be Eclipsed [Vanguard]," *Saturday Review of Literature* (Mar. 5, 1960), pp. 45–48.

LeGalley, Donald P. (ed.), *Space Exploration.* New York: McGraw Hill, 1964.

Lehman, Milton, *This High Man: The Life of Robert H. Goddard.* New York: Farrar, Straus, 1963.

Lehner, Ernst and Johanna, *Lore and Lure of Outer Space.* New York: Tudor, 1964.

LeMay, Gen. Curtis E., "The Ultimate Weapon is Foresight," *Air Force and Space Digest* (May 1962), pp. 26–31.

Levine, Arthur, *U.S. Aeronautical Research Policy, 1915–1958.* New York: Columbia Univ. Thesis, 1963.

Levy, Lillian (ed.), *Space: Its Impact on Man and Society.* New York: Norton, 1965.

Ley, Willy, *Rockets, Missiles, and Space Travel.* New York: Viking Press, 1961.

Ley, Willy, *Watchers of the Skies.* New York: Viking, 1963.

Link, Mae Mills, *Space Medicine in Project Mercury.* Washington: NASA SP–4003, 1965.

Loosbrock, J. F., and R. M. Skinner (eds.), *The Wild Blue: The Story of American Airpower.* New York: Putnam's, 1961.

Medaris, John B., *Countdown for Decision.* New York: Putnam's, 1960.

Milbank, J., *The First Century of Flight in America.* Princeton: Princeton Univ., 1943.

Murry, Don, "O'Sullivan's Wonderful Lead Balloon [ECHO I]," *Reader's Digest* (February 1961), pp. 45–50.

National Academy of Sciences, *I.G. Bulletin* (monthly), July 1957–date.

National Academy of Sciences Space Science Board, *A Review of Space Research.* Washington: NAS Pub. 1079, 1962.

NACA, *Annual Reports, 1915–1958.* Washington: GPO, 1916–1959.

NASA, *Astronautics and Aeronautics, 1963: A Chronology on Science, Technology, and Policy* (SP–4004), prepared by the NASA Historical Staff. Washington: NASA, 1964.

NASA, *Astronautics and Aeronautics, 1964, Chronology on Science, Technology, and Policy* (SP–4005), prepared by the NASA Historical Staff. Washington: NASA, 1965.

NASA, *Conference on Space, Science, and Urban Life* (SP–37). Washington: NASA, 1963.

NASA, *Chronology of Major NASA Launchings.* Washington: NASA (HHR–8), 1962–date.

NASA, *History of Marshall Space Flight Center* (semiannual vols.), prepared by MSFC MS–H, 1960–date.

NASA, *Mercury Project Summary: Including Results of the Fourth Manned Orbital Flight May 15 and 16, 1963* (SP–45), prepared by NASA Manned Spacecraft Center. Washington: NASA, 1963.

NASA, *Proceedings of the Conference on the Law of Space and of Satellite Communications* (SP–44). Washington: NASA, 1964.

NASA, *Proceedings of the Conference on Space-Age Planning* (SP–40). Washington: NASA, 1963.

NASA, *Proceedings of the NASA-Industry Program Plans Conferences.* Washington: NASA, 1960, 1963.

NASA, *Proceedings of the NASA-University Conference on the Science and*

Technology of Space Exploration, 2 vols. (SP–11). Washington: NASA, 1962.

NASA, *Proceedings of the National Conferences on the Peaceful Uses of Space*. Washington: NASA, 1961–65.

NASA, *Semiannual Reports to Congress, October 1, 1958–Present*. Washington: GPO, 1959–date.

NASA, *Space Activities Summary*, prepared by the Office of Public Information. Washington: NASA, 1958–date.

NASA, *X–15: Research Results* (SP–60). Washington: NASA, 1965.

Naugle, John E., *Unmanned Space Flight*. New York: Holt, Rinehart, and Winston, 1965.

Newell, Homer E. (ed.), *Sounding Rockets*. New York: McGraw-Hill, 1959.

Newell, Homer E., *Express to the Stars*. New York: McGraw-Hill, 1961.

Nicolson, Marjorie, *Voyages to the Moon*. New York: Macmillan, 1960.

Oates, Stephen B., "NASA's Manned Spacecraft Center at Houston, Texas," *Southwestern Historical Quarterly*, Vol. LXVII (January 1964), pp. 350–375.

Odishaw, Hugh (ed.), *The Challenges of Space*. Chicago: Univ. of Chicago, 1962.

Pendray, G. Edward, *The Coming Age of Rocket Power*. New York: Harper, 1945.

Price, Don K., *Government and Science: Their Dynamic Relation in American Democracy*. New York: Oxford Univ., 1962.

Ramo, Simon (ed.), *Peaceful Uses of Outer Space*. New York: McGraw-Hill, 1961.

Rechtschaffen, Lt. Col. Oscar H. (ed.), *Reflections on Space: Its Implications for Domestic and International Affairs*. Colorado Springs, Colo.: U.S. Air Force Academy, 1964.

Ronan, Colin, *Changing Views of the Universe*. New York: Macmillan, 1961.

Rosen, Milton W., *The Viking Rocket Story*. New York: Harper, 1955.

Rosenthal, Alfred, *The Early Years: Goddard Space Flight Center, Historical Origins and Activities Through December 1962*. With a Foreword by Mrs. Robert H. Goddard. Washington: NASA, 1964.

Saenger, Eugen, *Space Flight*, trans. K. Frucht. New York: McGraw-Hill, 1965.

Schlaifer, Robert, and S. D. Heron, *Development of Aircraft Engines, Development of Aviation Fuels: Two Studies of Relations Between Government and Business*. Boston: Harvard Univ. Graduate School of Business Administration, 1950.

Schweibert, Ernest G., *USAF Ballistic Missiles, 1954–64*. New York: Praeger, 1965.

Shapley, Harlow, *The View from a Distant Star: Man's Future in the Universe*. New York: Basic Books, 1963.

Silverstein, Abe, "Research in Space Flight Technology," *Journal of the Royal Aeronautical Society* (December 1961), pp. 779–795.

Stehling, Kurt, *Project Vanguard*. New York: Doubleday, 1961.

Stuhlinger, Ernst, *et al.* (eds.), *From Peenemünde to Outer Space*. Huntsville, Ala.: NASA George C. Marshall Space Flight Center, 1962.

Sullivan, Walter, *Assault on the Unknown: The International Geophysical Year*. New York: McGraw-Hill, 1961.

Thomas, Shirley, *Men of Space* (projected 12 vols. of biographies). Philadelphia: Chilton, 1960–.

Thomas, Shirley, *Space Tracking Facilities: Their History and Operation*. New York: Holt, Rinehart and Winston, 1963.

Tregaskis, Richard W., *X–15 Diary.* New York: Dutton, 1961.

U.S. Air Force Systems Command, *The Rocket Research Aircraft Program, 1946–1962.* Edwards AFB: AFFTC, 1962.

U.S. Congress, House, Select Committee on Astronautics and Space Exploration, *The Next Ten Years in Space, 1959–1960* (House Doc. No. 115). Washington: GPO, 1959.

U.S. Congress, House, Committee on Science and Astronautics, *The Practical Values of Space Exploration* (House Report No. 1276). Washington: GPO, 1961.

U.S. Congress, House, Committe on Science and Astronautics, *Project Mercury,* First and Second Interim Reports (House Report No. 1228, No. 671). Washington: GPO, 1960, 1961.

U.S. Congress, House, Committee on Science and Astronautics, *Astronautical and Aeronautical Events of 1962,* prepared by the NASA Historical Staff. Washington: GPO, 1963.

U.S. Congress, Senate, Committee on Aeronautical and Space Sciences, *Legal Problems of Space Exploration—A Symposium,* prepared by the Legislative Reference Service of the Library of Congress. (Doc. No. 26.) Washington: GPO, 1961.

Van Dyke, Vernon, *Pride and Power: The Rationale of the Space Program.* Urbana, Ill.: Univ. of Illinois, 1964.

von Braun, Wernher, *et al., Project Satellite.* New York: British Book Centre, 1958.

von Braun, Wernher, *First Men to the Moon.* New York: Holt, Rinehart, and Winston, 1960.

von Braun, Wernher, "Where Are We in Space?" *This Week* (Jan. 1, 1961).

Webb, James E., "Interview: Why Spend $20 Billion To Go to the Moon?" *U.S. News and World Report* (July 3, 1961), pp. 58–63.

Webb, James E., "International Relations and Space," *Vital Speeches* (Oct. 1, 1961), pp. 762–768.

Webb, James E., "Space: Priorities for Peaceful Progress," *General Electric Forum* (January–March 1962), pp. 8–12.

Webb, James E., "Administration and the Conquest of Space," address to the American Society for Public Administration, Detroit, Apr. 13, 1962.

Webb, James E., "1963—The Greatest Year in Space," *Aerospace* (March 1963), pp. 2–7.

Webb, James E., "New Age of Discovery," *Airpower Historian* (July 1964), pp. 86–88.

Webb, James E., "NASA and USAF: A Space Age Partnership," *The Airman* (August 1964), pp. 6–11.

Webb, James E., "Space Exploration: New Pioneering Era," *Vital Speeches,* Aug. 1, 1964.

Weil, Joseph, *Review of the X–15 Program* (TN D–1278). Washington: NASA, 1962.

Wheelock, Harold J., *Mariner Mission to Venus.* New York: McGraw-Hill, 1963.

White House, *U.S. Aeronautical and Space Activities,* annual report with message from the President to the Congress. Washington: NASC, 1958, 1959, 1960, 1961, 1962, 1963, 1964.

Widger, William K., *Meteorological Satellites.* New York: Holt, Rinehart, and Winston, 1965.

Wilson, J. Tuzo, *I.G.Y.: The Year of the New Moons.* New York: Knopf, 1961.

Young, Louise B. (ed.), *Exploring the Universe.* New York: McGraw-Hill, 1963.

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