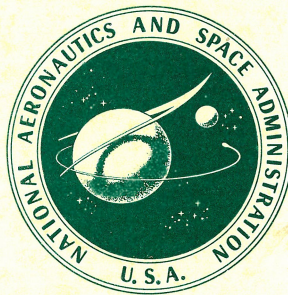


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ORIGINS OF NASA NAMES



NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ORIGINS OF NASA NAMES

*Helen T. Wells, Susan H. Whiteley,
and Carrie E. Karegeannes*

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FOREWORD

This book was started many years ago. From time to time, the work was interrupted in favor of tasks that seemed more pressing. Meanwhile, the number of names generated by NASA continued to grow, and the work to be done increased. Now it has been brought to completion, and I am happy to offer it to the public. From the number of times the staff has consulted the manuscript to answer telephone queries, the publication should prove useful.

MONTE D. WRIGHT
Director, NASA History Office
June 1975

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PREFACE

This book was designed to answer questions about the origins of NASA-associated names. The impetus for its preparation came from the Johnson Space Center Historian, James M. Grimwood, who called attention to the need for such a compilation. If, besides answering specific questions, the book raises further questions or stimulates the reader to delve further into the subject of space exploration, it will have served its purpose well.

Names given to spaceflight projects and programs have originated from no single source or method. Some have their foundations in mythology and astrology, some in legend and folklore. Some have historic connotations. Some are based on a straightforward description of their mission, often resulting in acronyms. (As Webster puts it, an acronym is a “word formed from the initial letters or syllables of the successive parts of a compound term”; hence, “TIROS” for “Television and Infra-Red Observation Satellite.”) Some grew out of a formal process within NASA under the NASA Project Designation Committee. Others evolved somewhat casually and were officially adopted after their use had become widespread. Many others, of course, were originated by non-NASA sources when ongoing projects were transferred to NASA from other agencies.

Parts I through V list names of launch vehicles, spacecraft, manned spaceflight programs, and sounding rockets. Some of these were the primary responsibility of NASA. Some names apply to projects for which NASA shared responsibility or had a major support role—for instance, the international Alouette satellites. Some names apply to hardware that NASA purchased from another agency, such as the Air Force Agena launch vehicle stage. Part VI lists NASA field installations and gives the origins of their names.

This study is limited to names of approved projects through 1974; it does not include names of numerous projects which have been or are being studied or projects that were canceled or postponed before reaching actual flight—such as the Nova large launch vehicle. It does not attempt to record the history of the listed projects except as it may be related to the naming process, nor does it attempt to describe the projects and hardware beyond a

PREFACE

nontechnical statement of mission or function. It does, however, present the origins of each name, answering as far as possible who or what organization devised the name, when they adopted it, and what the reasoning was for its selection. The information about each name is as specific as the available documentation could provide. Because of the passage of time, the multiplicity of organizations participating, and the unavailability of full written documentation, it is, we regret, inevitable that some persons deserving of credit in the naming processes have been overlooked.

So many persons have provided information that it would be impossible to acknowledge each one's contribution. Reference notes attempt to credit specific assistance on particular points. Special mention is due the historians, their staffs, and historical monitors at NASA Centers, who coordinated local research, and to Dr. Eugene M. Emme, NASA Historian, and Dr. Frank W. Anderson, Jr., Publications Manager, who gave invaluable guidance in organizing and editing the manuscript. Arthur G. Renstrom of the Library of Congress was very helpful in finding illustrative materials, and NASA Archivist Lee D. Saegesser spent many hours tracking down historical photographs of spacecraft and vehicles. Sources of the photographs of mythological figures are listed at the end of the Reference Notes.

Comments and additional information on the origins of NASA names will always be welcomed.

HTW
SHW
CEK

NOTE

For consistency and to avoid confusion, the numerical designations of spacecraft within the text conform to the arabic numeral system. Until 1969, NASA chose roman numerals to designate successful flight missions, although there were notable exceptions. Italics indicate spacecraft that have attained orbit, space probes that have achieved an altitude above 64 000 kilometers, and all manned suborbital flights. Spacecraft launch failures retain their preflight letter designations.

No single system of numbering spacecraft and launch vehicles has been followed by NASA through the years, and often two or more designations have existed for one spacecraft. Usually, however, spacecraft in a series are given letter designations in alphabetical order before launch and successful launches within a series are numbered consecutively with arabic numerals.

Many satellites and space probes have followed this pattern and most launch vehicles have been numbered separately. There were exceptions: launches that failed sometimes upset the numbering sequence (for example, *Pioneer 3* followed *Pioneer 1*) and designations for spacecraft within a series at times did not appear to follow a given sequence (ATS-B was launched before ATS-A; *OAO 2* was known as *OAO-A2* before launch). Launch vehicle development flights were numbered consecutively, including suborbital flights (Atlas-Centaur 2; Atlas-Centaur 3, suborbital; Atlas-Centaur 4).

The numbering systems for the first three manned spaceflight programs—as the new space agency developed approaches in an evolving field—were not consistent. In addition to the overall flight number, each manned flight had a separate designation, named and numbered in sequence, for the launch vehicle combination that was employed. Except for flights in the Mercury program and unmanned flights in the Gemini program, these secondary designations were not official names, but were used by NASA for reference (in the Gemini program) or launch vehicle designation (Apollo). For example, *Freedom 7* was also known as *Mercury-Redstone 3* and *Friendship 7* as *Mercury-Atlas 6*.

In the Mercury program, the choice of the number “7” by the original seven Mercury astronauts precluded the use of roman numerals for the

NOTE

spacecraft. Project Gemini was the only manned program to use roman numerals, and even its early unmanned flights were named by the Mercury system (*Gemini-Titan 1*, *Gemini-Titan 2*). In the Apollo program, each mission was assigned an overall number and each command and service module and lunar module was given a separate number designating a specific flight unit (for example, “CSM-108” and “LM-6” designated the specific *Apollo 12* modules). Each Apollo launch vehicle was assigned a flight number that indicated both the vehicle model and the specific vehicle used on that mission, such as “AS-201” and “AS-507.” The “200” and “500” series referred to Saturn IB and Saturn V launch vehicles; “AS” to “Apollo Saturn.” The 10 Saturn I development flights, on the other hand, were designated “Saturn Apollo.”

In addition, each spacecraft or piece that separately entered earth orbit was given a number and letter designation, according to the international designation system (see Appendix B). Spacecraft that separated while in orbit or after leaving earth orbit also were given designations (for example, the *Apollo 15 Subsatellite*, ejected into lunar orbit from the Apollo command module, and the Soviet softlanding capsules that descended to the Martian surface from the *Mars 2* and *3* space probes).

I

LAUNCH VEHICLES



Dr. Robert H. Goddard with the world's first liquid-propellant rocket, launched 16 March 1926 at Auburn, Massachusetts.

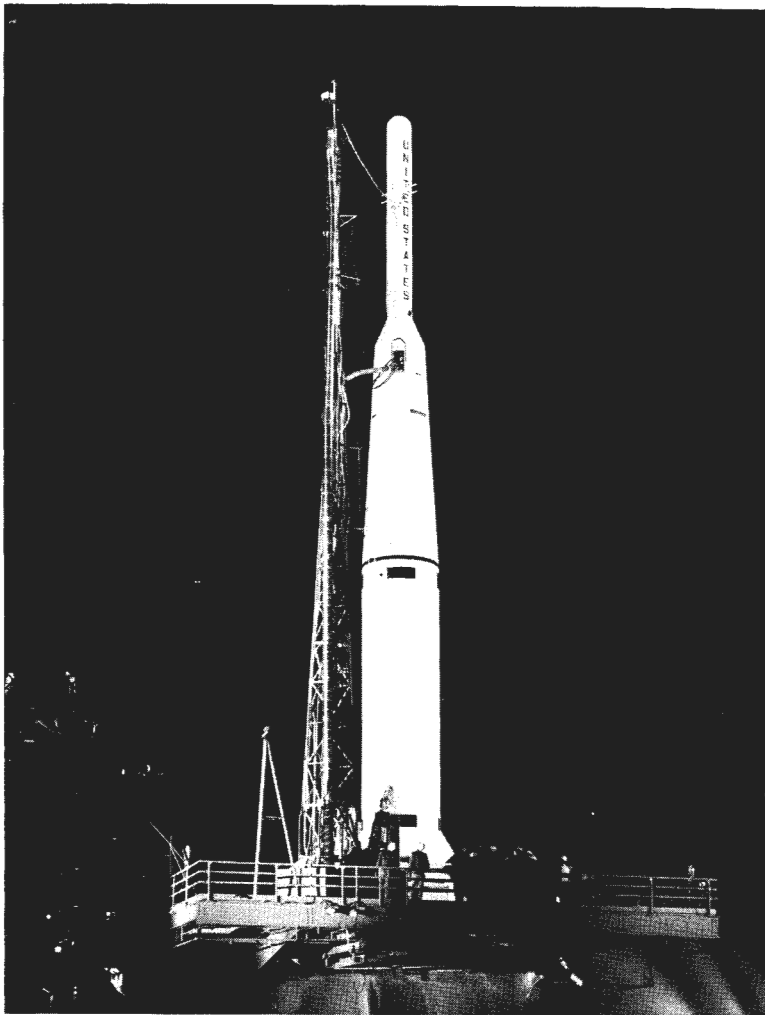
LAUNCH VEHICLES

Launch vehicles are the rocket-powered systems that provide transportation from the earth's surface into the environment of space. In the early days of the U.S. civilian space program the term "launch vehicle" was used by NASA in preference to the term "booster" because "booster" had been associated with the development of the military missiles. "Booster" now has crept back into the vernacular of the Space Age and is used interchangeably with "launch vehicle."

In 1971 NASA managed five launch vehicles in the National Launch Vehicle Program: Scout, Thor-Delta, Atlas-Centaur, Saturn IB, and Saturn V. In 1974 a new combination, the Titan-Centaur, launched its first satellite. Performance capability of these vehicles varied greatly, ranging from Scout, which was used to launch small scientific payloads, to Saturn V, which launched manned Apollo missions into circumlunar flight. Beginning in the 1980s, NASA's reusable Space Shuttle was scheduled to replace many expendable boosters for orbiting satellites and manned missions (see Space Shuttle in Part IV).

Names listed in this section include designations of launch vehicles and major vehicle stages, or sections, that are used or have been used in the past by NASA. Nearly all the names came from the military services or the Department of Defense, which traditionally turned to ancient mythology in selecting names for ballistic missiles and space boosters.

LAUNCH VEHICLES



Thor-Able

ABLE. The Able upper stage was one of several derived in 1958 by the Department of Defense's Advanced Research Projects Agency, Douglas Aircraft Company, and Space Technology Laboratories from Vanguard launch vehicle components. It was used with Thor or Atlas first stages. The name signified "A" or "first" (from military phonetic communications practice of stipulating key words beginning with each letter of the alphabet).¹ (See Delta.)

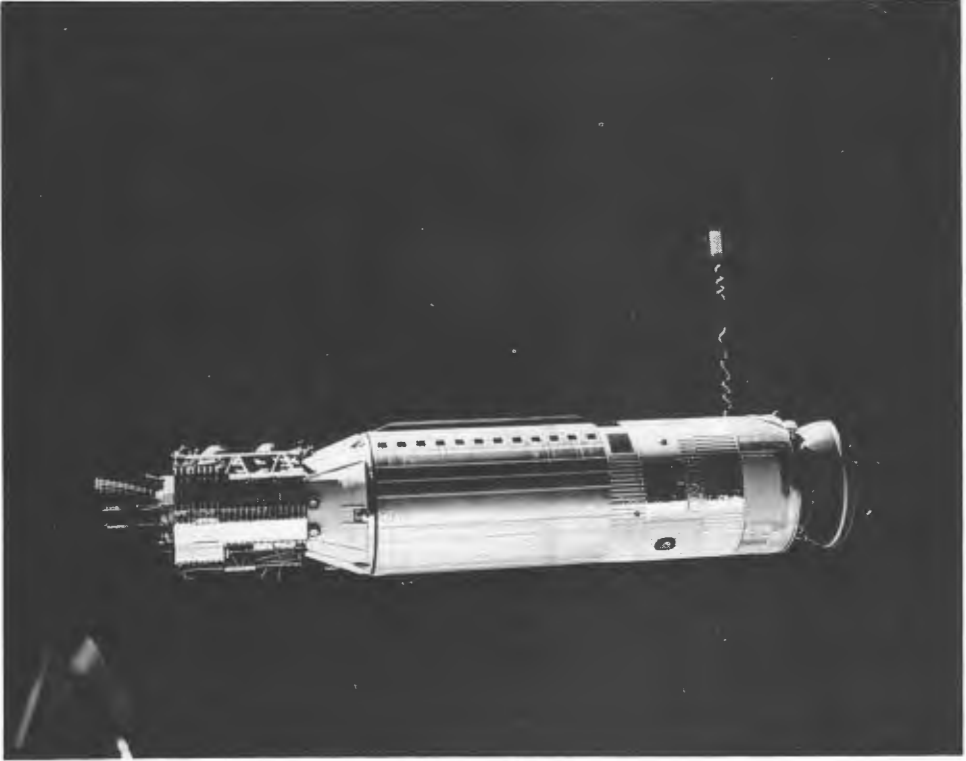
ORIGINS OF NASA NAMES



Thor-Agena B before launch from the Pacific Missile Range, at left. Opposite, the Gemini Agena Target Vehicle as seen from the Gemini 8 spacecraft during approach for rendezvous and docking 16 March 1966.

AGENA. An upper-stage launch vehicle used in combination with Thor or Atlas first stages, Agena originally was developed for the U.S. Air Force by Lockheed Missiles Systems Division (now Lockheed Missiles & Space Company). The Department of Defense's Advanced Research Projects Agency (ARPA) proposed to name the stage in 1958 for the star Agena in the constellation Centaurus because the rocket was an upper stage "igniting in the sky."¹ "Agena" first appeared in the *Geography of the Heavens*, published in the 1800s by the "popularizing Connecticut astronomer" Elija H. Burritt, and was preserved in American dictionaries as the popular name for the

LAUNCH VEHICLES



star Beta Centauri.² Burritt was thought to have coined the name from *alpha* and *gena* (“the knee”) because he had located the star near the “right foreleg” of the constellation.³ Lockheed approved the choice of the name since it followed Lockheed’s tradition of naming aircraft and missiles after stellar phenomena—such as the Constellation aircraft and Polaris intercontinental ballistic missile.⁴ ARPA formally approved the name in June 1959.⁵

Agena A, the first version of the stage, was followed by the Agena B, which had a larger fuel capacity and engines that could restart in space. The later Agena D was standardized to provide a launch vehicle for a variety of military and NASA payloads.⁶ NASA used Atlas-Agena vehicles to launch large earth satellites as well as lunar and interplanetary space probes; Thor-Agena vehicles launched scientific satellites, such as OGO (Orbiting Geophysical Observatory) and Alouette, and applications satellites, such as the *Echo 2* communications satellite and Nimbus meteorological satellites. In Project Gemini the Agena D, modified to suit the specialized requirements of space rendezvous and docking maneuvers, became the Gemini Agena Target Vehicle (GATV).

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Launch of Mercury-Atlas carrying Astronaut John H. Glenn, Jr., in Friendship 7 for the first U.S. manned orbital space flight 20 February 1962.

Atlas (courtesy Library of Congress)



LAUNCH VEHICLES



Models of Atlas upper-stage configurations. Left to right: Atlas, Atlas-Agena, Mercury-Atlas, Atlas-Centaur, Atlas-Able.

ATLAS. The Atlas launch vehicle was an adaptation of the U.S. Air Force Atlas intercontinental ballistic missile. The modified Atlas launched the four manned orbital flights in Project Mercury and NASA used it with the Agena or Centaur upper stages for a variety of unmanned space missions.

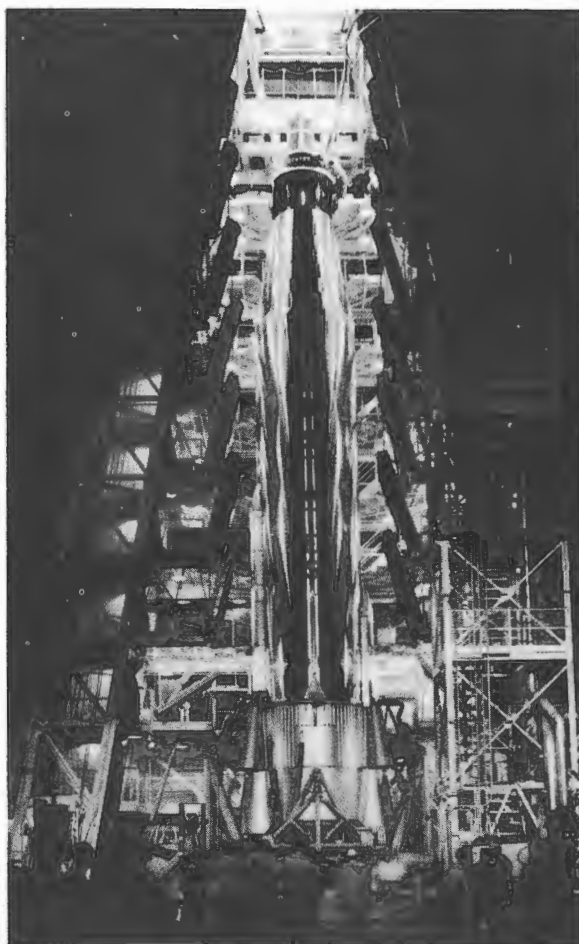
Early in 1951 Karel J. Bossart, head of the design team at Convair (Consolidated Vultee Aircraft Corporation) that was working on the missile project for the Air Force, decided the project (officially listed as MX-1593) should have a popular name. He asked some of his staff for ideas and they considered several possibilities before agreeing upon “Atlas”—Bossart’s own suggestion. The missile they were designing would be the biggest and most powerful yet devised. Bossart recalled that Atlas was the mighty god of ancient Greek mythology who supported the world on his powerful shoulders. The appropriateness of the name seemed confirmed by the fact that the parent company of Convair was the Atlas Corporation.¹ The suggestion was submitted to the Air Force and was approved by the Department of Defense Research and Development Board’s Committee on Guided Missiles in August 1951.²

The Atlas-Centaur, a high-energy vehicle for launching medium-weight spacecraft into planetary or synchronous orbits, could put 4700 kilograms into 555-kilometer orbit or 1810 kilograms into transfer orbit for a synchronous orbit.³ (See Centaur.)

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BIG JOE. “Big Joe” was the name of a single Atlas booster and its test flight. Part of Project Mercury, Big Joe tested a full-scale Mercury capsule at full operational speed for the critical reentry into the earth’s atmosphere. It was a key test of the heatshield, in preparation for Mercury’s manned orbital space flights. The name, which developed in 1958, was attributed to Maxime A. Faget, then at Langley Research Center. It was a logical progression from the previously named Little Joe, a smaller test booster for demonstration flight tests in Project Mercury.¹ (See Little Joe.)

Big Joe before launch at Cape Canaveral.



LAUNCH VEHICLES



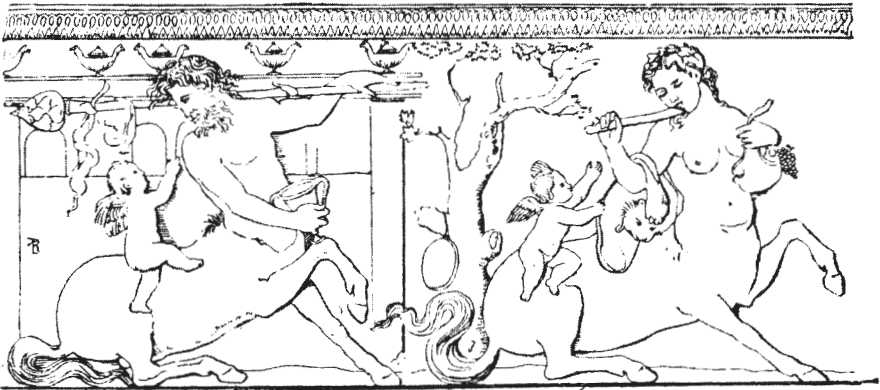
Atlas-Centaur

CENTAUR. Centaur was known from 1956 to 1958 simply as the “high-energy upper stage” because it proposed to make first use of the theoretically powerful but problem-making liquid hydrogen as fuel. The stage was named in November 1958 when the Department of Defense’s Advanced Research Projects Agency (ARPA) awarded the initial contract for six research and development flight-test vehicles to Convair/Astronautics Division of General Dynamics Corporation. The Centaur stage was required to increase the payload capability of the Atlas and to provide a versatile second stage for use in complex space missions. Krafft Ehrlicke of General Dynamics, who conceived the vehicle and directed its development, proposed the name and ARPA approved it. The name derived from the legendary Centaur, half man and half horse. The horse portion represented the “workhorse” Atlas, the “brawn” of the launch vehicle; the man represented the Centaur—

ORIGINS OF NASA NAMES

which, containing the payload and guidance, was in effect the “brain” of the Atlas-Centaur combination. Eugene C. Keefer of Convair was credited with proposing the name to Ehricke.¹

NASA, which received management responsibility for the Atlas-Centaur, used the launch vehicle in the Intelsat IV series of comsats and the Surveyor series of space probes. Centaur was also used to launch some of the larger satellites and space probes—such as *OAO 2* and *3*, *ATS 5*, and the heavier *Mariner* and *Pioneer* space probes—and was mated with the Air Force Titan III for the heavier payloads flown in the mid-1970s. NASA launched the U.S.-German *Helios I* into orbit of the sun on a Titan IIIE-Centaur on 10 December 1974. (See also Atlas and Titan.)



Centaur figures (courtesy of the Library of Congress)

DELTA. When NASA was formed in 1958 it inherited from the Department of Defense’s Advanced Research Projects Agency (ARPA) the booster programs using combinations of Thor or Atlas boosters with Vanguard upper stages. The first of these upper-stage configurations was designated “Able.”¹ The Delta was similar to the previous Thor-based combinations and was a fourth—or “D”—version. Milton W. Rosen of NASA was responsible for the name. He had been referring to the combination as “Delta,” which became the firm choice in January 1959 when a name was required because NASA was signing a contract for the booster. The vehicle was variously called “Delta” and “Thor-Delta.”²

Over the years the Thor-Delta was repeatedly updated by additions and modifications. The liftoff thrust of the Thor first stage was increased in 1964 by adding three strapped-on solid-propellant rocket motors. With the Delta second stage, the launch vehicle was called “thrust-augmented Delta” (TAD). In 1964 NASA undertook upgrading the Delta capability by enlarging the second-stage fuel tanks. When this more powerful version—



Thor-Delta



Thrust-augmented improved Delta



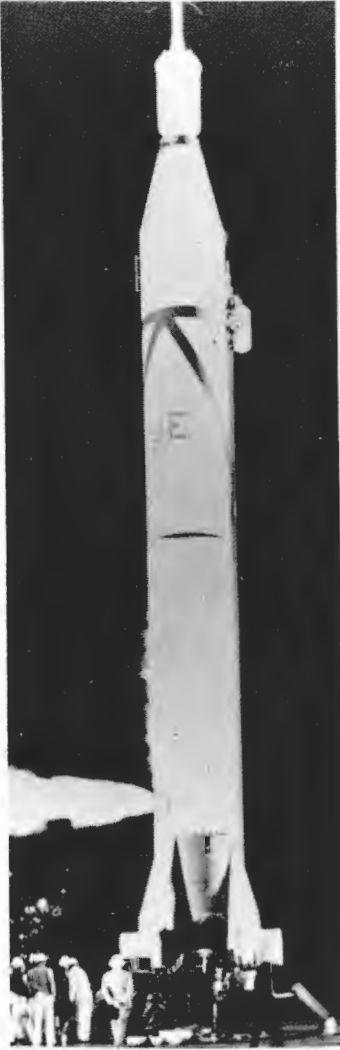
Straight Eight Thor-Delta with nine strap-on rockets

introduced in 1965 and designated “improved Delta”—was used with the thrust-augmented Thor first stage, the vehicle was called “thrust-augmented improved Delta” (TAID). In 1968 NASA incorporated an elongated Thor first stage with added fuel capacity for heavier payloads, and the three strapped-on motors were uprated. This version, with the improved Delta second stage, was called “long-tank thrust-augmented Thor-Delta (LTTAT-Delta), or “thrust-augmented long-tank Delta.”³

The “Super Six” version, with six strap-on Castor rockets for extra thrust, was first used in 1970, and nine strap-ons went into use in 1972. A more powerful third stage, TE-364-4, was also introduced in 1972, as was the “Straight Eight” Thor-Delta, with 2.4-meter (8-foot) diameter for all three stages including the fairing. The wider fairing could accommodate larger spacecraft.⁴

In 1960 the Thor-Delta placed 60 kilograms in a 1600-kilometer orbit. By

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Juno I, above, on the launch pad at Cape Canaveral before launching Explorer 1 on 31 January 1958. At right, Little Joe launch in a test of the Mercury spacecraft.



Juno (courtesy of the Library of Congress)



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the end of 1974, the vehicle could launch a 700-kilogram spacecraft into orbit for transfer to a 35 500-kilometer synchronous orbit, an 1800-kilogram payload into a 185-kilometer orbit, or 386 kilograms on a trajectory to Mars or Venus.⁵

The economical, reliable Thor-Delta was a workhorse vehicle used for a wide range of medium satellites and small space probes in two-stage or three-stage combinations, with three, six, or nine strap-on thrust-augmentor rockets. Among its many credits were meteorological satellites (Tiros, TOS), communications satellites (Echo, Telstar, Relay, Syncom, Intelsat), scientific satellites (Ariel, Exploror, OSO), and the Earth Resources Satellite *ERTS 1*. The vehicle's first three-satellite launch orbited *NOAA 4*, *OSCAR 7*, and *INTASAT* on 15 November 1974.

JUNO. Juno I and Juno II were early launch vehicles adapted from existing U.S. Army missiles by the Army Ballistic Missile Agency (ABMA) and the Jet Propulsion Laboratory (JPL). The ancient Roman goddess Juno, queen of the gods, was the sister and wife of Jupiter, king of the gods. Since the new launch vehicle was the satellite-launching version of the Jupiter C (Jupiter Composite Reentry Test Vehicle), the name Juno was suggested by Dr. William H. Pickering, JPL Director, in November 1957. Army officials approved the proposal and the name was adopted.¹

Juno I, a four-stage configuration of the Jupiter C, orbited the first U.S. satellite, *Explorer 1*, 31 January 1958. The "UE" painted on the Redstone first stage of that Juno I indicated that the Redstone was No. 29 in a series of launches. The ABMA code for numbering Redstone boosters was based on the word "HUNTSVILLE," with each letter representing a number, after deletion of the second "I" to avoid confusion:

H U N T S V I L E ²
1 2 3 4 5 6 7 8 9.

Later that year, at the request of the Department of Defense's Advanced Research Projects Agency, ABMA and JPL designed the Juno II, which was based on the Jupiter intercontinental ballistic missile and had the upper stages of the Juno I. Responsibility for Juno II was transferred to NASA after its establishment 1 October 1958. Juno II vehicles launched three Explorer satellites and two Pioneer space probes. "Juno V" was the early designation of the launch vehicle that became the Saturn I.³

LITTLE JOE. A relatively simple and inexpensive launch vehicle, Little Joe was designed specifically to test the Mercury spacecraft abort system in a series of suborbital flights. Based on a cluster of four solid-propellant rocket motors, as conceived by Langley Research Center's Maxime A. Faget and

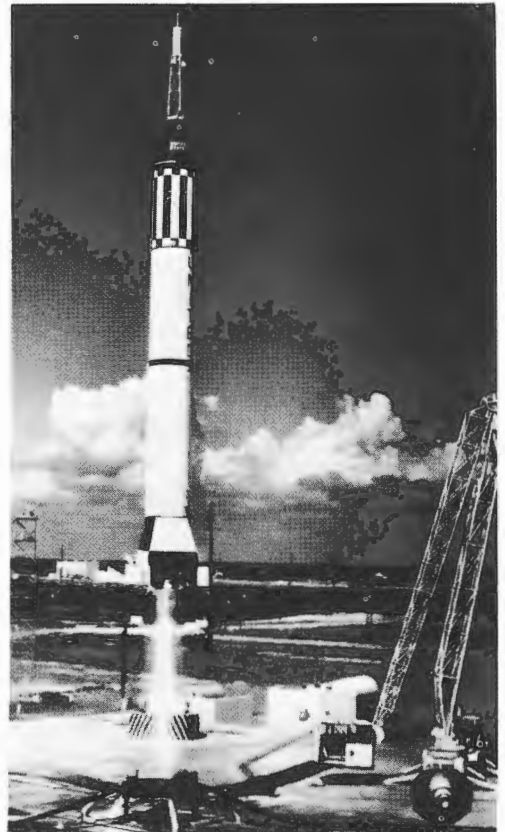
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Paul E. Purser, the booster acquired its name in 1958 as Faget's nickname for the project gradually was adopted. The configuration used in the tests added four Recruit rockets, but the original concept was for four Pollux rocket motors fired two at a time—a pair of twos. “Since their first cross-section drawings showed four holes up, they called the project ‘Little Joe,’ from the crap game throw of a double deuce on the dice. . . . The appearance on engineering drawings of the four large stabilizing fins protruding from its airframe also helped to perpetuate the name Little Joe had acquired.”¹ Little Joe II was similar in design and was used to check out the Apollo spacecraft abort system.

REDSTONE. Predecessor of the Jupiter and Juno rockets, Redstone was a battlefield missile developed by the U.S. Army and adapted for use by NASA as a launch vehicle for suborbital space flights in Project Mercury. After being called various nicknames, including “Ursa” and “Major,” the missile was officially named “Redstone” 8 April 1952 for the Army installation Redstone Arsenal at Huntsville, Alabama, where it was developed.¹ The name of the Arsenal, in turn, referred to the rock and soil at Huntsville.²

On 5 May 1961, the Redstone launched the first U.S. astronaut, Alan B. Shepard, Jr., into suborbital flight on the *Freedom 7* in Project Mercury.

Launch of Mercury-Redstone from Cape Canaveral 5 May 1961, carrying Astronaut Alan B. Shepard, Jr., on the first U.S. manned space flight.



LAUNCH VEHICLES



Saturn I being readied for launch from Cape Kennedy with boilerplate model of the Apollo spacecraft.

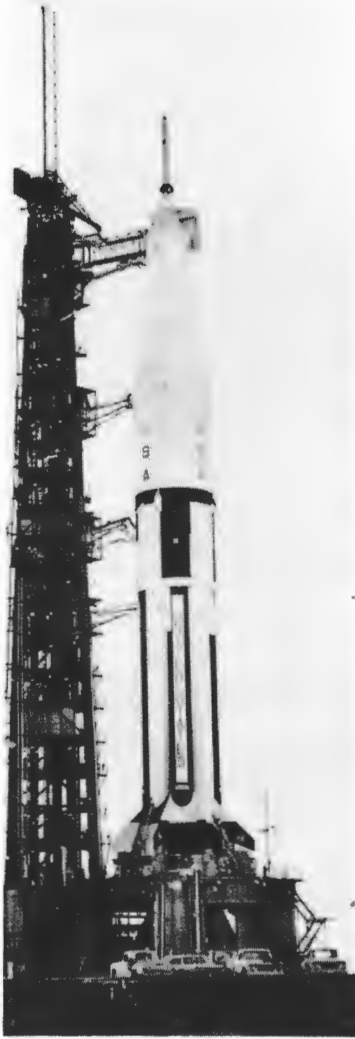
SATURN I, SATURN IB. Evolution of nomenclature for the Saturn family of launch vehicles was one of the most complex of all NASA-associated names. On 15 August 1958 the Department of Defense's Advanced Research Projects Agency (ARPA) approved initial work on a multistage launch vehicle with clustered engines in a 6.7-million-newton-thrust (1.5-million-pound-thrust) first stage. Conceived by designers at the Army Ballistic Missile Agency (ABMA), the vehicle was unofficially known as "Juno V." (Juno III and Juno IV were concepts for space vehicles to follow Juno II but were not built.)¹

In October 1958 Dr. Wernher von Braun, the Director of ABMA's Development Operations Division, proposed the Juno V be renamed "Saturn," and on 3 February 1959 ARPA officially approved the name change. The name "Saturn" was significant for three reasons: the planet Saturn appeared brighter than a first-magnitude star, so the association of this name with such a powerful new booster seemed appropriate; Saturn was the next planet after Jupiter, so the progression was analogous to ABMA's progression from missile and space systems called "Jupiter"; and Saturn was the name of an ancient Roman god, so the name was in keeping with the U.S. military's custom of naming missiles after mythological gods and heroes.²

Throughout the second half of 1959, studies were made of possible upper stages for the new Saturn vehicle. The interagency Saturn Vehicle Evaluation Committee,* considered many combinations, narrowing the choice to

*Chaired by NASA's Abe Silverstein and often referred to as "the Silverstein Committee," the committee was composed of representatives of NASA, ARPA, DOD, and USAF.

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Saturn IB, above, on the launch pad at Complex 34 and Saturn of mythology (courtesy of the Library of Congress). At right, the rollout of Saturn V for the launch of Apollo 8 to the moon.



LAUNCH VEHICLES

design concepts labeled "Saturn A," "Saturn B," and "Saturn C." In December 1959, following the recommendation of this committee, NASA authorized building 10 research and development models of the first "C" version, or "Saturn C-1" design proposal.³ For the time being the booster was called "Saturn C-1."

In the meantime Saturn became a NASA project and also had become an important link with the Nation's manned lunar program, Project Apollo. In 1962, NASA decided a more powerful version of the Saturn C-1 would be needed to launch Apollo lunar spacecraft into earth orbit, to prepare and train for manned flights to the moon later in the 1960s. NASA called this launch vehicle "Saturn C-1B."⁴ In February 1963, NASA renamed these vehicles. At the suggestion of the NASA Project Designation Committee, Saturn C-1 became simply "Saturn I" and the Saturn C-1B, "Saturn IB."⁵ The Saturn IB was composed of the S-IB first stage, a modified version of the S-I first stage that could develop 7.1 million newtons (1.6 million pounds) of thrust by 1973, and the S-IVB second stage, an uprated version of the S-IV stage that could develop 1 million newtons (230 000 pounds) of thrust.

On 9 June 1966 NASA changed the name of the Saturn IB to "Uprated Saturn I." The redesignation was suggested to the Project Designation Committee by Dr. George E. Mueller, NASA Associate Administrator for Manned Space Flight. "The Committee agreed with Dr. Mueller that the booster is acutally an uprated Saturn I and should be so called."⁶ In December 1967, however, NASA decided to return to the use of the simpler term, "Saturn IB." The proposal was made by the Office of Manned Space Flight and approved by Administrator James E. Webb.⁷

The Saturn IB launched the first manned Apollo spacecraft, *Apollo 7*, on successful flight 11 October 1968 and, after the completion of the Apollo program, launched three missions to man the Skylab Orbital Workshop in 1973. It was scheduled to launch the American crew in the July 1975 U.S.-U.S.S.R. Apollo-Soyuz Test Project docking mission.

SATURN V. In January 1962 NASA initiated development of the large launch vehicle for Project Apollo manned lunar flight. The vehicle selected was the Saturn C-5, chosen after six months of studying the relative merits of Saturn C-3, C-4, and C-5 designs.¹ These designs were all based on a large clustered-engine first stage but with various combinations of upper stages. The numerical designation followed the sequence established with the Saturn C-1 (see Saturn I, where the origin of the name "Saturn" also is explained).

Alternately referred to in 1962 as “Advanced Saturn,” the Saturn C-5 was renamed early the following year. Nominations were submitted to the NASA Project Designation Committee as well as proposed by the Committee members themselves. After considering many alternate names—the leading contender for a while was “Kronos”—the Committee suggested, through Assistant Administrator for Public Affairs George L. Simpson, Jr., to NASA Associate Administrator, Dr. Robert C. Seamans, Jr., that the new name be “Saturn V.”² The recommendation was approved and the new name adopted early in February 1963.³

The final configuration of the Saturn V comprised the S-IC first stage with 34-million-newton (7.7-million-pound) thrust, the S-II second stage with 5.1-million-newton (1.2-million-pound) thrust, and the S-IVB stage of the Saturn IB.⁴

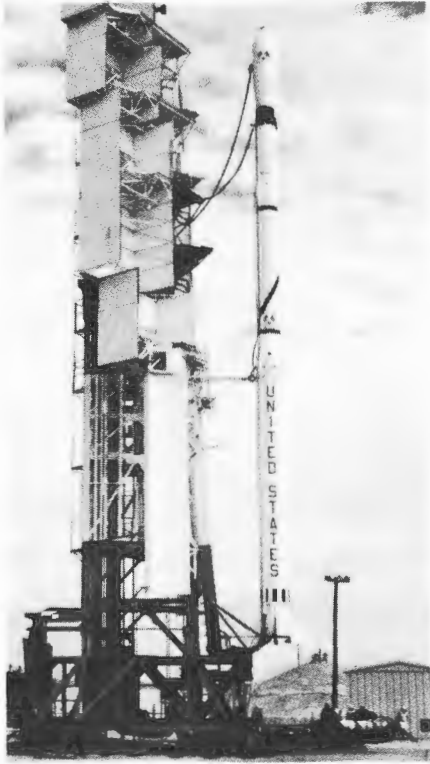
On 21 December 1968 the Saturn V launched *Apollo 8*, the first manned Apollo spacecraft to escape the earth’s gravitational field, into flight around the moon. Saturn V launches through *Apollo 17* in December 1972 put 27 men into lunar orbit, 12 of them landing on the moon to explore its surface. On 14 May 1973 the Saturn V orbited the first U.S. experimental space station, the *Skylab 1* Orbital Workshop, which was manned by three successive three-man crews during the year.

SCOUT. The Scout launch vehicle was named in mid-1958 by William E. Stoney, Jr., prominent in development of the vehicle at NACA Langley Aeronautical Laboratory (later NASA Langley Research Center). He thought of the name as a parallel to “Explorer,” a name being given to a series of spacecraft. “Scout” seemed appropriate for a vehicle with payloads performing similar tasks—“scouting the frontiers of space environment and paving the way” for future space exploration.¹

Smallest of the basic launch vehicles, Scout was designed at Langley as a reliable, relatively inexpensive launch vehicle for high-altitude probes, reentry experiments, and small-satellite missions. Among the satellites it launched were scientific satellites such as Explorers and international satellites such as the San Marco series. It was the only U.S. satellite launch vehicle to use solid propellants exclusively; the stages for Scout had grown out of the technology developed in the Polaris and Minuteman programs. The Air Force, which used Scout to launch Department of Defense spacecraft, called its version “Blue Scout.”

Scout usually consisted of four stages and could put 186 kilograms into a 555-kilometer orbit.² The first stage, “Algol,” was named for a star in the constellation Perseus; the second stage, “Castor,” for the “tamer of the horses” in the constellation Gemini; the third stage, “Antares,” for the

LAUNCH VEHICLES



Scout on the launch pad at Wallops Flight Center, at left. Below, Shotput ready at Wallops.



brightest star in the constellation Scorpio; and the fourth stage, "Altair," for a star in the constellation Aquila.³ In June 1974 a new Scout E, incorporating a solid-fueled rocket motor in a fifth stage and adaptable for highly eccentric orbits, launched the *Hawkeye 1* Explorer satellite.⁴

SHOTPUT. A special-purpose composite rocket to test balloon-satellite ejection and inflation in space, Shotput was used in five launches from Wallops Station in 1959 and 1960 in tests of the *Echo 1* satellite payload. It was also

used to test the Italian San Marco satellite in suborbital flights. The solid-propellant Shotput vehicle consisted of a first-stage Sergeant rocket boosted by two Recruit rockets and a second stage X-248 rocket that later was used as the third stage of the Delta launch vehicle.¹ Shotput launched the balloon payload to a 400-kilometer altitude, where the packaged sphere was ejected from the vehicle's nose and inflated above the atmosphere. Shotput was so named because it "tossed" the Echo sphere up above the earth's atmosphere in a vertical trajectory.²

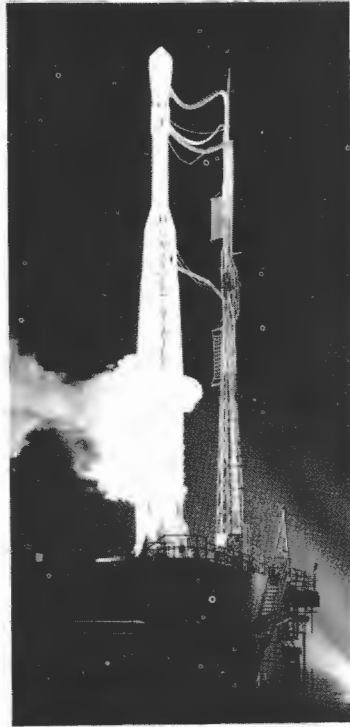
THOR. Adapted for use as a launch vehicle in combination with various upper stages, Thor was originally developed as a U.S. Air Force intermediate-range ballistic missile by Douglas Aircraft Company. The name, which came into use in 1955,¹ derived from the ancient Norse god of thunder—"the strongest of gods and men."²

The origin of the name has been traced back to Joe Rowland, Director of Public Relations at the Martin Company, who was assigned to suggest names for Martin's new intercontinental ballistic missile in preparation for a meeting at Air Research and Development Command (ARDC) Headquarters. At the meeting were to be representatives of other missile contractors, Convair/Astronautics Division of General Dynamics Corporation and Douglas Aircraft Company. Of Rowland's list of proposed names, "Titan" was the one preferred by his colleagues, with "Thor" as second choice. At the ARDC meeting, the first-choice "Titan" was accepted as the appropriate name for the Martin Company's project. Through a misunderstanding, Douglas had prepared no name to propose for its missile. Rowland—with "Titan" now firm for his company's project—offered his alternate "Thor" to Donald Douglas, Jr. Douglas and his Vice President of Public Relations agreed it was an attractive name and proposed it to ARDC officials; it was officially adopted.³

NASA used Thor as a first stage with both Agena and Delta upper stages. The Air Force-developed "thrust-augmented Thor" (TAT), with three added solid-propellant rocket motors strapped on the base of the Thor, also was used with both Agena and Delta upper stages. When TAT was used with Agena, the configuration was called "thrust-augmented Thor-Agena";⁴ with Delta, the vehicle was known as "thrust-augmented Delta" (TAD) or "thrust-augmented Thor-Delta" (TAT-Delta).

In 1966 the Air Force procured a new version of the Thor first stage, elongated to increase fuel capacity, for heavier payloads—the "long-tank thrust-augmented Thor" (LTTAT), sometimes also called "Thorad." LTTAT used with an Agena upper stage was called "long-tank thrust-augmented Thor-Agena" or "Thorad-Agena."⁵ With Delta, it was "long-

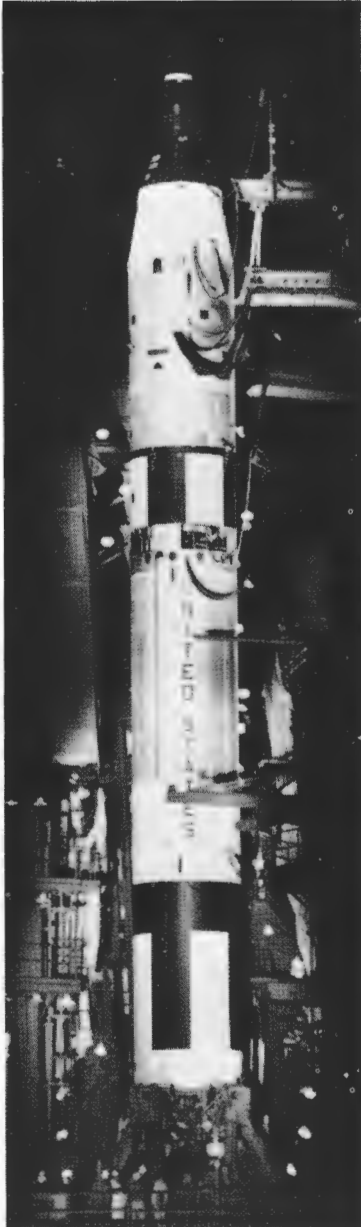
LAUNCH VEHICLES



Thor-Delta, above, in countdown for the Telstar 1 launch. At right, the long-tank Thor-Delta poised for launch from the ETR. The Norse god Thor at left (courtesy of the Library of Congress).

tank thrust-augmented Thor-Delta.” NASA began using the long-tank Thor with the improved Delta second stage in 1968, going to six strap-on rockets for extra thrust in 1970 and introducing nine strap-on rockets in 1972. Combinations varied according to the performance needed for the mission. (See Delta.)

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LAUNCH VEHICLES

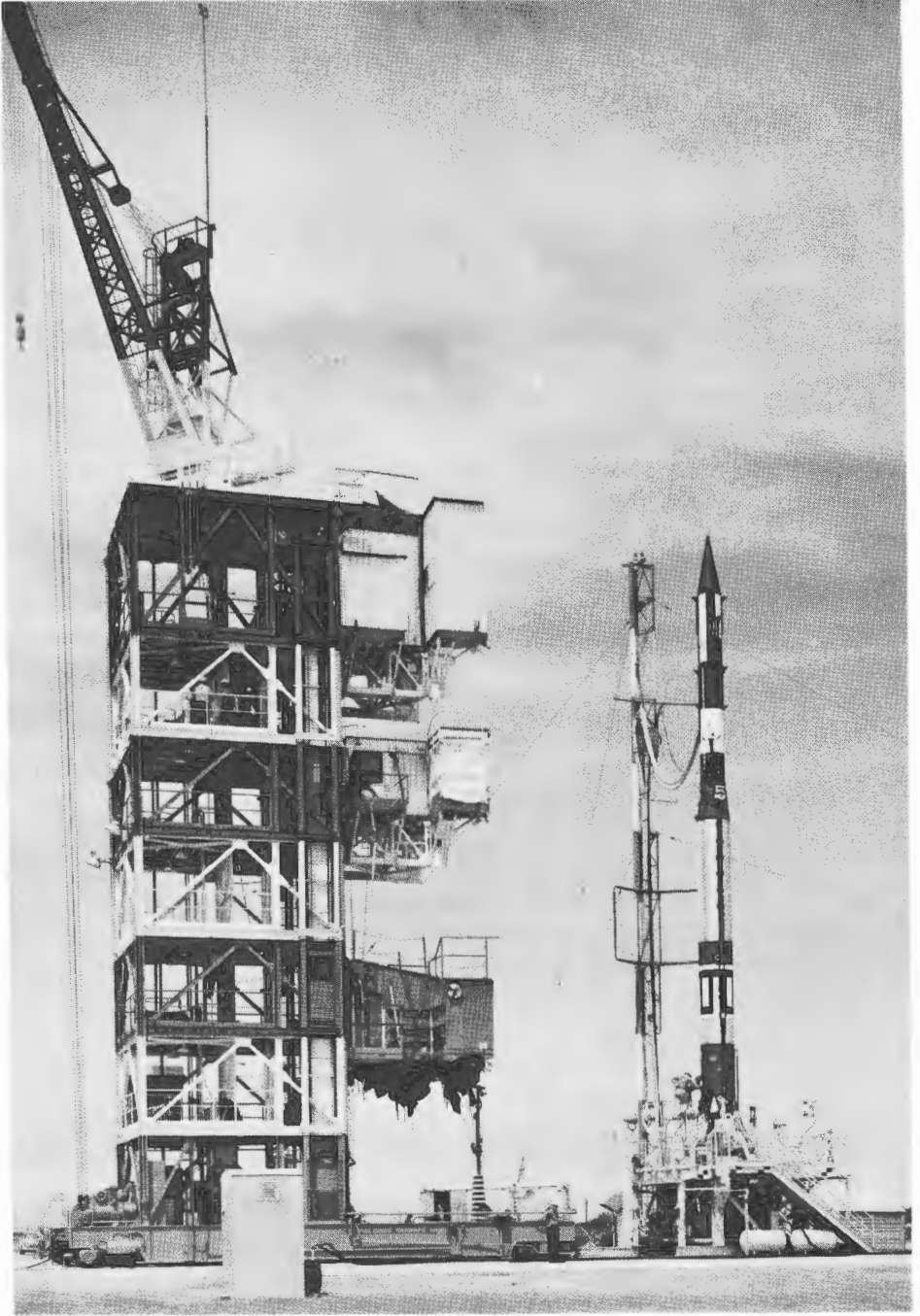
TITAN. The Titan II launch vehicle was adapted from the U.S. Air Force intercontinental ballistic missile to serve as the Gemini launch vehicle in NASA's second manned spaceflight program. Originating in 1955, the name "Titan" was proposed by Joe Rowland, Director of Public Relations at the Martin Company, producer of the missile for the Air Force. Rowland was assigned the task of suggesting possible names for the project, requested of Martin by the Air Research and Development Command. Of the list of possible names, "Titan" was preferred.¹ He took the name from Roman mythology: the Titans were a race of giants who inhabited the earth before men were created. ARDC approved the nomination and "Titan" became the official name. When the improved version of the missile was developed, the original Titan came to be known as Titan I and the second, Titan II.² Titan II was chosen as the Gemini launch vehicle because greater thrust was required to orbit the three-and-a-half-metric-ton Gemini spacecraft; also its storable fuels promised the split-second launch needed for rendezvous with the target vehicle.

The Titan III—an improved Titan II with two solid-propellant strap-on rockets—was developed for use by the Air Force as a standardized launch vehicle that could lift large payloads into earth orbit. NASA contracted for Titan III vehicles for a limited number of missions to begin in the mid-1970s: ATS satellites would require the Titan IIIC vehicles and HEAO satellites, the Titan IIID configuration. Interplanetary missions requiring high-velocity escape trajectories—the Viking Mars probes and Helios solar probes—began using the Titan III–Centaur configuration on completion of the Centaur integration program in 1974. A Titan IIIE–Centaur launched *Helios 1* into orbit of the sun 10 December 1974.

In 1974 the Titan IIIC—which launched *ATS 6* on 30 May 1974—could put an 11 820-kilogram payload into a 555-kilometer orbit or 1500 kilograms into synchronous orbit. The Titan IIIE–Centaur could launch 5135 kilograms into an earth-escape orbit or 3960 kilograms to Mars or Venus.³

Gemini-Titan I on the launch pad at Cape Kennedy during prelaunch tests (far left) and Titan IIIE–Centaur. At right, Ocean, one of the Titans of mythology (courtesy of the Library of Congress).





Vanguard

LAUNCH VEHICLES

VANGUARD. The name "Vanguard," adopted in 1955, applied to the U.S. International Geophysical Year satellite project as well as to the launch vehicle developed to orbit the satellites (see Vanguard under Satellites). Stages of the Vanguard rocket were later adapted to the NASA Delta vehicle.

II

SATELLITES



Full-disc photograph of the earth from equatorial orbit, transmitted by ATS 3 on 10 November 1967. A cold front moves eastward over the central United States and a tropical storm is at bottom center.

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Astronomy's traditional definition of a satellite is "a celestial body orbiting another of larger size." ¹ Through the balance of gravitational attraction, velocity, and centrifugal force, the moon revolves around, or orbits, the earth; hence, it is a satellite of the earth. Since 1957, man has been using rocket-powered launch vehicles to place man-made objects in orbit around the earth. Because they orbit the earth, these objects are earth "satellites."

Technically, of course, orbiting manned spacecraft also became satellites of the earth. Other satellites, in the strict sense of the word, were the spent rocket stages and uninstrumented pieces of hardware—popularly called "space junk"—placed in orbit incidentally. For purposes of the space exploration program, the term "satellite" was applied to man-made, instrumented objects placed intentionally in earth orbit to perform specific functions.

NASA unmanned satellites are divided into two categories: scientific satellites (which obtain scientific information about the space environment) and applications satellites (which perform experiments that will have everyday usefulness for man on earth). Satellites in the Explorer series were typical of the scientific satellites, gathering a variety of scientific data and telemetering it to stations on earth. Examples of applications satellites were Tiros meteorological satellites, designed to provide cloud-cover photographs to aid in forecasting weather conditions, and Relay and later communications satellites, designed to receive and transmit voice and facsimile communications between distant points on the earth.

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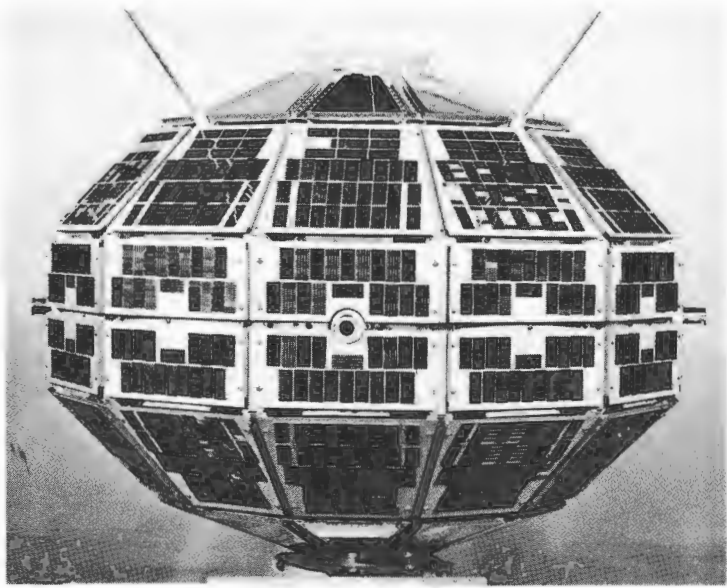


Artist's concept of Aeros in orbit.

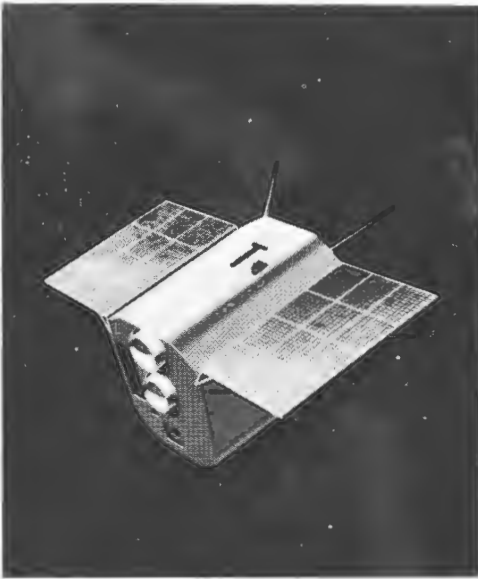
AEROS. In June 1969 NASA and the German Ministry for Scientific Research (BMwF) reached an agreement on a cooperative project that would orbit a German scientific satellite designed to investigate particle behavior in the earth's upper atmosphere.¹ In early 1969 BMwF had named the proposed aeronomy satellite after Aeros, ancient Greek god of the air.² *Aeros*, the second U.S.-German cooperative research satellite, was designated GRS-A-2 by NASA (see also Azur) before launch, assuming its proper name when successfully launched into orbit 16 December 1972.³ *Aeros 2* was orbited by NASA 16 July 1974.

("Aeros" also had been used earlier for the Synchronous Meteorological Satellite project [see SMS].)

ORIGINS OF NASA NAMES



Alouette 1, above, before launch, and an artist's concept of ANS below. Ariel 4, at right, was the first satellite in the Ariel series to carry a United States experiment.



SATELLITES

ALOUETTE. An international satellite program, Alouette was a Canadian project in cooperation with NASA ¹ and was given its name in May 1961 by the Canadian Defence Research Board. The name was selected because, as the French-Canadian name for meadowlark, it suggested flight; the word “Alouette” was a popularly used and widely known Canadian title; and, in a bilingual country, it called attention to the French part of Canada’s heritage.² NASA supported the Board’s choice of name for the topside sounder scientific satellite.³

Alouette 1, instrumented to investigate the earth’s ionosphere from beyond the ionospheric layer, was launched into orbit by NASA from the Pacific Missile Range 28 September 1962. It was the first satellite designed and built by a country other than the United States or the Soviet Union and was the first satellite launched by NASA from the West Coast. *Alouette 2* was orbited later as part of the U.S.–Canadian ISIS project (see ISIS).

NASA’s *Explorer 20*, launched 25 August 1964, was nicknamed “Topsi” for “topside sounder”; it returned data on the ionosphere to be compared with Alouette data, as well as data from *Ariel 1* and *Explorer 8* and sounding rockets.⁴

ANS. In June 1970 NASA and the Netherlands Ministries of Economic Affairs and Education and Science reached agreement to launch the first Netherlands scientific satellite in 1974. The satellite was designated “ANS,” an acronym for “Astronomical Netherlands Satellite,” and an ANS Program Authority was created by the Ministries to direct the cooperative project. NASA provided an experiment and the Scout launch vehicle, and the Program Authority designed, built, and tested the spacecraft and provided tracking and data acquisition.¹ The satellite—launched 30 August 1974—carried an ultraviolet telescope to study selected stellar ultraviolet sources and instruments to investigate both soft and hard x-ray sources.

ARIEL. The world’s first international satellite, *Ariel 1* was a cooperative project between the United Kingdom and NASA. The satellite was named in February 1962 for the spirit of the air who was released by Prospero in Shakespeare’s play *The Tempest*. The name “Ariel”—a traditional name in British aeronautics—was chosen by the U.K. Minister of Science and endorsed by NASA.¹ Other satellites followed in the program.

Ariel 1 (UK-1 before orbit), launched from Cape Canaveral 26 April 1962, was built by NASA’s Goddard Space Flight Center and instrumented with six British experiments to make integrated measurements in the iono-

sphere. *Ariel 2*, containing three U.K.-built experiments, was placed in orbit 27 March 1964. *Ariel 3*, designed and built in the United Kingdom, was launched 5 May 1967 with five experiments. The U.K.-built *Ariel 4* carried four U.K. and one U.S. experiment into orbit 11 December 1971 to investigate plasma, charged particles, and electromagnetic waves in the ionosphere. *Ariel 5* (UK-5), also British-built, was launched 15 October 1974 to study x-ray sources.

The UK-X4 satellite was in a different series from the Ariels. An “X” added to the prelaunch designation indicated it was experimental and, when orbited March 1974 to test spacecraft systems and sensors, the spacecraft was christened *Miranda*. It was a United Kingdom satellite launched by NASA under a contract for reimbursable services, rather than a joint research mission.²

The United Kingdom’s Skynet satellites belonged to still another series. The Skynet I and II series of U.K. Ministry of Defence communications satellites were launched by NASA, beginning in 1969, under agreement with the U.S. Air Force, which reimbursed NASA for launch vehicles and services.

ATS. The name “ATS”—an acronym for “Applications Technology Satellite”—referred to the satellite mission: to test technological experiments and techniques for new practical applications of earth satellites. The name evolved through several transitions, beginning with the project’s study phase. In 1962–1963, at NASA’s request, Hughes Aircraft Company conducted feasibility and preliminary design studies for an “Advanced Syncom” satellite. The concept was of a communications spacecraft in synchronous orbit with a new stabilization system and a multiple-access communication capability. Other names in use were “Advanced Synchronous Orbit Satellite,” “Advanced Synchronous Satellite,” and “advanced synchronous communications satellite.”¹

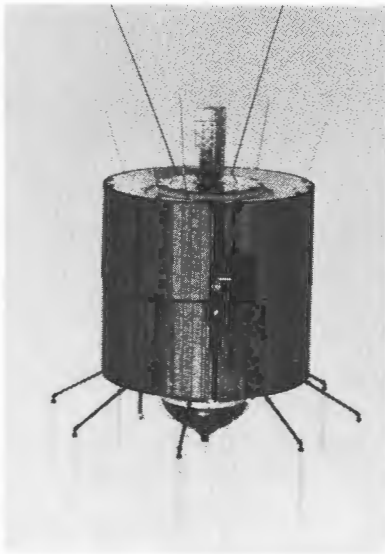
By March 1964 NASA had decided Advanced Syncom should not only test communications technology but also support development of “meteorological sensing elements, measurements of the space environment in various orbits such as the synchronous orbit, and the conduct of experiments on general stabilization systems which apply not only to communications systems but to other systems.”² As the concept of the satellite was changed, so was its name—becoming “Advanced Technological Satellite (ATS).” Hughes was selected to build five ATS spacecraft.³

The change to “Applications Technology Satellite” came in October 1964. Dr. Homer E. Newell, NASA Associate Administrator for Space Sci-

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ence and Applications, and Dr. John F. Clark, Director of Space Sciences, had concluded that the adjectives “Advanced Technological” were undesirable because they seemed to conflict with responsibilities of NASA’s Office of Advanced Research and Technology.⁴ On 2 October Dr. Newell formally proposed, and Associate Administrator Robert C. Seamans, Jr., approved, the change to “Applications Technology Satellite”—bringing “the name of the project more into line with its purpose, applications technology, while retaining the initials ATS by which it is commonly known.”⁵

Launched 6 December 1966, *ATS 1* took the first U.S. high-quality photographs of the earth from synchronous orbit, showing the changing cloud-cover patterns. In addition to weather data, the satellite relayed color television across the United States and voice signals from the ground to aircraft in flight. *ATS 3*, launched 5 November 1967, carried advanced communications, meteorology, and navigation experiments and made high-resolution color photographs of one complete side of the earth. *ATS 6* was launched 30 May 1974 to support public health and education experiments in the United States and India. It was the first communications satellite with the power to broadcast TV photos to small local receivers.



ATS 3, at left, suspended during antenna pattern testing. The model of ATS 6, below, shows the nine-meter reflector deployed.



ORIGINS OF NASA NAMES

AZUR. A 17 July 1965 memorandum of understanding between NASA and the German Ministry for Scientific Research (BMwF) initiated a cooperative project that would orbit a German scientific satellite to investigate the earth's inner radiation belt. The agreement provided for the launch of the satellite after a successful series of sounding rocket tests to check out the proposed satellite instrumentation.¹ NASA would provide the Scout launch vehicle, conduct launch operations, provide tracking and data acquisition, and train BMwF personnel. In June 1966 NASA designated the satellite GRS-A, an acronym for "German Research Satellite-A."* "Azur," the German word for the color "sky blue," was chosen by BMwF in early 1968 as the name for the satellite, and GRS-A was officially designated *Azur* by NASA after launch 7 November 1969.² (See also *Aeros*.)

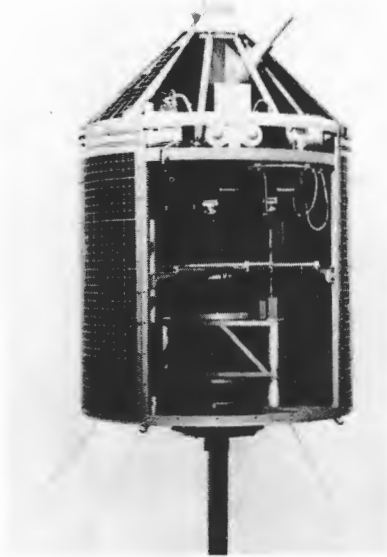
BIOSATELLITE. As the name suggests, Biosatellites were used to conduct space experiments with living organisms, both plant and animal. The biological specimens in orbit underwent prolonged weightlessness, radiation, and other conditions of the space environment; scientists could study the effects on various life processes. Physiological effects included growth and form of entire organisms, structure of growth of cells and tissues, and basic biochemistry of the cell.¹

The NASA Project Designation Committee, asked by the Director of Bioscience Programs in June 1962 to consider an official name for such a project should it be initiated, devised the name "Biosatellite," a contraction of the phrase "biological satellite." The shorter "Bios" formed the basis for the new name and occasionally appeared as a substitute for Biosatellite.² But Biosatellite should not be confused with "BIOS" ("Biological Investigation of Space"), the name of a separate reentry spacecraft flown in 1961. The Project Designation Committee reserved the name "Biosatellite" for project use, pending approval of the orbiting biological payload project.³

In March 1963 NASA contracted for spacecraft feasibility studies for a "bio-satellite program." After evaluating the results of these studies and obtaining funding for the project, NASA selected the General Electric Company to build the spacecraft and later chose the biological experiments to be flown on them. By early 1964 the project was well under way and the name "Biosatellite" had been adopted.

*"GRS-A" became "GRS-A-1" when an agreement was reached to orbit a second research satellite, designated "GRS-A-2" (*Aeros*). (NASA, "Project Approval Document," 15 June 1966.)

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Cutaway models of the German-built Azur, at left, and NASA's Biosatellite, below.



Biosatellite 1 was launched 14 December 1966; it functioned normally in orbital space flight but failed to reenter as it should have three days later. *Biosatellite 2*, launched 7 September 1967, obtained information on the effects of radiation and weightlessness on plant and low-order animal life forms. The program ended with the flight of *Biosatellite 3*, launched 28 June 1969, which was prematurely terminated after eight and one-half days. Analysis of the death of the pigtailed monkey orbited during that flight provided additional information on the effects of prolonged weightlessness during manned flights.



Echo 1 during inflation tests before launch.

ECHO. The idea of an inflatable, spherical space satellite was conceived in January 1956 by William J. O'Sullivan, Jr., aeronautical engineer at NACA's Langley Aeronautical Laboratory (later NASA Langley Research Center), and proposed as an air-density experiment for the International Geophysical Year (1 July 1957 to 31 December 1958).¹ The balloon satellite was similar to one described by John R. Pierce of Bell Telephone Laboratories in his 1955 article, "Orbital Radio Relays."² Pierce was interested in the orbiting inflated sphere for use as a reflector for radio signals and he proposed a cooperative communication experiment using O'Sullivan's balloon satellite. By early 1959 O'Sullivan's original proposal for IGY air-density studies had become NASA's passive communications satellite project.³

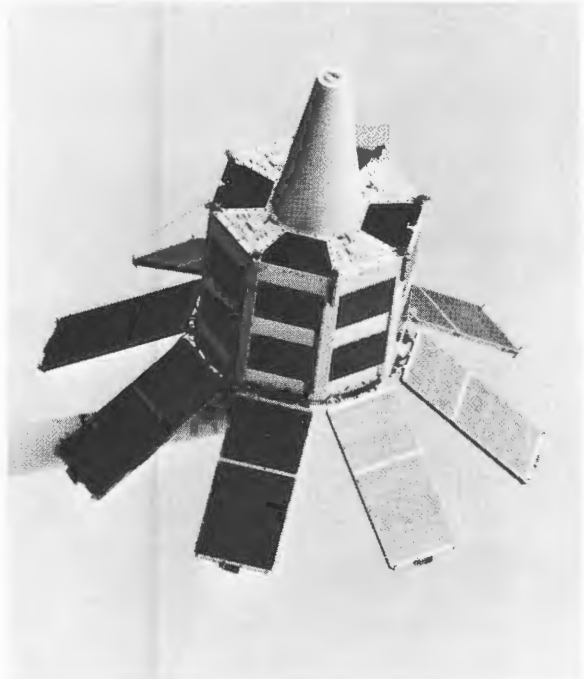
The word "echo" was often used in the radio and radar sense to describe the reflection of ground-transmitted signals from the surface of an orbiting balloon. The name "Project Echo," derived through informal use, was given to the 30-meter inflatable-structure satellite.⁴ O'Sullivan's design was tested in a series of Shotput launches and the Echo project proved that an

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aluminized-Mylar sphere could be carried aloft by a rocket, be inflated in space, and remain in orbit to provide a means of measuring atmospheric density as well as a surface for reflecting radio communications between distant points on the earth.

Echo 1 passive communications satellite, orbited by NASA 12 August 1960, was the fruition of O'Sullivan's labors. His inflatable-sphere concept also was employed in three air-density Explorer satellites, in *Echo 2*, and in *Pageos 1*.

EOLE. NASA and France's Centre National d'Études Spatiales (CNES) signed a memorandum of understanding 27 May 1966 providing for development of a cooperative satellite-and-instrumented-balloon network to collect meteorological data for long-range weather forecasts.¹ "Eole," the French name for Aeolus, ancient Greek god of the winds, was chosen by CNES as the name for the satellite project.² Known as "FR-2 [see also *FR-1*]" until late 1968—and also as simply "French Satellite" before December 1968—the project was redesignated by NASA "CAS-A," an acronym for the first in a series of international "Cooperative Applications Satellite(s)." ³ The satellite was given its permanent name *Eole* after successful launch into orbit 16 August 1971.



Eole, cooperative French and U.S. satellite to collect meteorological data for forecasts.

ORIGINS OF NASA NAMES



ERTS 1 (renamed LANDSAT 1) after prelaunch tests at General Electric.

ERTS, EOS, SEOS. The name “ERTS”—an acronym for “Earth Resources Technology Satellite”—was a functional designation; it was derived from early concepts of an “earth resources” satellite system to provide information on the environment by using remote-sensing techniques. Between 1964 and 1966, studies of remote-sensing applications were conducted jointly by NASA and the Departments of Interior and Agriculture and NASA initiated

SATELLITES

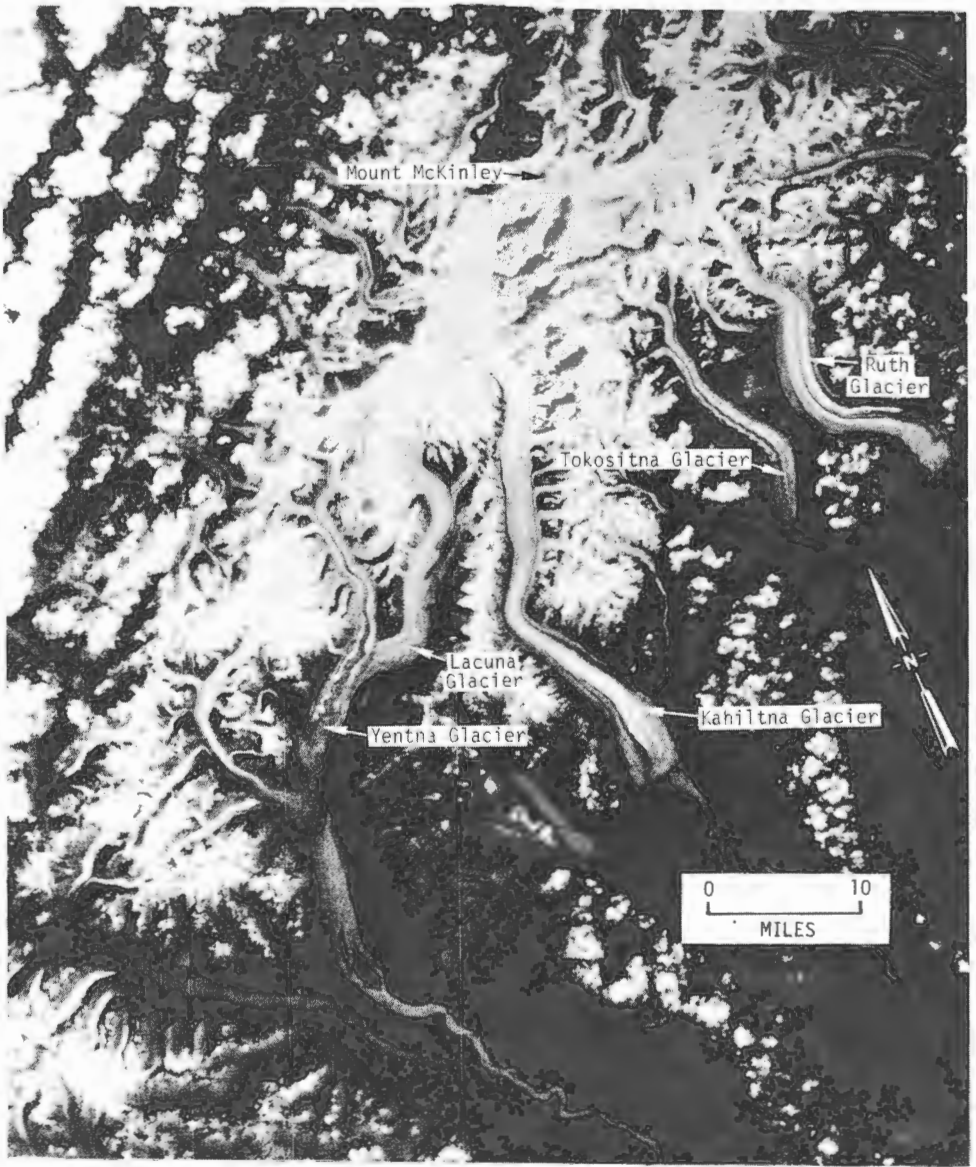
a program of aircraft flights to define sensor systems for remote-sensing technology. The studies indicated that an automated remote-sensing satellite appeared feasible and that a program should be initiated for the development of an experimental satellite.¹

In early 1967 NASA began definition studies for the proposed satellite, by then designated ERTS, and by early 1969 the project was approved.² Two satellites, ERTS-A and ERTS-B, were subsequently planned for launch. ERTS-A became *ERTS 1* on launch 23 July 1972; it was still transmitting data on earth resources, pollution, and environment at the end of 1974, for users worldwide. ERTS-B was scheduled for 1975 launch.*

The early nomenclature for both the program and the proposed satellites was confusing. The "Earth Resources Program" was variously known as the "Natural Resources Program," the "Earth Resources Survey Program," and the "Earth Resources Observation Program."³ The designation "Earth Resources Survey Program" was eventually used to include ERTS and remote-sensing aircraft programs, as well as the "Earth Resources Experiment Package" (EREP) flown on Skylab missions in 1973-1974. These programs formed a part of NASA's overall "Earth Observations Programs," which also included the meteorology and earth physics program.⁴

Before 1967 several names were in use for the proposed earth resources satellite, including the designation "ERS"—a shortened acronym for "Earth Resources Survey Satellite"—which was in conflict with an identical designation for an Air Force satellite project known as the "Environmental Research Satellite."⁵ Further confusion arose when the Department of the Interior, which in cooperation with NASA had been studying the application of remote-sensing techniques, announced the name "EROS"—an acronym for "Earth Resources Observation Satellite"—for the satellite

*NASA announced 14 January 1975 that *ERTS 1* had been renamed *LANDSAT 1* and ERTS-B would become *LANDSAT 2* when launched 22 January. Associate Administrator for Applications Charles W. Mathews said that, since NASA planned a SEASAT satellite to study the oceans, "LANDSAT" was an appropriate name for the satellite that studied the land. Dr. George M. Low, Deputy Administrator of NASA, had suggested a new name be found for ERTS, with more public appeal. John P. Donnelly, Assistant Administrator for Public Affairs, had therefore requested NASA office heads and Centers to submit ideas for new names by the end of December 1974. From a number of replies received, the NASA Project Designation Committee made its recommendation, and "LANDSAT" was approved. (NASA, News Release 75-15; Mathews, ERTS-B Mission Briefing, NASA Hq., 14 Jan. 1975; Howard G. Allaway, Public Affairs Officer, NASA, telephone interview, 3 Feb. 1975; and Bernice Taylor, Administrative Assistant to Assistant Administrator for Public Affairs, NASA, telephone interview, 12 Feb. 1975.)



“Gallop,” or surging, glaciers in Alaska identified by U.S. Geological Survey scientists on images taken by ERTS 1. Glacier behavior could give warning of floods and clues to sources of water supply.

project.⁶ In early 1967, when NASA initiated the definition studies of the experimental satellite, the name “ERTS” came into use.⁷

In early 1970 the NASA Project Designation Committee met to choose a

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new name for the ERTS satellites and several names were suggested, including "Earth," "Survey," and "Ceres"—the ancient Greek goddess of the harvest. The Committee favored "Earth" but, after submitting the name to the other Government agencies in the program and receiving unfavorable responses from some, it dropped the name "Earth," and "ERTS" was used up through the end of 1974.⁸

EOS. A follow-on to ERTS was to be the Earth Observatory Satellite (EOS)—given a functional name in NASA. Results from the first Earth Resources Technology Satellite showed that greater spectral and spatial resolutions were needed for some applications, such as classifying and monitoring the use of land for urban planners and increasing accuracy in predicting agricultural yield. And since 1970 NASA had seen a need for a multipurpose satellite in low earth orbit to survey the earth and oceans, detect pollution, and monitor the weather. Definition studies were begun in 1974 of a low-cost EOS spacecraft that could be launched, resupplied or serviced, and eventually returned by the Space Shuttle, but could also be launched by a conventional booster before the shuttle became operational. Modular systems for power and different spacecraft functions would permit the Shuttle to unplug and replace malfunctioning systems.⁹

EOS-A was tentatively scheduled for 1979 launch as a land-and-water-use mission, with EOS-B possibly in 1981.

SEOS. An advanced study also was under way in 1974 of a Synchronous Earth Observatory Satellite (SEOS) for experimental meteorological and earth resources observations using a large telescope with improved resolution and an infrared atmospheric sounder. The geosynchronous orbit would provide the short intervals needed to detect and warn of natural disasters such as hurricanes, tornadoes, forest fires, floods, and insect crop damage.¹⁰

ESRO. The European Space Research Organization (ESRO), a 10-member Western European group to conduct scientific space research, came into formal existence in March 1964 (the ESRO Convention had been signed 14 June 1962). The Organization named its first satellites "ESRO" in honor of its own abbreviation.¹ An 8 July 1964 NASA-ESRO agreement originally called for two cooperative satellites, ESRO 1 to investigate the polar ionosphere and ESRO 2 to study solar astronomy and cosmic rays. With development of the scientific payloads, it became apparent that ESRO 1 had a rather narrow launch opportunity and that it was important to launch it in



European designed and built ESRO 1 was also given the name Aurorae in orbit. In the photo the satellite was being tested at the Western Test Range before launch.

the fall; therefore ESRO 2 was moved up for first launch, although the number designations were not changed.²

After launch by NASA on 3 October 1968, *ESRO 1* was also assigned the name *Aurorae* by ESRO; it was designed to study the aurora borealis and related phenomena of the polar ionosphere. Its numerical designation later became *ESRO 1A* when a duplicate backup satellite, *ESRO 1B*, was launched 1 October 1969. *ESRO 1B* was designated *Boreas* by ESRO.³

ESRO 2A, scheduled to be the first ESRO satellite, failed to reach orbit 29 May 1967. Its backup, *ESRO 2B*, was given the name *IRIS*—an acronym for

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“International Radiation Investigation Satellite”—by ESRO after successful launch 16 May 1968.⁴

Under the 1964 memorandum of understanding, NASA’s participation in the cooperative venture was to provide Scout launch vehicles, conduct launch operations, provide supplemental tracking and data acquisition services, and train ESRO personnel. No funds were exchanged in the project.⁵

Under a 30 December 1966 memorandum of understanding, ESRO became the first international space group to agree to pay NASA for launchings; it would reimburse NASA for launch vehicle and direct costs of equipment and services. The first satellite orbited under this agreement, *HEOS 1*—“Highly Eccentric Orbit Satellite”—was launched 5 December 1968.⁶

Later scientific and applications satellites planned by ESRO—and to be launched by NASA—were given functional names:⁷

Cos-B, scheduled for 1975 launch to study cosmic rays from the galaxy, especially gamma radiation, was to be one of the successors to the *TD-1A* astronomical satellite launched by NASA for ESRO in March 1972.

GEOS, “Geostationary Scientific Satellite” (a different satellite from NASA’s Geodetic Explorers or Geodynamic Experimental Ocean Satellite), was scheduled for 1976 launch to study cosmic radiation over a long period.

EXOSAT, a high-energy astronomy satellite, was planned for 1979 launch for x-ray astronomy.

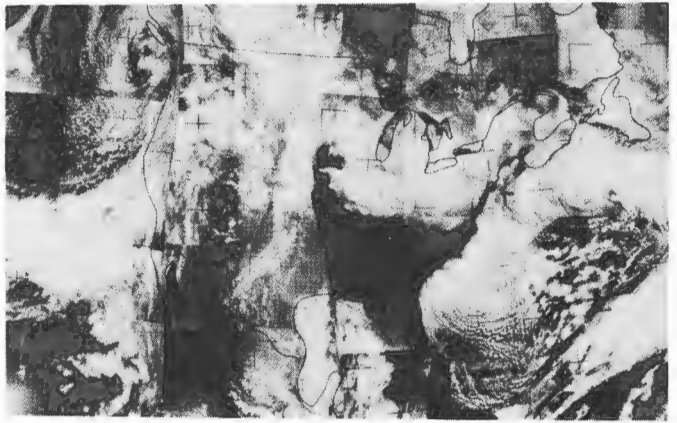
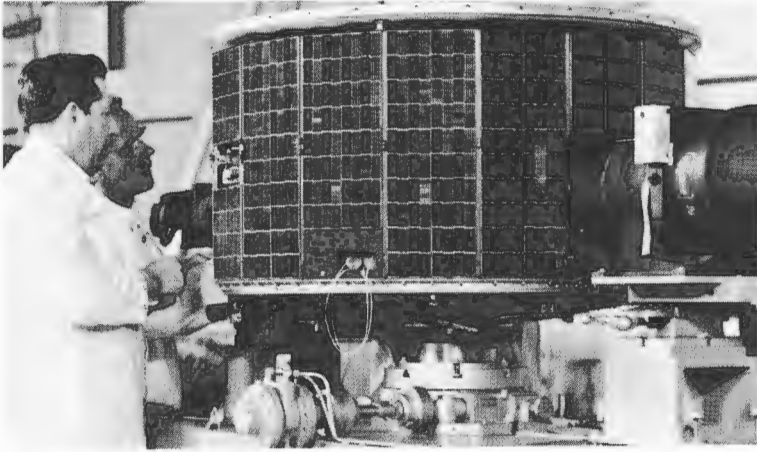
METEOSAT, a geostationary meteorological satellite, was planned for 1976 launch.

OTS, geostationary “Orbital Test Satellite,” was to be launched in 1976 or 1977 as a forerunner of the European Communications Satellite (ECS; formerly CEPT, for *Conférence Européenne des Postes et Télécommunications*, or CETS, for *Conference on European Telecommunications Satellite*).

AEROSAT, joint “Aeronautical Satellite” to be developed with the U.S. Federal Aviation Agency and a U.S. contractor, was to be launched in 1977 or 1978 for air traffic control, navigation, and communications.

MAROTS, “Maritime Orbital Test Satellite,” an adaptation of OTS funded principally by the United Kingdom, was planned for 1977 launch for civil maritime communications and navigation.

ESRO was also cooperating with NASA in the International Sun-Earth Explorer (ISEE) program and the International Ultraviolet Explorer (IUE) program (see Explorer).



Engineers check out ESSA 5 in the top photo. The first complete coverage of North America from ESSA 1, in the lower photo, was transmitted 5 February 1966.

ESSA. The ESSA satellites were meteorological satellites in the Tiros Operational Satellite (TOS) system that were financed and operated by the Environmental Science Services Administration (ESSA). The name was selected by ESSA early in 1966 and was an acronym derived from “Environmental Survey Satellite”;¹ it was also the abbreviation for the operating agency.

Between 1966 and 1969 NASA procured, launched, and checked out in orbit the nine ESSA satellites, beginning with *ESSA 1*, orbited 3 February 1966.

On 3 October 1970 ESSA was incorporated into the new National Oceanic

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and Atmospheric Administration (NOAA). After launch by NASA, the subsequent series of satellites—in the Improved TOS (ITOS) system—were turned over to NOAA for operational use. The first ITOS spacecraft funded by NOAA, launched 11 December 1970, was designated *NOAA 1* in orbit,² following the pattern set by the ESSA series. (See also Tiros, TOS, and ITOS.)

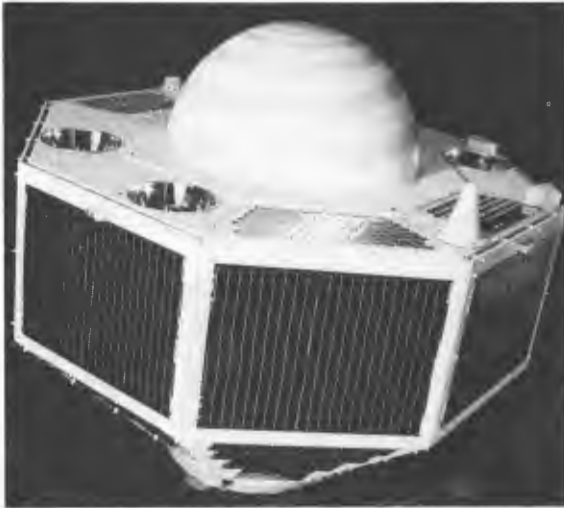
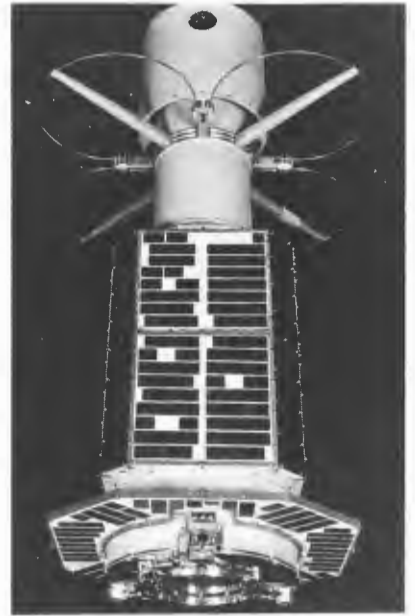
EXPLORER. The name “Explorer,” designating NASA’s scientific satellite series, originated before NASA was formed. “Explorer” was used in the 1930s for the U.S. Army Air Service-National Geographic stratosphere balloons. On 31 January 1958, when the first U.S. satellite was orbited by the U.S. Army as a contribution to the International Geophysical Year (IGY), Secretary of the Army Wilbur M. Brucker announced the satellite’s name, *Explorer 1*. The name indicated the mission of this first satellite and its NASA successors—to explore the unknown.¹

The Army Ballistic Missile Agency (ABMA) had previously rejected a list of explorer names for the satellite. Jet Propulsion Laboratory, responsible for the fourth stage of the Jupiter C rocket (configured as the Juno I launch vehicle) and for the satellite, had called the effort “Project Deal” (a loser in a poker game always called for a new deal—and this satellite was the answer to the Russian Sputnik). On the day of the launch, ABMA proposed the name “Top Kick,” which was not considered appropriate. The list of names was brought out again. All the names on the list had been crossed out and only the heading “Explorers” remained. The late Richard Hirsch, a member of the National Security Council’s Ad Hoc Committee for Outer Space, suggested that the first American satellite be called simply “Explorer.” The name was accepted and announced.²

When NASA was being formed in 1958 to conduct the U.S. civilian space program, responsibility for IGY scientific satellite programs was assigned to NASA. The decision was made by the National Advisory Committee for Aeronautics (NACA) to continue the name “Explorer” as a generic term for future NASA scientific satellites.³ Explorers were used by NASA to study (1) the atmosphere and ionosphere, (2) the magnetosphere and interplanetary space, (3) astronomical and astrophysical phenomena, and (4) the earth’s shape, magnetic field, and surface.

Many of the Explorer satellites had project names that were used before they were orbited and then supplanted by Explorer designations once they were placed in orbit. Other Explorer satellites, particularly the early ones, were known before orbit simply by numerical designations. A listing of some of the Explorers’ descriptive designations illustrates the variety of scientific missions performed by these satellites: Aeronomy Explorer, Air

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Some of the Explorer satellites, left to right above: Explorer 1; Explorer 11 Gamma-ray Astronomy Satellite; and Explorer 29 Geodetic Satellite.

Density Satellite, Direct Measurement Explorer, Interplanetary Monitoring Platform (IMP), Ionosphere Explorer, Meteoroid Technology Satellite (MTS), Radio Astronomy Explorer (RAE), Solar Explorer, Small Astronomy Satellite (SAS).

SAS-A, an X-ray Astronomy Explorer, became *Explorer 42* when launched 12 December 1970 by an Italian crew from the San Marco platform off the coast of Kenya, Africa. It was also christened *Uhuru*, Swahili for “Freedom,” because it was launched on Kenya’s Independence Day. The small satellite, mapping the universe in x-ray wavelengths for four years, discovered x-ray pulsars and evidence of black holes.⁴

Geodetic Satellites (GEOS) were also called “Geodetic Explorer Satellites” and sometimes “Geodetic Earth Orbiting Satellites.” *GEOS 1* (Ex-

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Atmosphere Explorer (above), named Explorer 32 in orbit, and an artist's drawing of an Interplanetary Monitoring Platform (Explorer 34) at right.



plorer 29, launched 6 November 1965) and GEOS, 2 (Explorer 36, launched 11 January 1968) refined knowledge of the earth's shape and gravity field. GEOS-C, to be launched in 1975 as a successor to GEOS 1 and 2, was renamed "Geodynamic Experimental Ocean Satellite" to emphasize its specific mission in NASA's earth and ocean physics program while retaining the GEOS acronym. GEOS-C was to measure ocean currents, tides, and wave heights to improve the geodetic model of the earth and knowledge

of earth-sea interactions. (The European Space Research Organization's Geostationary Scientific Satellite—also called GEOS, planned for 1976 launch—was not a part of the Geodetic Explorer series. See ESRO.)⁵

The 52nd Explorer satellite was launched by NASA 3 June 1974—*Hawkeye 1*, also called *Explorer 52*, a University of Iowa-built spacecraft. The University's Injun series had begun with *Injun 1* on 29 June 1961, to study charged particles trapped in the earth's magnetosphere. The first three Injuns were launched by the Air Force (*Injun 2* failed to reach orbit; *Injun 3* was orbited 13 December 1962). NASA launched the next three, adding the Explorer name. *Hawkeye 1* originally carried the prelaunch designation "Injun F" but this was discarded; the Hawkeye name was approved by the NASA Project Designation Committee in June 1972. (*Injun 4*, 21 November 1964, was also named *Explorer 25*; *Injun 5*, 8 August 1968, was *Explorer 40*.)⁶

Two International Sun-Earth Explorers, ISEE-A (sometimes called "Mother") and ISEE-B (sometimes called "Daughter"), were planned for dual launch in 1977, to be followed by ISEE-C ("Heliocentric") in 1978. The joint NASA and European Space Research Organization program—earlier called the International Magnetosphere Explorer (IME) program—was to investigate sun-earth relationships and solar phenomena.⁷

An International Ultraviolet Explorer (IUE; originally designated SAS-D in the Small Astronomy Satellite series) was scheduled for 1976 launch as a cooperative NASA, United Kingdom, and ESRO satellite to gather high-resolution ultraviolet data on astronomical objects.⁸

An Applications Explorer, the Heat Capacity Mapping Mission (HCMM) was planned for 1977 launch. A "small, dedicated satellite," the HCMM was to be a simple, low-cost spacecraft with one sensor for one purpose, making thermal measurements of the earth's surface across the United States. Measurements would map kinds of rocks and soil, help find mineral resources, and show whether geothermal energy sources could be found by spacecraft.⁹

FR-1. *FR-1* was the designation of the French satellite orbited by NASA 6 December 1965 in a cooperative U.S.–French program to investigate very-low-frequency electromagnetic waves. The name developed in 1964, when NASA and France's Centre National d'Études Spatiales (CNES) agreed, after preliminary sounding rocket experiments, to proceed with the satellite project.¹ CNES provided the satellite and designated it "FR-1" for "France" or "French" satellite number one.² The first flight unit was

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FR-1 in testing at the Western Test Range.



Artist's concept of HEAO.

designated "FR-1A" and the backup unit, "FR-1B." The second U.S.-France cooperative satellite, "FR-2," was later renamed "Eole." (See Eole.)

HEAO. In September 1967 NASA established the Astronomy Missions Board to consult the scientific community and submit for consideration a long-range

program for the 1970s. The Board's X-Ray and Gamma-Ray Panel completed its report in September 1968, recommending an Explorer-class spacecraft with a larger payload capability, designated "High Energy A" by the Panel and "Heavy Explorer" in other sections of the AMB position paper.¹ The spacecraft was alternately referred to as the "Super Explorer," but all three names were later dropped because of the undesirable connotation of their abbreviations ("HEX" and "SEX"). The name "HEAO"—an acronym for "High Energy Astronomy Observatory"—first appeared in June 1969 and was officially adopted as the concept for the spacecraft evolved to that of an observatory-class satellite.²

HEAO was originally planned to be the largest unmanned spacecraft orbited by the U.S., weighing almost 10 metric tons and capable of carrying the larger instruments required to investigate high-energy electromagnetic radiation from space—including x-rays, gamma rays, and high energy cosmic rays. The first satellite in the series, HEAO-A, was to be launched by a Titan IIIE launch vehicle in 1975.

In January 1973 the project was suspended because of budget cuts. A scaled-down project was substituted in FY 1975, calling for three spacecraft instead of four, to be launched by an Atlas-Centaur vehicle instead of the Titan IIIE, in 1977, 1978, and 1979. With the smaller launch vehicle, HEAO was revised to carry fewer instruments and weigh about 3200 kilograms. The first mission was to make an x-ray survey, the second detailed x-ray studies, and the third a gamma and cosmic ray survey of the sky. Launches of spacecraft from NASA's Space Shuttle after 1980 would carry heavier gamma and cosmic ray experiments to complete the scientific objectives.³

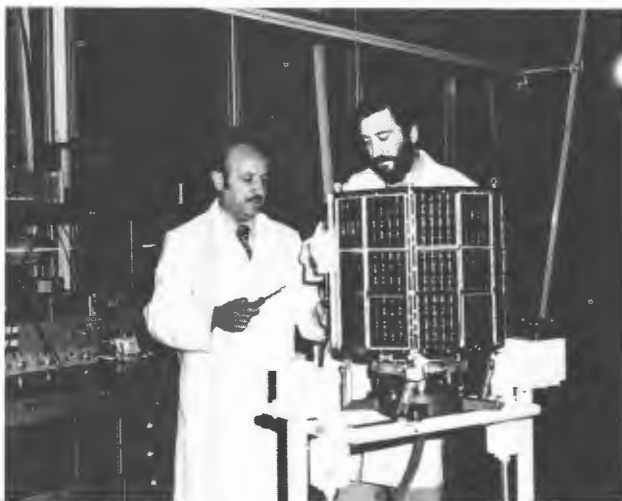
HEOS. The name of the HEOS satellite, built and named by the European Space Research Organization (ESRO), is an acronym for "Highly Eccentric Orbit Satellite." ¹ *HEOS 1* was launched 5 December 1968 to investigate interplanetary magnetic fields and study solar and cosmic ray particles outside the magnetosphere. Nine scientific groups in five countries provided experiments on board the satellite. Under a 30 December 1966 memorandum of understanding and an 8 March 1967 contract with ESRO, the mission was the first cost-reimbursed NASA launch of a foreign scientific satellite.² *HEOS 2*, the second satellite in the series, was launched by NASA 31 January 1972, to continue the study of the interplanetary medium. (See also ESRO.)

INTASAT. NASA and Spain signed a memorandum of understanding in May 1972 on a joint research program in which NASA would launch Spain's first

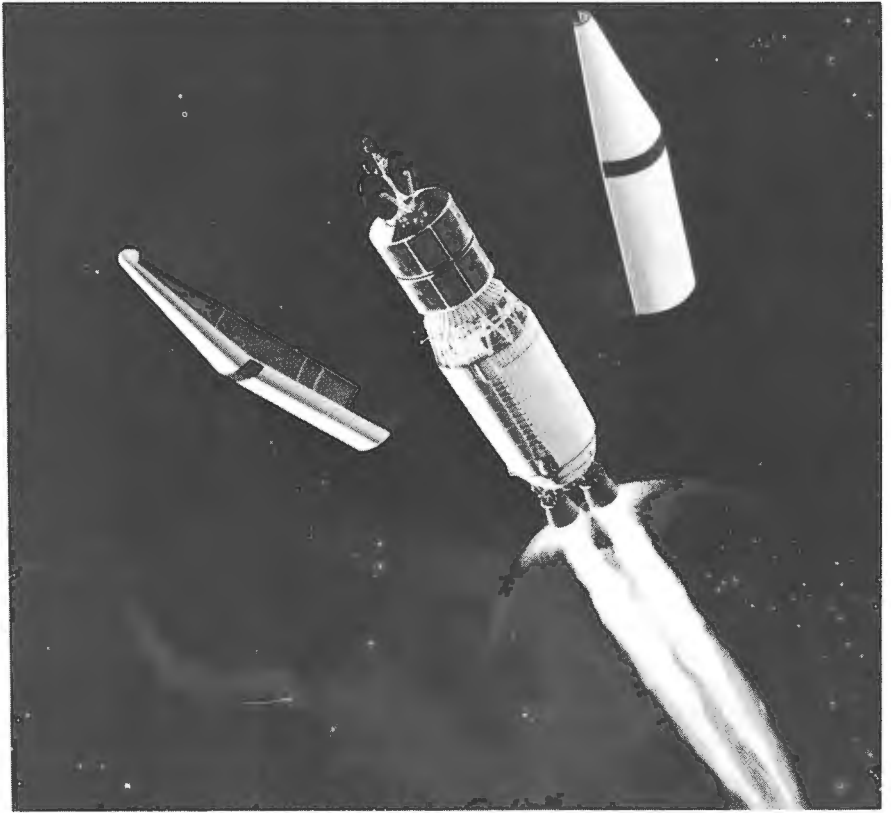
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HEOS 1, at left, in preparation for its 30 December 1966 launch with experiments from five countries. INTASAT, below, was launched as Spain's first satellite 15 November 1974.



satellite. The Spanish Space Commission—Comisión Nacional de Investigación del Espacio (CONIE)—named the satellite “INTASAT,” an acronym for the Instituto Nacional de Técnica Aeroespacial (INTA), the government laboratory responsible for development of the satellite. Designed and developed in Spain to measure the total electron count in the ionosphere and ionospheric irregularities, *INTASAT* was launched pickaback in a three-satellite launch (with *NOAA 4* and *OSCAR 7*) on 15 November 1974. The 15-kilogram satellite was to beam data to 25 to 30 scientists around the world from its sun-synchronous, polar orbit for two years.¹



An Intelsat IV series comsat jettisons its nosecone shroud in an artist's drawing. The Centaur stage of the launch vehicle is still attached.

INTELSAT. Intelsat satellites were owned and operated by the International Telecommunications Satellite Organization (INTELSAT). They were launched and tracked, on a reimbursable basis, by NASA for the Communications Satellite Corporation, the U.S. representative in and manager of INTELSAT. INTELSAT's method of designating its satellites went through numerous changes as new satellites were launched, producing alternate names for the same satellite and varying the numbering system.

The first of the INTELSAT satellites, *Intelsat I*, was named "Early Bird" because it was the satellite in the "early capability program"—the program to obtain information applicable to selection and design of a global commercial system and to provide experience in conducting communications

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satellite operations.¹ *Early Bird*, the world's first commercial comsat, was launched by NASA 6 April 1965 and placed in synchronous orbit over the Atlantic Ocean.

Intelsat II-A, also called "Lani Bird," was the first communications satellite of the Consortium's Intelsat II series. *Lani Bird* was launched in October 1966 to transmit transpacific communications, but failed to achieve synchronous orbit. It was named by the Hawaiian press; "Lani" meant "bird of heaven."² *Intelsat II-B*, or *Pacific 1*, the second in the Intelsat II series, was launched in January 1967 and placed in orbit to provide transpacific service.³ *Intelsat II-C* (later redesignated *Intelsat-II F-3* for flight 3 in series II), or *Atlantic 2*,* was the second INTELSAT satellite to provide transatlantic service.⁴ It was placed in synchronous orbit over the Atlantic in March 1967.

Subsequent satellites followed the same sequences: *Intelsat II-D*, or *Pacific 2*, was launched in September 1967 and later renumbered *Intelsat-II F-4*; *Intelsat III-A* (later *Intelsat-III F-1*) failed to achieve orbit in September 1968; *Intelsat-III F-2*, or *Atlantic 3*, was launched in December 1968.⁵

Satellites in the Intelsat IV series were numbered according to a different system, beginning with *Intelsat-IV F-2*, launched 25 January 1971. Although *Intelsat-IV F-2* was the first in the series to be launched, the "F-2" referred to the second "fabrication"—the second satellite built—rather than the second "flight" in the series.⁶ Other satellites in the series followed this pattern, with *Intelsat-IV F-8* launched into orbit 21 November 1974.

Each successive series of satellites increased in size and communications capacity: satellites in the Intelsat II series were improved versions of *Early Bird*; Intelsat III satellites had 5 times the communications capacity of the II series; and Intelsat IV satellites not only had an increased capacity—more than 5 times that of the III series—but also were nearly 10 times as heavy.

IRIS. "IRIS," an acronym for "International Radiation Investigation Satellite," was designed, developed, and built by the European Space Research Organization (ESRO). ESRO assigned the name to *ESTRO 2B*—a backup satellite to *ESRO 2A*, which had been launched 29 May 1967 but had failed to achieve orbit.¹ Under an agreement with ESRO, NASA

*UPI nicknamed it "Canary Bird" because of the association with the Canary Islands earth station. "Canary Bird" appeared widely in the press as its designation, but was not adopted by INTELSAT.

launched *IRIS 1* on 16 May 1968, to study solar astronomy and cosmic ray particles. (See also ESRO.)

(NASA also briefly used a sounding rocket with the name “Iris.”)

ISIS. ISIS was a cooperative satellite project of NASA and the Canadian Defence Research Board to continue and expand ionospheric experiments of the *Alouette 1* topside sounder satellite. The name was devised in January 1963 by John Chapman, project manager of the Canadian team; Dr. O. E. Anderson, NASA Office of International Affairs; and other members of the topside sounder Joint Working Group. They selected “Isis” because it was the name of an ancient Egyptian goddess and an acronym for “International Satellites for Ionospheric Studies.”¹

The first ISIS launch, known as “ISIS-X,” was achieved 28 Nov. 1965, when NASA launched *Alouette 2* and *Explorer 31* from Western Test Range with a single Thor-Agena B booster. The Canadian topside sounder and the U.S. Direct Measurement Explorer were designed to complement each other’s scientific data on the ionosphere. Both *ISIS 1* (launched 29 January 1969) and *ISIS 2* (launched 31 March 1971) carried experiments to continue the cooperative investigation of the ionosphere.

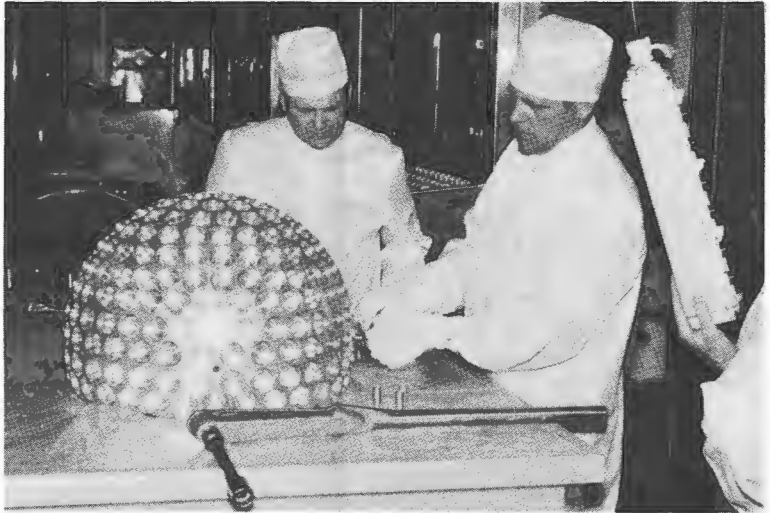
In 1969 the Canadian government proposed the substitution of an experimental communications satellite for the last of the projected ISIS spacecraft (ISIS-C).² The satellite was redesignated “CAS-C”—an acronym used by NASA to denote an international “Cooperative Applications Satellite.”³ In April 1971 a memorandum of understanding was signed by NASA and the Canadian Department of Communication providing for the launch of CAS-C, which later was again redesignated “CTS-A,” an acronym for “Communications Technology Satellite.”⁴ CTS-A was scheduled for 1975 launch.

LAGEOS. In 1971 NASA was considering the possibility of launching a passive satellite, “Cannonball,” on a Saturn launch vehicle left from the Apollo program. Definition and documentation were completed in late 1971. Subsequently the Office of Applications began defining a similar but less costly satellite as a new project to begin in Fiscal Year 1974. The redefined satellite was given the functional name “Laser Geodynamic Satellite,” or “LAGEOS.” LAGEOS was to be the first of a series of varied satellites within NASA’s earth and ocean physics applications program (EOPAP)—including spacecraft launched on unmanned vehicles in 1976 and 1977 and later ones on the Space Shuttle.¹

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ISIS 2, at left, carried 12 ionosphere experiments into orbit 31 March 1971. Below, technicians complete the final assembly of the LAGEOS satellite structure, which was to carry 426 precision optical laser retroreflectors into orbit in 1976.



Approved as a “new start” for Fiscal Year 1974, with a 1976 launch date, the terrestrial reference satellite was to be a very heavy ball—weighing 411 kilograms although less than a meter in diameter—covered with laser reflectors to permit highly accurate measurements of the earth’s rotational movements and movements of the earth’s crust. The orbit and the weight of the

simple, passive satellite were planned to provide a stable reference point for decades. The high, 5900-kilometer orbit would permit simultaneous measurements by laser ranging from earth stations a continent apart. Data would be used in earthquake prediction and other applications.²

NIMBUS. The meteorological satellite Nimbus was named from the meteorological term meaning “precipitating clouds” (from the Latin “rainstorm” or “cloud”). The satellite name was suggested in late 1959 by Edgar M. Cortright, Chief of NASA’s Advanced Technology Programs, who directed the formation of NASA’s meteorological satellite programs, including Nimbus and Tiros.¹ Nimbus was a second-generation research satellite following the first meteorological satellite series, Tiros. *Nimbus 1* was orbited 28 August 1964 and provided photographs of much higher resolution than those of Tiros satellites until it ceased transmission 23 September 1964. *Nimbus 2* (1966) and 3 (1969) operated a few years, followed by *Nimbus 4* and 5 in April 1970 and December 1972, to continue providing meteorological data and testing a variety of weather-sensing and measuring devices.

NOAA. From 1970, ITOS meteorological satellites launched by NASA were financed and operated by the National Oceanic and Atmospheric Administration (NOAA), which was established 3 October 1970 and incorporated the Environmental Science Services Administration (ESSA). Following ESSA’s tradition of using the agency’s acronym for the satellite name, the new series was named NOAA. *NOAA 1* (ITOS-A—following after the experimental Tiros-M, which had become *ITOS 1* on launch 23 January 1970) was launched 11 December 1970 to begin the new operational series. (See ESSA; and TIROS, TOS, and ITOS.)

OAO. The first satellite proposed for the “Orbiting Observatory” series, an astronomy satellite, was called the “Orbiting Astronomical Observatory” in early planning documents. It retained its original designation through the years, with the abbreviation OAO used as a short title. The term “Orbiting Astronomical Observatories” was first mentioned in writing by Dr. James E. Kupperian, Jr., in a December 1958 draft project outline, and NASA project officials approved this name as a working designation.¹ The question of a new name arose in March 1959 when NASA was preparing the first official project document. The long name had been shortened in common usage to “OAO.” The NASA officials—Dr. Kupperian, Dr. G. F. Schilling, and Dr. Nancy Roman—decided to keep the long title with OAO as a short

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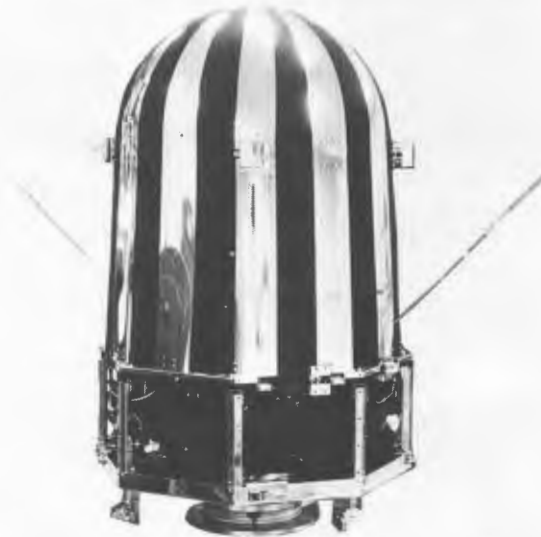
Nimbus 1, at right, and the photograph it returned of Hurricane Alma on 11 September 1964. At bottom OAO 3 being checked out at Kennedy Space Center.



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title. The intent at the time was to keep a meaningful name, one which was short, descriptive, and professional.²

The first satellite of the program, *OAO 1*, was launched into almost perfect orbit 8 April 1966, but its power supply failed. *OAO 2*, launched 7 December 1968, took the first ultraviolet photographs of stars, returning data previously unobtainable. *OAO 3*, launched 21 August 1972, contained the largest telescope orbited by the U.S. to that date. It was given the additional name *Copernicus* after launch in honor of the Polish astronomer as part of the international celebration of the 500th anniversary of his birth.³



OFO, the Orbiting Frog Otolith spacecraft, studied the adaptability of the inner-ear balance mechanism to weightlessness.

OFO. “OFO” was an acronym for “Orbiting Frog Otolith”—not to be confused with similar acronyms describing the Orbiting Observatory series of spacecraft. The name, derived through common use, was a functional description of the biological experiment carried by the satellite (“otolith” referred to the frog’s inner-ear balance mechanism).¹

The Frog Otolith Experiment (FOE) was developed by Dr. Torquato Gualtierotti of the University of Milan, Italy, when he was assigned to the Ames Research Center as a resident Research Associate sponsored by the National Academy of Sciences.² The experiment was designed to study the adaptability of the otolith to sustained weightlessness, to provide information for manned space flight. Originally planned in 1966 to be included on an early Apollo mission, the experiment was deferred when that mission was

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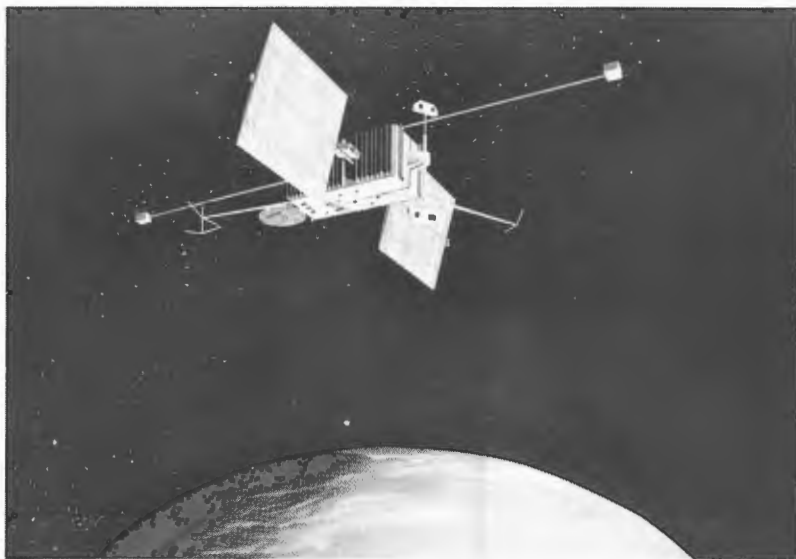
canceled. In late 1967 authorization was given to orbit the FOE when a supporting spacecraft could be designed.³ The project, part of NASA's Human Factor Systems program, was officially designated "OFO" in 1968.⁴ After a series of delays, *OFO* was orbited 9 November 1970.

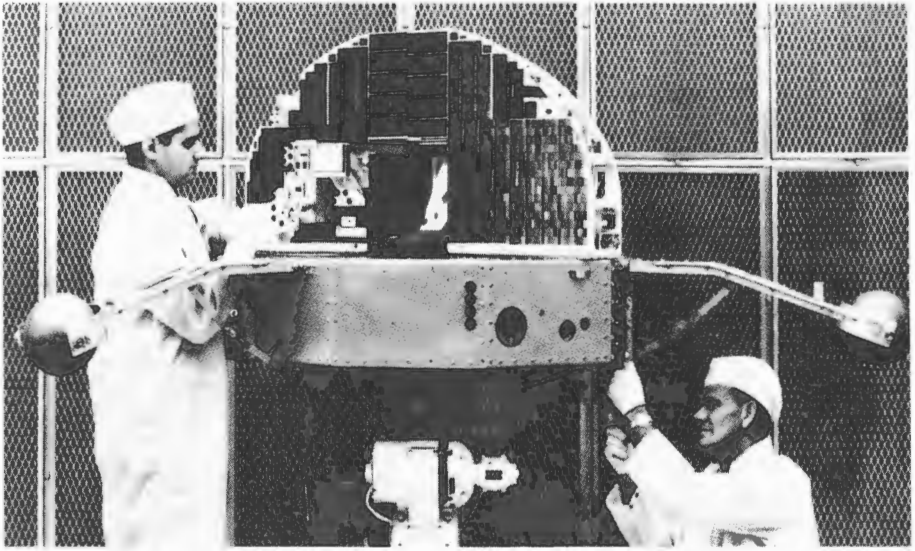
OGO. An acronym for "Orbiting Geophysical Observatory," the name was derived from NASA's concept for an observatory-class satellite. In late 1959 and early 1960, the concept evolved from that of a larger general-purpose scientific satellite (as opposed to the special-purpose Explorers), which would be a standardized spacecraft housing a variety of instruments to be flown regularly on standardized trajectories. "Orbiting Observatory" became the term used for this class of spacecraft, and "Orbiting Geophysical Observatory" developed as a functional description for this particular satellite.

The names "EGO" and "POGO" also were developed during this period to apply to OGO satellites in particular orbital trajectories: highly eccentric (Eccentric Geophysical Observatory) and polar orbit (Polar Orbiting Geophysical Observatory).¹ Between 1964 and 1969 NASA orbited six OGO satellites and results from the successful OGO program included the first global survey by satellite of the earth's magnetic field.

OSO. An acronym for "Orbiting Solar Observatory," OSO evolved from the NASA concept for larger, general-purpose spacecraft for scientific ex-

Artist's concept of an OGO spacecraft in orbit.





OSO 3 undergoing spin-balance tests before launch.

periments (see OGO). The name was a functional description of the satellite, indicating it was of the orbiting-observatory class of satellites whose purpose was to measure phenomena of the sun.¹ *OSO 1*, launched 7 March 1962, was the first satellite in the “Orbiting Observatory” series to be placed in orbit. *OSO 7* was launched 29 September 1971.

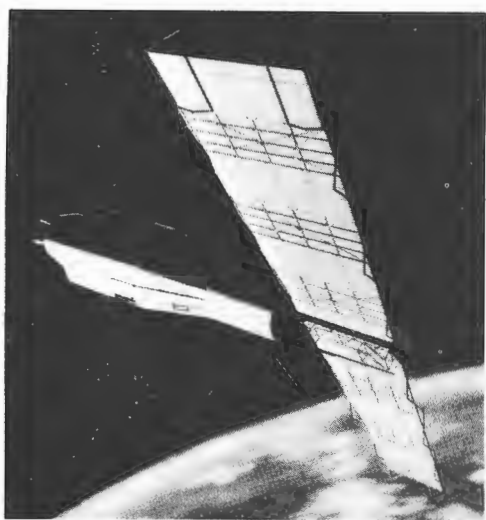
The OSO satellites were designed to provide observations of the sun during most of its 11-year cycle. Results included the first full-disc photograph of the solar corona, the first x-ray observations from a spacecraft of a beginning solar flare and of solar “streamers”—structures in the corona—and the first observations of the corona in white light and extreme ultraviolet.

PAGEOS. The acronym for “Passive Geodetic Earth Orbiting Satellite”¹ came into use among project officials and found its way into documents through common use.² “PAGEOS” paralleled the name “GEOS” that designated the active (instrumented) geodetic satellites in the Explorer series. In August 1964 NASA approved Langley Research Center’s proposal for the PAGEOS project. *Pageos 1*, a balloon 30 meters in diameter—similar to the Echo balloon satellite—achieved orbit and inflated 23 June 1966. The uninstrumented (passive) satellite reflected sunlight and, photographed by ground stations around the world, provided a means of precision mapping the earth’s surface.³

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PAGESOS 1 inflation test, above, and a Pegasus satellite with wings outspread in an artist's drawing.



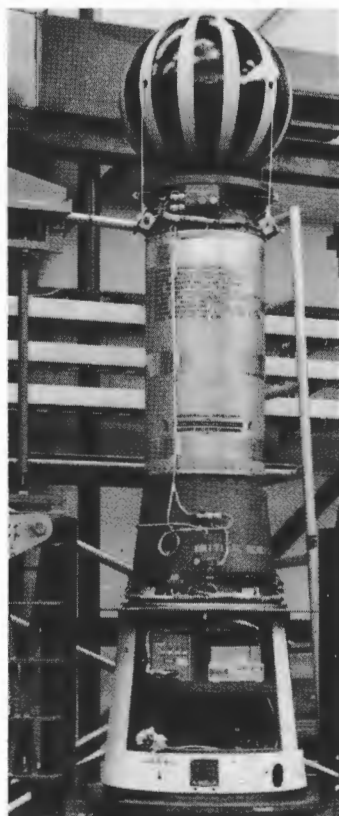
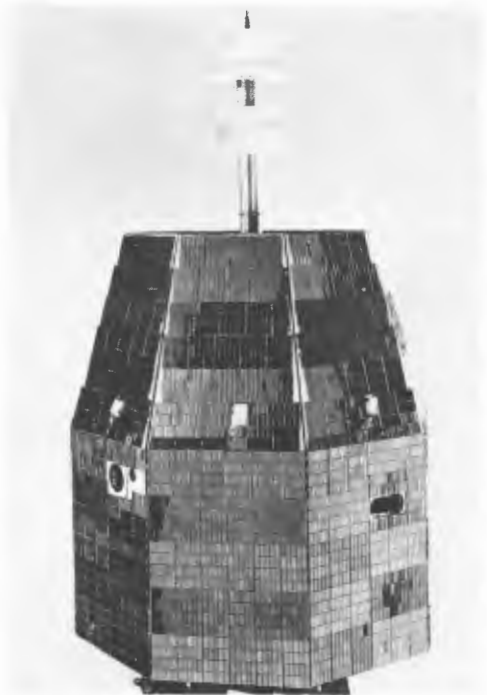
PEGASUS. The outstanding feature of the Pegasus satellites was their huge winglike panels, 96 meters tip to tip, sweeping through space to determine the rate of meteoroid penetrations. The program office said when choosing from proposed names that the spacecraft, to be the heaviest yet orbited, would be “somewhat of a ‘horse’ as far as payloads are concerned” and

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there could be “only one name for a horse with wings”—Pegasus, the name of the winged flying horse of ancient Greek mythology.¹

The original suggestion for the name had come from an employee of the spacecraft contractor, Fairchild Stratos Corporation. The contractor, with the concurrence of the NASA Office of Space Vehicle Research and Technology and Marshall Space Flight Center, had held an in-house competition in 1963 to select a name for the project. From more than 100 suggestions by Fairchild Stratos employees, the NASA program office recommended the name “Pegasus” to the Project Designation Committee. The Committee approved the selection in July 1964* and NASA announced the name in August.²

A Relay satellite, below; and San Marco 1, at right, in checkout at Wallops.



*The NASA Project Designation Committee originally agreed on “Project Pegasus” as the name for the experiments before launch. The satellites were to be supplanted with an Explorer designation in orbit. (Julian W. Scheer, Assistant Administrator for Public Affairs, NASA, memorandum for Raymond L. Bisplinghoff, Associate Administrator for Advanced Research and Technology, with concurrence of Robert C. Seamans, Jr., Associate Administrator, 6 July 1964.)

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Three Pegasus satellites were placed in orbit, all by Saturn I launch vehicles: *Pegasus 1* on 16 February 1965, *Pegasus 2* on 25 May 1965, and *Pegasus 3* on 30 July 1965.

RELAY. NASA's medium-altitude, active-repeater communications satellite was formally named "Relay" in January 1961* at the suggestion of Abe Silverstein, NASA's Director of Space Flight Programs.¹ The name was considered appropriate because it literally described the function of an active-repeater comsat: the satellite received a signal, amplified it within the satellite, and then relayed the signal back toward the earth.² *Relay 1*, orbited 13 December 1962, and its successor *Relay 2*, orbited 21 January 1964, both demonstrated the feasibility of this kind of communications satellite. After its research role was completed, *Relay 2* was turned over to the Department of Defense to assist in military communications over the Pacific.

SAN MARCO. The Italian space program was conceived in 1960 by Professor Luigi Broglio, Professor Carlo Buongiorono, and Dr. Franco Fiorio.¹ By 1962 they and their colleagues had decided that an ocean platform in nonterritorial waters should serve as the base for launching their satellite booster. ENI, Italy's state-owned oil industry, made available a suitable platform, which happened to be named "San Marco" (Saint Mark). The name "San Marco" grew into the designation for the entire cooperative space project—including preparatory phases not associated directly with the sea-based launch site. Professor Broglio was particularly pleased to adopt the name for the project because Saint Mark was the patron saint of Venice, his birthplace. Saint Mark was also the patron of all who sailed the sea.²

The San Marco project was a cooperative effort of NASA and the Italian Space Commission, with NASA providing launch vehicles, use of its facilities, and training of Italian personnel. On 15 December 1964, the San Marco Scout 1 booster, launched from Wallops Station by an Italian crew, orbited the Italian-designed-and-built *San Marco 1* satellite. The launch was the first satellite launch in NASA's international cooperation program that was conducted by non-U.S. personnel and was the first Western European satellite launch. *San Marco 2* was launched into equatorial orbit 26 April 1967 from

*Eight months earlier, Lloyd E. Jones, Jr., a member of the NASA Ad-Hoc Committee to Name Space Projects and Objects, had suggested to the Committee a group of names for applications satellites. The Committee approved the name "Relay" for an active comsat 19 May 1960. (NASA Ad Hoc Committee to Name Space Projects and Objects, minutes of meeting 19 May 1960.)

the San Marco platform in the Indian Ocean. *San Marco 3*, launched 24 April 1971, was the third satellite orbited from the platform (the second had been NASA's *Explorer 42*, launched 12 December 1970). *San Marco 4* was launched from the platform 18 February 1974.

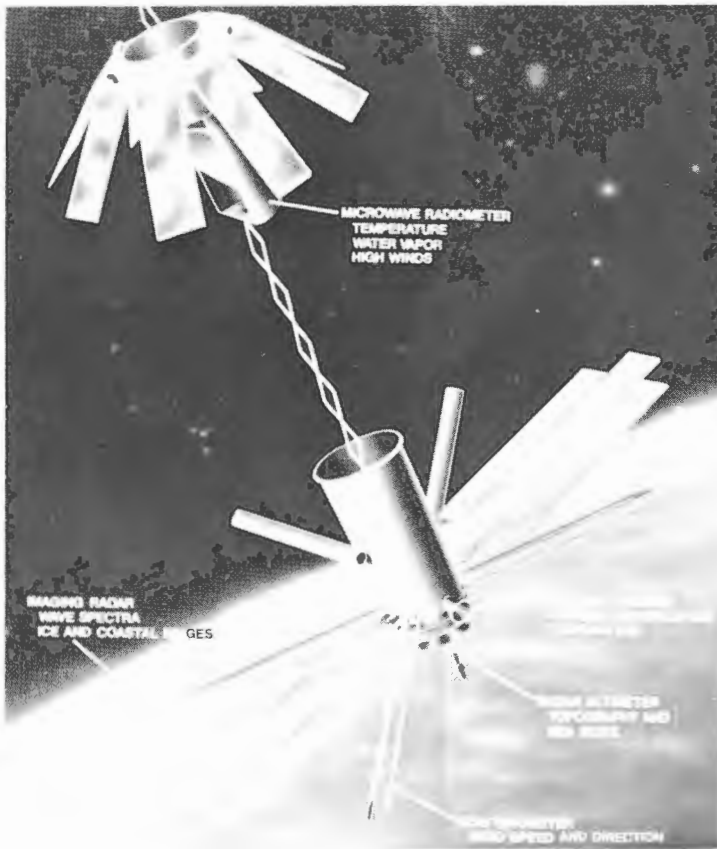
The San Marco satellites were scientific satellites designed to conduct air-density experiments using a variety of instruments; in addition, *San Marco 1* and 2 measured ionospheric characteristics related to long-range radio transmission.

SEASAT. The name of the “sea satellite”—“Specialized Experimental Applications Satellite,” shortened to the acronym “SEASAT”—was chosen before the program was officially established. A 1969 conference of scientists and representatives from the National Oceanic and Atmospheric Administration, Department of Defense, NASA, other Government agencies, universities, and scientific institutions met at Williams College, Williamstown, Massachusetts, to review activities needed in the earth and ocean physics fields. The conference identified a number of activities, including satellite projects. SEASAT and LAGEOS (see LAGEOS) were among them, the names growing out of the thinking of a number of the participants and fitting the tasks of the satellites within NASA's earth and ocean physics applications program (EOPAP).¹

After studies and definition of requirements in cooperation with numerous Government agencies and private institutions, through the SEASAT User Working Group, NASA introduced SEASAT as a “new start” in its Fiscal Year 1975 program. The new satellite was scheduled for 1978 launch, following technological evolution of equipment on the Skylab and GEOS-C missions; it would be the first devoted entirely to studying the oceans. SEASAT was to circle the globe 14½ times a day to observe weather and sea conditions of all the earth's oceans with accurate microwave devices. Information was to be distributed to a large user community for predicting weather, routing shipping, and issuing disaster warnings. This first satellite in the program was to be a proof-of-concept spacecraft for later operational missions.

SIRIO. In March 1970 NASA and the Italian National Research Commission signed a memorandum of understanding providing for the reimbursable NASA launch of Italian scientific spacecraft.¹ The first satellite planned for launch under this agreement was SIRIO—an acronym for “Satellite Italiano Ricerche Orientate (Italian Research-Oriented Satellite).”² Tentatively

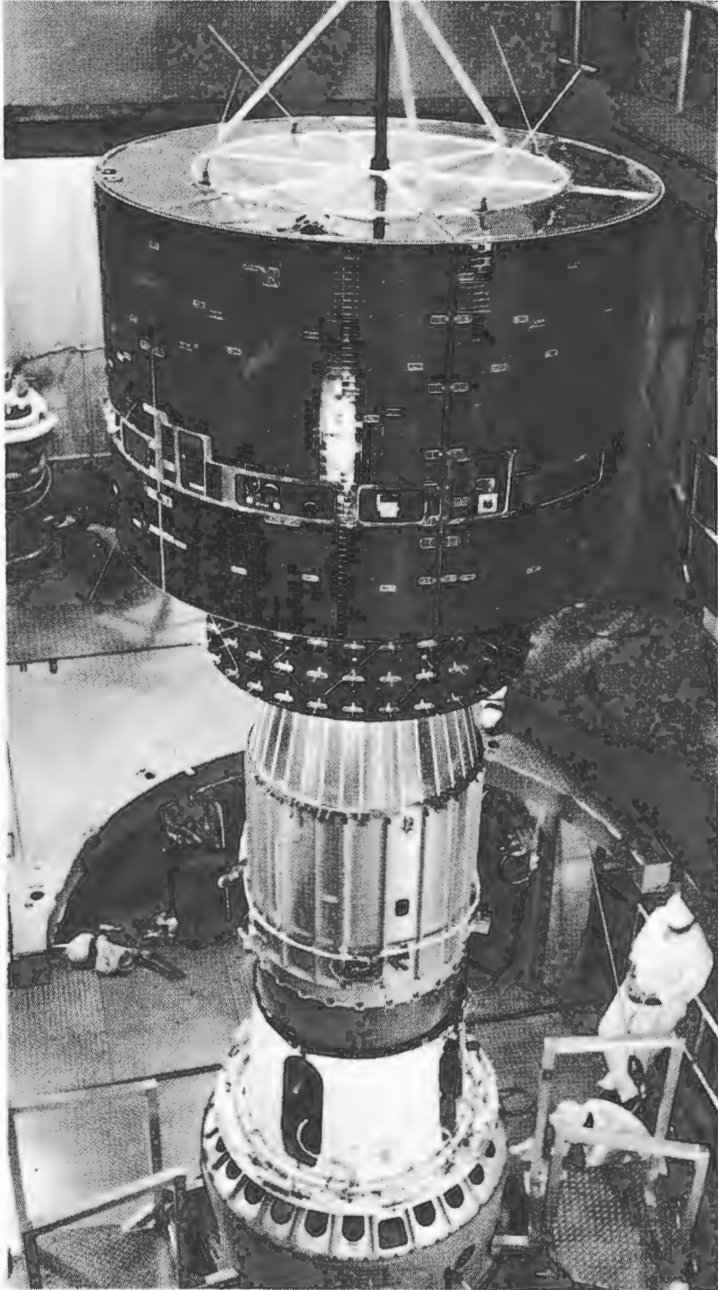
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An artist's concept of SEASAT, a satellite to study oceans.

scheduled for launch in 1975, SIRIO would conduct telecommunications, technology, and scientific experiments from synchronous orbit.

SMS. An operational satellite system that could provide continuous observation of weather conditions from a fixed position above the earth had been under study since the first weather satellites were launched in the early 1960s. Studies of the requirements for a stationary weather satellite were begun in early 1960 and the proposed project was named for Aeros, ancient Greek god of the air.¹ Conceived as the third phase of a program consisting of Tiros and planned Nimbus satellites, Aeros would be a synchronous satellite in equatorial orbit that could track major storms as well as relay cloud-cover photographs of a large portion of the earth.²



The second SMS satellite, erected atop its Delta launch vehicle at Kennedy Space Center's Launch Complex 17.

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By late 1962 the name Aeros had been dropped in favor of the more functional designation "SMS," an acronym for "Synchronous Meteorological Satellite."³ Meanwhile, studies were being made of a Tiros spacecraft ("Tiros-K") that could be modified for a near-synchronous orbit to determine the capability of an SMS.⁴ Tiros-K was subsequently canceled in 1965 as development plans for the ATS satellites permitted the inclusion of experiments to test the proposed instrumentation for the SMS.⁵

After the successful photographic results of *ATS 1* and *3*, two experimental SMS satellites were approved and tentatively planned for launch. SMS-A and SMS-B, funded by NASA, would be prototypes for the later operational satellites funded by the National Oceanic and Atmospheric Administration (NOAA). Following launch and checkout by NASA, both satellites were to be turned over to NOAA for use in the National Operational Meteorological Satellite System (NOMSS).^{*} Successive satellites in the series would be designated "GOES"—an acronym for "Geostationary Operational Environmental Satellite"—by NOAA.⁶ An operational system of two or more SMS satellites and a single ITOS spacecraft could provide the coverage required for accurate long-range weather forecasts.

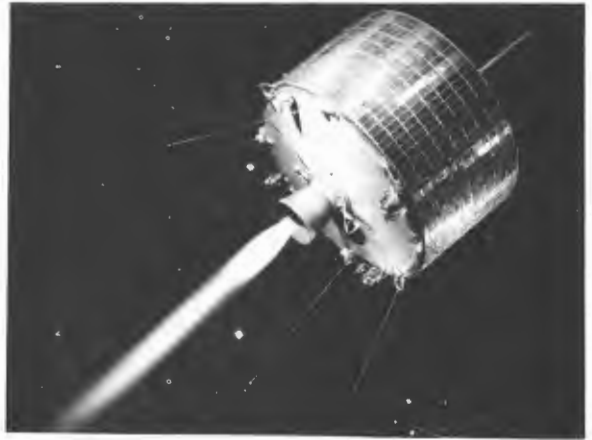
SMS-A became *SMS 1* on launch into orbit 17 May 1974 and supported the international Global Atmospheric Research Program's Atlantic Tropical Experiment (GATE) before becoming part of NOAA's operational system late in the year. SMS-B and GOES-A (SMS-C) were scheduled for 1975 launch. The European Space Research Organization, Japan, and the U.S.S.R. were planning to launch their own geostationary satellites during the decade to complement the SMS system for global use.⁷

SPHINX. Planned as one of NASA's smallest scientific satellites, the 113-kilogram SPHINX took its name from the acronym for "Space Plasma High Voltage Interaction Experiment." It was to be launched pickaback on the proof flight of the newly combined Titan III-Centaur launch vehicle, along with a dynamic model of the Viking spacecraft. The planned year-long mission was to measure effects of charged particles in space on high-voltage solar cells, insulators, and conductors. Data would help determine if future spacecraft could use high-voltage solar cells, instead of the present low-voltage cells, to operate at higher power levels without added weight or cost. The Centaur stage failed on launch 11 February 1974, however, and the satellite was destroyed.¹

^{*}NOMSS was also known by NOAA as the National Operational Environmental Satellite System.



Flight model of the French-German Symphonie above. A Syncom fires its apogee motor in orbit in the photographic composite.



SYMPHONIE. The experimental Franco-German Symphonie communications satellites were designed and built in Europe for launch by NASA with launch vehicles and services paid for by France and West Germany.

Two satellites were developed by the joint Consortium Industriel France-Allemand pour le Satellite Symphonie (CIFAS) under the direction of the French space agency Centre National d'Études Spatiales (CNES) and the West German space agency Gesellschaft für Weltraumforschung (GfW). The three-axis stabilized satellites were to test equipment for television, radio, telephone, telegraph, and data transmission from synchronous orbit, 35 900 kilometers above the equator. They were planned for launch from

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French Guiana on the Europa II launch vehicle, but when the European Launcher Development Organization (ELDO) canceled its vehicle project the countries turned to NASA. The contract for NASA launch services was signed in June 1974.¹

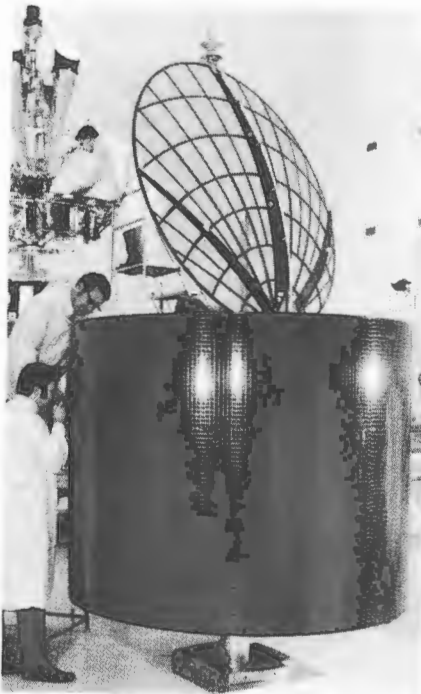
In 1967 France had a stationary (synchronous) orbit communications satellite, SAROS (Satellite de Radiodiffusion pour Orbit Stationnaire), in the design stage and West Germany was about to begin designing its Olympia satellite. The two nations agreed in June 1967 to combine their programs in a new joint effort. Participants in the 1967 discussions in Bonn—the Federal Republic of Germany’s capital on the Rhine River—sought a new name for the joint satellite just before the agreement was signed. Gerard Dieulot, technical director of the French program, was reminded of the German composer Robert Schumann by the name of French Minister Maurice Schumann, negotiator for France. The new accord in the Rhine Valley, Dieulot suggested, was a “symphony by Schumann.” “Symphonie,” the French spelling of the word coming originally from the Latin and Greek “symphonia,” “harmony” or “agreement,” was adopted when the Franco-German satellite agreement was signed in June.²

NASA launched *Symphonie 1* (Symphonie-A before launch) into orbit from Eastern Test Range 18 December 1974. Symphonie-B was scheduled for September 1975 launch.

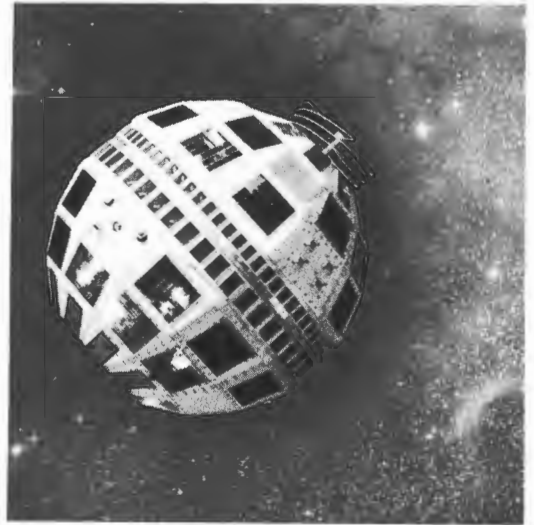
SYNCOM. A word coined from the first syllables of the words “synchronous communications,” “Syncom” referred to communications satellites in synchronous earth orbit. The name was devised by Alton E. Jones of NASA Goddard Space Flight Center. Early in August 1961, when he was working on the preliminary project development plan, he decided that a name was required before the plan could go to press the next day. He invented the name “Syncom.”¹ Before the end of August, NASA Headquarters officials had approved the preliminary plan and NASA had issued a press release using the name.²

Three Syncom satellites were developed and launched. After a launching success but communications failure with *Syncom 1* (14 February 1963), *Syncom 2* was launched 26 July 1963, into the first synchronous orbit and *Syncom 3*, launched 19 August 1964, was put into the first truly stationary orbit. The Department of Defense participated in Syncom research and development, providing ground stations and conducting communications experiments. Early in 1965, after completing the research and development program, NASA transferred use of the two Syncom satellites to the Department of Defense.

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Structural model of TD-1A (above) showing the telescope, suspended for a space simulation test (ESC photo). At left, Telesat satellite Anik 1 in production (Hughes Aircraft Co. photo); below a composite photograph of the Telstar 1 spacecraft in space.



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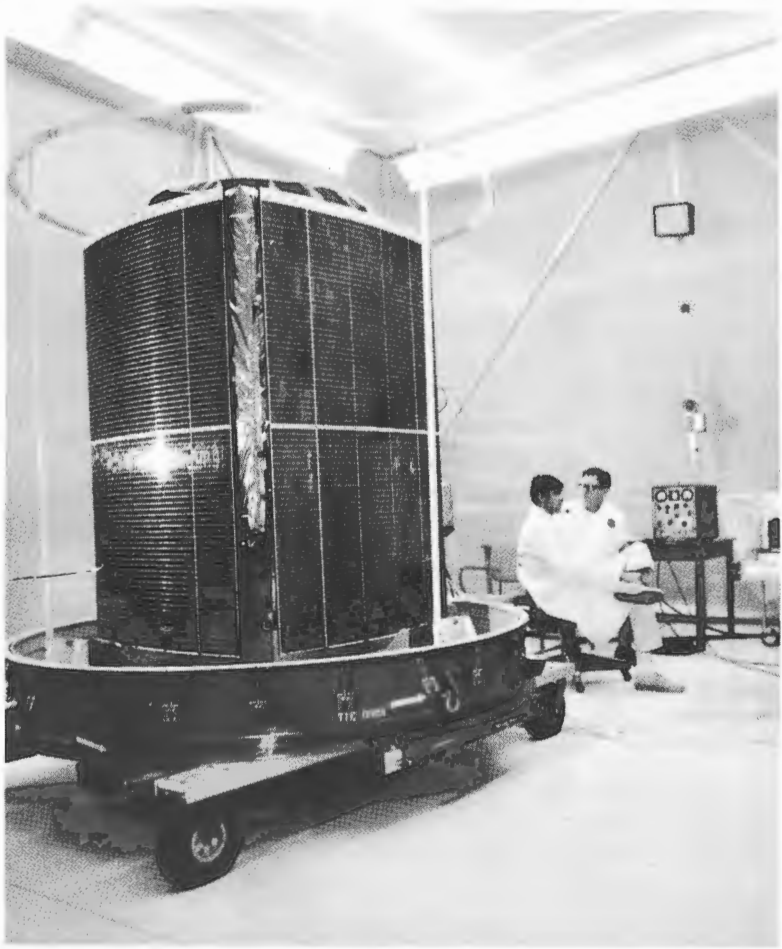
TD. "TD," an abbreviation for the U.S. Thor-Delta launch vehicle, was the name given to a satellite project by the European Space Research Organization (ESRO).¹ *TD-1A*, a solar astronomy satellite designed to carry a variety of instruments including a large telescope, was launched by NASA 11 March 1972. Under a 1966 memorandum of understanding with ESRO, NASA was reimbursed for the launch.²

Proposals for the satellite, then unnamed, had been discussed at an astronomy colloquium soon after the formal establishment of ESRO in March 1964.³ By 1965, ESRO had planned a series of TD satellites and in 1967, after several program delays, signed a contract with NASA for the launch of two satellites, TD-1 and TD-2.⁴ In April 1968, however, ESRO announced the cancellation of both satellites because of problems in financing. The project was later reinstated and a second contract for a single Thor-Delta launch was signed with NASA in June 1970. The satellite was subsequently redesignated "TD-1A" because it differed from the two earlier configurations and combined the TD-2 design with several experiments originally planned for TD-1.⁵

TELESAT. In early 1969 the Canadian Ministry of Communications proposed plans for a satellite system that could be used entirely for domestic communications.¹ The system would be managed and operated by Telesat ("Telecommunications Satellite") Canada, a new corporation supported by industry, government, and public investment. The first two satellites in the system, Telesat-A and B, would be launched into synchronous equatorial orbit and be capable of relaying TV, telephone, and data transmissions throughout Canada. Under an agreement with Telesat, NASA would provide the Thor-Delta launch vehicles and be reimbursed for the satellite launches.²

In orbit each Telesat satellite would be designated "Anik," the Eskimo word for "brother."³ *Anik 1* was launched into orbit 9 November 1972 and *Anik 2* on 20 April 1973. *Anik 3* was scheduled for 1975.

TELSTAR. A contraction of "telecommunications" and "star," the name "Telstar" designated the active communications satellites developed by American Telephone & Telegraph Company. In November 1961, at the request of AT&T's Bell Telephone Laboratories, NASA endorsed the selection of "Telstar" as a name for the project.¹ NASA was responsible for launching, tracking, and data acquisition for the AT&T-built satellites on a cost-reimbursable basis. *Telstar 1*, the first active-repeater communications satellite, was the first privately funded satellite and relayed the first live transatlantic telecast after 10 July 1962 launch. It was followed by the equally successful *Telstar 2*, 7 May 1963.



ITOS-B being checked out before launch.

TIROS, TOS, ITOS. The Tiros meteorological satellite, which provided weather data from high above the earth's cloud cover, was given a name that described its function. In mid-1958, the Department of Defense's Advanced Research Projects Agency (initiator of the project) requested the Radio Corporation of America (contractor for the project) to supply a name for the satellite. RCA personnel concocted the name "TIROS," an acronym derived from the descriptive title "Television and Infra-Red Observation Satellite." ¹ The name eventually came to be written "Tiros" as it was used in other acronyms.

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In April 1959 responsibility for the Tiros research and development program was transferred from the Department of Defense to NASA, and on 1 April 1960 *Tiros 1* was launched into orbit. Meteorologists were to receive valuable data—including more than 5 000 000 usable cloud pictures—from 10 Tiros weather satellites.² By early 1964 NASA had orbited *Tiros 1* through *Tiros 8* and the U.S. Weather Bureau was making operational use of the meteorological data from them. These satellites were able to photograph about 20 percent of the earth each day.

On 28 May 1964 NASA and the Weather Bureau announced a plan for an operational meteorological satellite system based on Tiros research and development. They called the system “TOS”—an acronym for “Tiros Operational Satellite.” In accordance with the NASA-USWB agreement, *Tiros 9* was a NASA-financed, modified Tiros satellite, orbited to test the new “cartwheel” configuration on which the TOS would be based. *Tiros 10* was a USWB-financed, Tiros satellite similar to *Tiros 9*, orbited to continue testing the TOS concept. Early in 1966 NASA orbited the two operational satellites in the TOS system—financed, managed, and operated by the Weather Bureau, by then an agency of the new Environmental Science Services Administration (ESSA). Upon their successful orbit, ESSA designated the TOS satellites *ESSA 1* and *ESSA 2*—ESSA in this case being an acronym for “Environmental Survey Satellite.”³ These two satellites provided continuous cloud-cover pictures of the entire sunlit portion of the earth at least once daily.

In 1966 NASA announced plans for a design study of an improved TOS spacecraft that would be twice as large as the previous TOS satellites. This spacecraft would be able to scan the earth’s nighttime cloud cover and would more than double the daily weather coverage obtained in the TOS series of ESSA satellites.⁴ The first satellite in the Improved Tiros Operational Satellite (ITOS) series, *ITOS 1*—launched 23 January 1970—was a joint project of NASA and ESSA. With the exception of *ITOS 1*, spacecraft in the ITOS series would be funded by ESSA.⁵

On 3 October 1970, ESSA was combined with the major Federal programs concerned with the environments of the sea and air; programs from four departments and one agency were consolidated to form the National Oceanic and Atmospheric Administration (NOAA) in the Department of Commerce. The first operational ITOS spacecraft funded by NOAA—designated *NOAA 1* in orbit—was launched 11 December 1970. *NOAA 4* (ITOS-G) was put into orbit 15 December 1974 to join the still orbiting *NOAA 2* and *3* (launched 15 October 1972 and 6 November 1973) in obtain-

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ing global cloud-cover data day and night and global measurements of the earth's atmospheric structure for weather prediction.

VANGUARD. The name "Vanguard" applied to both the first satellite series undertaken by the United States and to the launch vehicle developed to orbit the satellites. In the spring of 1955, scientific interest in orbiting an artificial earth satellite for International Geophysical Year (1 July 1957 to 31 December 1958) was growing. Several launch vehicle proposals were developed for placing a U.S. satellite in orbit. The proposal chosen in August

Vanguard 2 atop its satellite launch vehicle.



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1955 to be the U.S. satellite project for the IGY was the one offered by the Naval Research Laboratory (NRL), based on Milton W. Rosen's concept of a new launch vehicle combining the Viking first stage, Aerobee second stage, and a new third stage.¹ Rosen became technical director of the new project at NRL.

The name "Vanguard" was suggested by Rosen's wife, Josephine. Rosen forwarded the name to his NRL superiors, who approved it. The Chief of Naval Research approved the name 16 September 1956.² The word denoted that which is "out ahead, in the forefront."

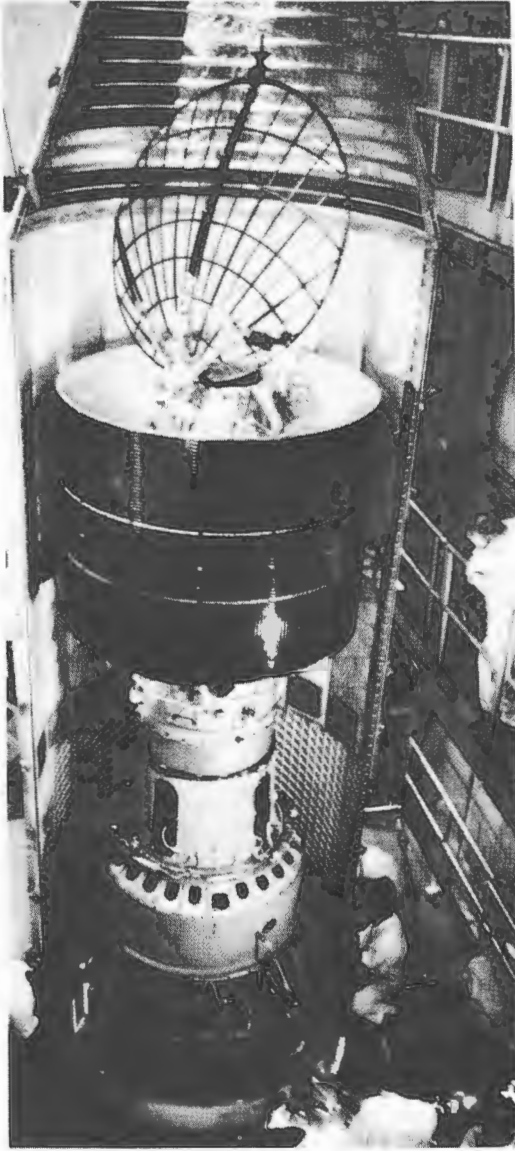
Vanguard 1, a 1.5-kilogram scientific satellite, was orbited 17 March 1958, although ironically it was not the first U.S. satellite (*Explorer 1* had been launched into orbit by the Army 31 January 1968). The NRL project Vanguard team was transferred to NASA when the space agency was established 1 October 1958. *Vanguard 1* was followed in 1959 by *Vanguard 2* and 3. Scientific results from this series included the first geodetic studies indicating the earth's slightly "pear" shape, a survey of the earth's magnetic field, the location of the lower edge of the earth's radiation belts, and a count of micrometeorite impacts.

WESTAR. Westar satellites were commercial communications satellites owned and operated by Western Union Telegraph Company and launched by NASA under a contract, to form the first United States domestic communications satellite system.

As early as 1966, Western Union petitioned the Federal Communications Commission for permission to build a domestic satellite system to relay telegraph traffic. The FCC was then making a detailed study of the need for such a system in response to requests from several organizations. When the FCC decided in 1970 to invite applications, Western Union was the first to respond, proposing a high-capacity multipurpose system to serve all 50 states.¹ The company won approval in January 1973 to build the first U.S. system, with authorization for three satellites. Hughes Aircraft Company was to build the comsats (or "domsats," as the press began to call them) and NASA signed a contract with Western Union in June 1973, agreeing to provide launch services, with reimbursement for the Thor-Delta launch vehicles and costs.²

Western Union asked its employees to suggest a name for the new satellites. From the suggestions, "Westar" was chosen—combining part of the company's name with "star," a reference to a body in space, or satellite.³

Westar 1 ("Westar-A" before launch) was orbited 13 April 1974 and began commercial operation 16 July. As a new postal service, *Westar 1* relayed the first satellite "Mailgrams" in 1974, from New York to Los



Westar 1 being encapsulated in its payload shroud on top the Delta launch vehicle at Kennedy Space Center's Launch Complex 17.

Anges at the speed of light. *Westar 2* was launched 10 October 1974 and *Westar-C* was held as a spare. In synchronous orbit, each drum-shaped satellite could relay 12 color TV channels, up to 14 400 one-way telephone circuits, or multiple data channels.

III

SPACE PROBES



Whirlpool-shaped galaxy.

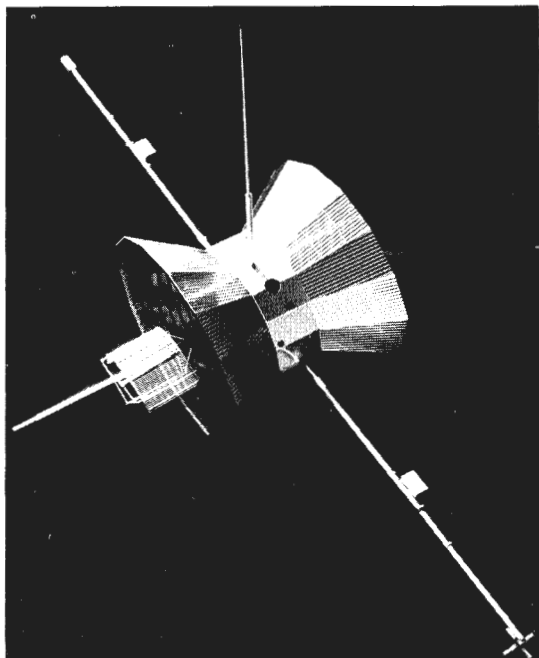
SPACE PROBES

Unmanned instrumented probes obtain scientific information about the moon, other planets, and the space environment. Probes are differentiated from sounding rockets in that they attain at least 6400-kilometer altitudes. When a probe is launched on an escape trajectory—attaining sufficient velocity to travel beyond the earth's gravitational field—it becomes, in effect, a satellite of the sun. The Lunar Orbiter probes, however, were sent into orbit around the earth's natural satellite, the moon.

First serious consideration of the concept of a space probe can be attributed to Dr. Robert H. Goddard, American rocket pioneer. As early as 1916, Goddard's calculations of his theoretical rocket and his experiments with flash powders led him to conclude that a rocket-borne payload exploding on the moon could be detected from earth.¹ On 20 September 1952 a paper entitled "The Martian Probe," presented by E. Burgess and C. A. Cross to the British Interplanetary Society, gave the term "probe" to the language.²

In May 1960—at the suggestion of Edgar M. Cortright, Assistant Director of Lunar and Planetary Programs—NASA adopted a system of naming its space probes. Names of lunar probes were patterned after land exploration activities (the name "Pioneer," designating the early series of lunar and related space probes, was already in use). The names of planetary mission probes were patterned after nautical terms, to convey "the impression of travel to great distances and remote lands." Isolated missions to investigate the space environment were "assigned the name of the mission group of which they are most nearly a part."³ This 1960 decision was the basis for naming Mariner, Ranger, Surveyor, and Viking probes.

U.S.-German Helios 1 solar probe on the spin table for system test and checkout before mating to the Titan III launch vehicle.



HELIOS. In June 1969 NASA and the German Ministry for Scientific Research (BMwF) agreed to a joint project for launching two probes, in 1974 and 1975, to study the interplanetary medium and explore the near-solar region. The probes would carry instruments closer to the sun than any previous spacecraft, approaching to within 45 million kilometers.¹

The project was designated "Helios," the name of the ancient Greek god of the sun, by German Minister Karl Kaesmeier. The name had been suggested in a telephone conversation between Minister Kaesmeier and Goddard Space Flight Center's Project Manager, Gilbert W. Ousley, in August 1968.² NASA had previously used the name for the Advanced Orbiting Solar Observatory (AOSO), canceled in 1965, which was to have performed similar experiments.³ The Helios probes were to be launched on Titan III-Centaur vehicles.

NASA launched West German-built *Helios 1* into orbit of the sun 10 December 1974. Helios-B was scheduled for 1976 launch.

LUNAR ORBITER. The name "Lunar Orbiter" was a literal description of the mission assigned to each probe in that project: to attain lunar orbit, whence it would acquire photographic and scientific data about the moon. Lunar Orbiter supplemented the Ranger and Surveyor probe projects, providing

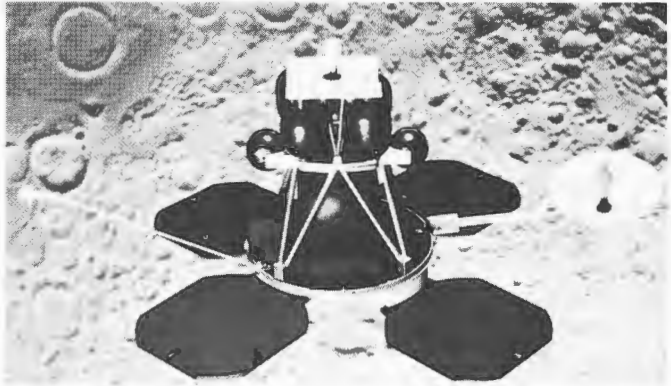
SPACE PROBES

lunar data in preparation for the Apollo manned landings and the Surveyor spacecraft softlandings.¹

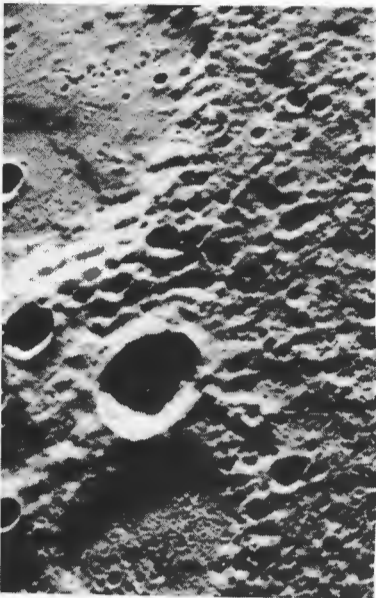
The name evolved informally through general use. NASA had had under consideration plans for a Surveyor spacecraft to be placed in orbit around the moon. This Surveyor was called "Surveyor Orbiter" to distinguish it from those in the lunar-landing series. When the decision was made to build a separate spacecraft rather than use Surveyor, the new probe was referred to simply as "Orbiter" or "Lunar Orbiter."²

Five Lunar Orbiter flights launched in 1966 and 1967 made more than 6000 orbits of the moon and photographed more than 99% of the lunar surface, providing scientific data and information for selecting the Apollo manned landing sites. Tracking data increased knowledge of the moon's gravitational field and revealed the presence of the lunar mascons.³

Scale models of a Lunar Orbiter spacecraft and the moon in the top photo demonstrate the approach to within 48 kilometers of the lunar surface. Below, a portion of the first closeup of the lunar crater Copernicus, taken 23 November 1966 by Lunar Orbiter 2.



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Mariner 9 spacecraft with thermal blanket covering the retro engine at top. Nix Olympica, gigantic volcanic mountain on Mars, photographed by Mariner 9 in January 1972, above. Mariner 10 photographed the densely cratered surface of Mercury on 29 March 1974, at 18 200 kilometers from the planet.

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MARINER. The space probes to investigate the vicinities of the earth's planetary neighbors, Venus and Mars, and eventually Mercury, Jupiter, and Saturn, were designated the "Mariner" series. The name was adopted in May 1960 as part of the Cortright system of naming planetary missions from nautical terms.¹

Mariner spacecraft made a number of record-setting missions, from the early years of the project. On 14 December 1962 NASA's *Mariner 2* came within 34 900 kilometers of Venus, climaxing a four-month space flight that provided new scientific data on interplanetary space and Venus. On 14 July 1965, after seven months of interplanetary flight, *Mariner 4* took the first close look at Mars from outside the earth's atmosphere, returning high-quality photographs and scientific data.

On 19 October 1967 *Mariner 5* flew within 4000 kilometers of Venus, obtaining additional information on the nature and origin of the planet and on the interplanetary environment during a period of increased solar activity. During 1969, *Mariner 6* and *7* continued the investigation of the Martian atmosphere, flying within 3500 kilometers of the planet. Following the unsuccessful *Mariner 8* launch attempt, * *Mariner 9* was launched 30 May 1971 and put into orbit around Mars on 13 November 1971—the first man-made object to orbit another planet. *Mariner 9* photographed the moons of Mars, mapped 100 percent of the planet, and returned data proving it was geologically and meteorologically alive.

Mariner 10, launched 3 November 1973, flew past Venus in February 1974 to a March 1974 encounter with Mercury, for the first exploration of that planet. The spacecraft's trajectory around the sun swung it back for a second encounter with Mercury in September 1974 and would return it for a third in March 1975. Venus data gave clues to the planet's weather system, suggested the planet's origin differed from the earth's, and confirmed the presence of hydrogen in its atmosphere. Mercury data revealed a strong magnetic field, a tenuous atmosphere rich in helium, a cratered crust, and possibly an iron-rich core; it brought new insight into the formation of the terrestrial planets.

Two Mariner Jupiter-Saturn probes were planned for launch in 1977 to study the environment, atmosphere, and characteristics of those planets.²

*Mariner H was designated Mariner 8 by NASA Associate Administrator John E. Naugle because of pressure from the press for easier identification. This designation was a departure from past precedent of assigning a number to spacecraft only after a successful launch. (NASA, Mariner Mars 1971 Project Office, telephone interview, 4 June 1971.)



Pioneer 11 spacecraft during checkout with a mockup of the launch vehicle's third stage, before launch. Jupiter's red spot and a shadow of the moon Io with the planet's cloud structure were photographed by Pioneer 10 on 1 December 1973.

PIONEER. “Pioneer” was chosen as the name for the first U.S. space probe, *Pioneer 1*, launched 11 October 1958, as well as for the following series of lunar and deep space probes. The Pioneer series had been initiated for the International Geophysical Year by the Department of Defense’s Advanced Research Projects Agency (ARPA), which assigned execution variously to the Air Force Ballistic Missile Division (AFBMD) and to the Army Ballistic Missile Agency (ABMA). Upon its formation in October 1958, NASA inherited responsibility for—and the name of—the probes.¹

Credit for naming the first probe has been attributed to Stephen A. Saliga, who had been assigned to the Air Force Orientation Group, Wright-Patterson AFB, as chief designer of Air Force exhibits. While he was at a briefing, the spacecraft was described to him as a “lunar-orbiting vehicle with an infrared scanning device.” Saliga thought the title too long and lacked theme for an exhibit design. He suggested “Pioneer” as the name of

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the probe since “the Army had already launched and orbited the Explorer satellite and their Public Information Office was identifying the Army as ‘Pioneers in Space,’ ” and by adopting the name the Air Force would “make a ‘quantum jump’ as to *who* really [were] the ‘Pioneers in Space.’ ”²

The first series of Pioneer spacecraft was flown between 1958 and 1960. *Pioneer 1*, *2*, and *5* were developed by Space Technology Laboratories, Inc., and were launched for NASA by AFBMD. *Pioneer 3* and *4* were developed by the Jet Propulsion Laboratory and launched for NASA by ABMA. In 1960 *Pioneer 5* transmitted the first solar flare data and established a communications distance record of 36.2 million kilometers.

With the launch of *Pioneer 6* (Pioneer A in the new series) in December 1965, NASA resumed the probes to complement interplanetary data acquired by Mariner probes. *Pioneer 7*, *8*, and *9*, second-generation spacecraft

launched between 1966 and 1968, continued the investigation of the interplanetary medium.

Between 1965 and 1967 NASA had been studying the concept for a space probe known as the “Galactic Jupiter Probe,” or “Advanced Planetary Probe,” that would investigate solar, interplanetary, and galactic phenomena in the outer region of the solar system.³ By 1968 NASA had included the probe in the Pioneer series, designating two such probes Pioneer F and G.⁴

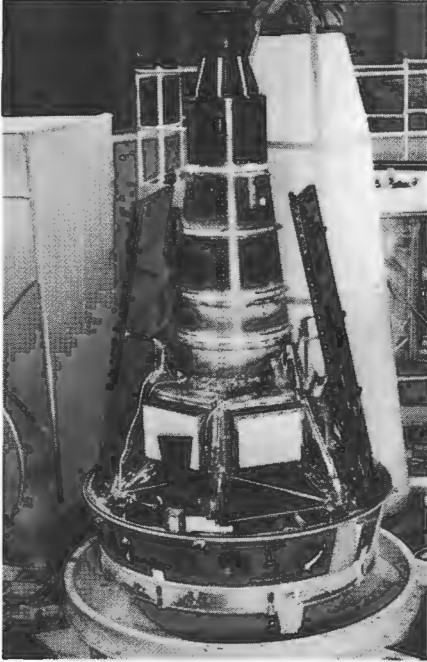
Pioneer 10 (Pioneer F), launched in March 1972, became the first spacecraft to cross the Asteroid Belt. It flew by Jupiter in December 1973, returning more than 300 closeup photos of the planet and its inner moons as well as data on its complex magnetic field and its atmosphere. Accelerated by Jupiter’s gravity, the probe was to reach the orbit of Saturn in 1976 and the orbit of Uranus in 1979; it was expected to become in 1987 the first spacecraft to escape the solar system.

Pioneer 11 (Pioneer G), launched in April 1973, crossed the Asteroid Belt, skimmed by Jupiter three times closer to the planet than *Pioneer 10* had, and was thrown by Jupiter’s gravity toward Saturn. The spacecraft sent back the first photos of Jupiter’s poles and information on the atmosphere, the equator regions, and the moon Callisto. On the night of 2 December 1974, when *Pioneer 11* set its new course for Saturn, NASA renamed the probe *Pioneer Saturn*.⁵ It was to pass close by Saturn in the fall of 1979.

Two Pioneer Venus spacecraft, an orbiter and a multiprobe lander, were to gather detailed information on the atmosphere and clouds of Venus in 1978. The lander was to release four probes to the planet’s surface.⁶

RANGER. A probe series to gather data about the moon, Ranger was assigned its name in May 1960 because of the parallel to “land exploration activities.”¹ NASA had initiated Project Ranger—then unnamed—in December 1959, when it requested Jet Propulsion Laboratory (JPL) to study spacecraft design and a mission to “acquire and transmit a number of images of the lunar surface.”² In February 1960 Dr. William H. Pickering, JPL Director, recommended that NASA Headquarters approve the name “Ranger” used by JPL for the project. The name had been introduced by the JPL program director, Clifford D. Cummings, who had noticed while on a camping trip that his pick-up truck was called “Ranger.” Cummings liked the name and, because it referred to “land exploration activities,” suggested it as a name for the lunar impact probe. By May 1960 it was in common use.³

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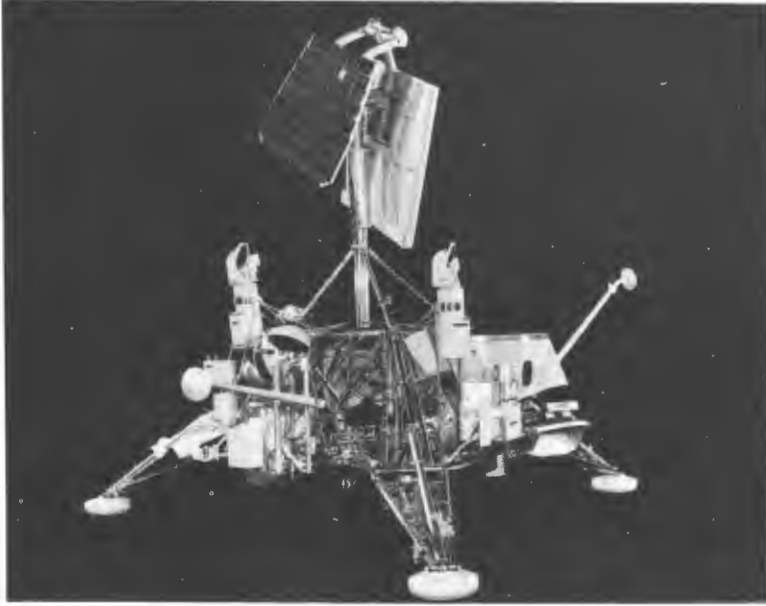


Ranger 7 before 28 July 1964 launch to the moon, at left. The television picture of craters on the lunar surface was taken by Ranger 9 before impact 24 March 1965.



The first U.S. spacecraft to hit the moon was *Ranger 4*, launched 23 April 1962. *Ranger 7*, *8*, and *9*, flown 1964–1965, provided thousands of close-up photographs of the moon before crashing on its surface. They were the first of the unmanned space probes—*Surveyor* and *Lunar Orbiter* were later ones—to provide vital planning information about the lunar surface for the Apollo manned lunar landing program.

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The Surveyor spacecraft, designed to make a softlanding on the moon. Surveyor 5's alpha-backscattering instrument, in the lower photo, analyzed chemical composition of the lunar surface after the 10 September 1967 landing.

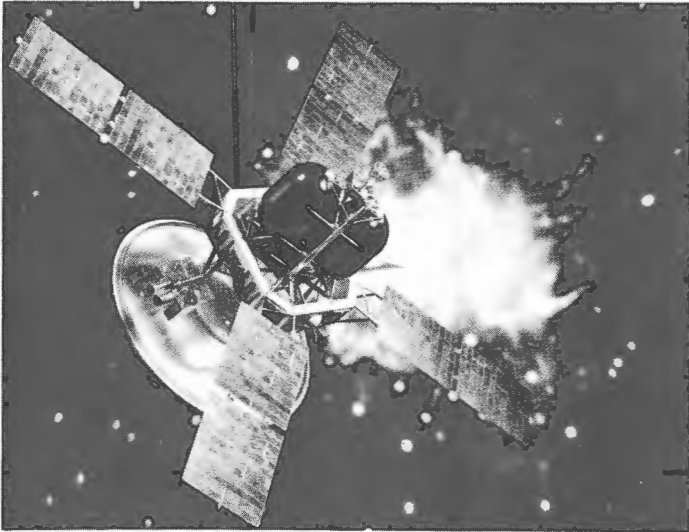
SPACE PROBES

SURVEYOR. “Surveyor” was chosen in May 1960 to designate an advanced spacecraft series to explore and analyze the moon’s surface. The designation was in keeping with the policy of naming lunar probes after “land exploration activities” established under the Cortright system of naming space probes.¹ Following the Ranger photographic lunar hardlanders, Surveyor probes marked an important advance in space technology: a softlanding on the moon’s surface to survey it with television cameras and analyze its characteristics using scientific instruments.

Five Surveyor spacecraft—*Surveyor 1* in 1966; *Surveyor 3*, *5*, and *6* in 1967; and *Surveyor 7* in 1968—softlanded on the moon and operated on the lunar surface over a combined time of approximately 17 months. They transmitted more than 87 000 photographs and made chemical and mechanical analyses of surface and subsurface samples.²

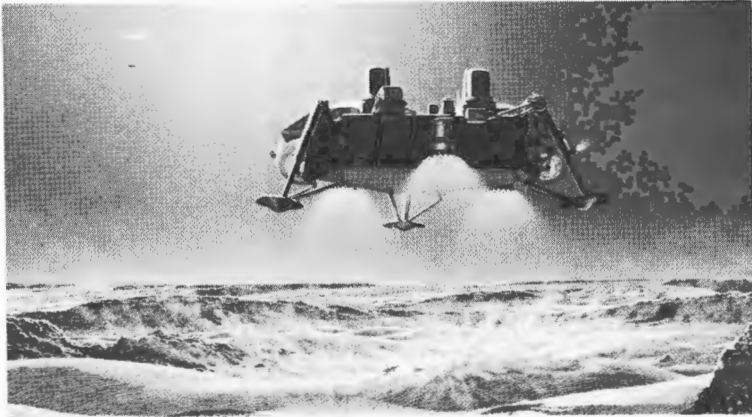
VIKING. The name “Viking” designated the planned first U.S. softlanding probes of the planet Mars.* The successor to Project Voyager, which was

Viking spacecraft model in simulated flight.



*“Viking had been previously used in the U.S. as the name for the early single-stage sounding rocket that later became the prototype for the first stage of the Vanguard launch vehicle. See Milton W. Rosen, *The Viking Rocket Story* (London: Faber and Faber, 1956) and Constance McL. Green and Milton Lomask, *Vanguard—A History*, NASA SP-4202 (Washington: NASA, 1970).

ORIGINS OF NASA NAMES



An artist's conception of the Viking Mars lander nearing touchdown on the Martian surface at Chryse. The parachute in the left background carries the aeroshell from which the lander detaches.

canceled in 1968, the Viking program was to send two unmanned spacecraft—each consisting of an orbiter and lander—to make detailed scientific measurements of the Martian surface, and search for indications of life forms.* The two Viking spacecraft, planned for launch in 1975 on Titan III–Centaur launch vehicles, were to reach Mars in 1976.

The name had been suggested by Walter Jacobowski in the Planetary Programs Office at NASA Headquarters and discussed at a management review held at Langley Research Center in November 1968.¹ It was the consensus at the meeting that “Viking” was a suitable name in that it reflected the spirit of nautical exploration in the same manner as “Mariner,” according to the Cortright system of naming space probes.² The name was subsequently sent to the NASA Project Designation Committee and approved.

*Project Voyager was terminated because of the projected high cost of the program (\$2.4 billion), which was related to the planned use of Saturn V launch vehicles.

IV

MANNED SPACE FLIGHT



View of the moon from Apollo 8.

MANNED SPACE FLIGHT

NASA's first four manned spaceflight projects were Mercury, Gemini, Apollo, and Skylab. As the first U.S. manned spaceflight project, Project Mercury—which included two manned suborbital flights and four orbital flights—“fostered Project Apollo and fathered Project Gemini.”¹ The second manned spaceflight project initiated was the Apollo manned lunar exploration program. The national goal of a manned lunar landing in the 1960s was set forth by President John F. Kennedy 25 May 1961:

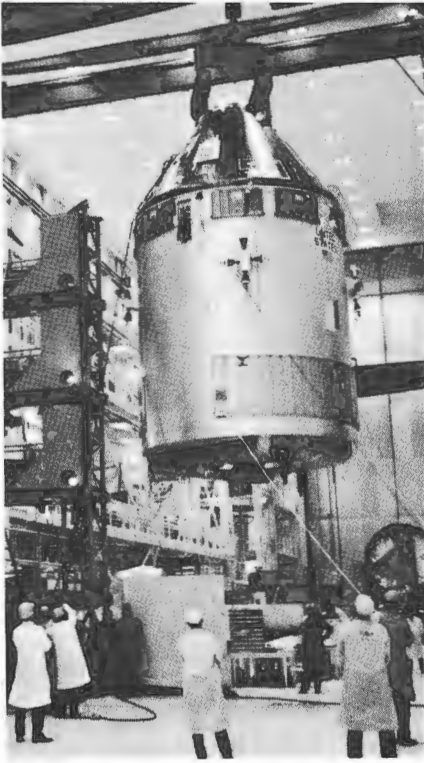
. . . I believe that this nation should commit itself to achieving the goals, before this decade is out, of landing a man on the moon and returning him safely to earth. No single space project in this period will be more impressive to mankind, or more important for the long-range exploration of space; and none will be so difficult or expensive to accomplish. . . . But in a very real sense, it will not be one man going to the moon—if we make this judgment affirmatively, it will be an entire nation.²

The interim Project Gemini, completed in 1966, was conducted to provide spaceflight experience, techniques, and training in preparation for the complexities of Apollo lunar-landing missions. Project Skylab was originally conceived as a program to use hardware developed for Project Apollo in related manned spaceflight missions; it evolved into the Orbital Workshop program with three record-breaking missions in 1973–1974 to man the laboratory in earth orbit, producing new data on the sun, earth resources, materials technology, and effects of space on man.

The Apollo-Soyuz Test Project was an icebreaking effort in international cooperation. The United States and the U.S.S.R. were to fly a joint mission in 1975 to test new systems that permitted their spacecraft to dock with each other in orbit, for space rescue or joint research.

As technology and experience broadened man's ability to explore and use space, post-Apollo planning called for ways to make access to space more practical, more economical, nearer to routine. Early advanced studies grew into the Space Shuttle program. Development of the reusable space transportation system, to be used for most of the Nation's manned and unmanned missions in the 1980s, became the major focus of NASA's program for the 1970s. European nations cooperated by undertaking development of Spacelab, a pressurized, reusable laboratory to be flown in the Shuttle.

ORIGINS OF NASA NAMES



Apollo 11 command and service module being readied for transport to the Vehicle Assembly Building at Kennedy Space Center, in left photo. Apollo 11 Astronaut Edwin E. Aldrin, Jr., below, setting up an experiment on the moon next to the lunar module. Opposite: the Greek god Apollo (courtesy of George Washington University).



MANNED SPACE FLIGHT



APOLLO. In July 1960 NASA was preparing to implement its long-range plan beyond Project Mercury and to introduce a manned circumlunar mission project—then unnamed—at the NASA/Industry Program Plans Conference in Washington. Abe Silverstein, Director of Space Flight Development, proposed the name “Apollo” because it was the name of a god in ancient Greek mythology with attractive connotations and the precedent for naming manned spaceflight projects for mythological gods and heroes had been set with Mercury.¹ Apollo was god of archery, prophecy, poetry, and music, and most significantly he was god of the sun. In his horse-drawn golden chariot, Apollo pulled the sun in its course across the sky each day.² NASA approved the name and publicly announced “Project Apollo” at the July 28–29 conference.³

Project Apollo took new form when the goal of a manned lunar landing was proposed to the Congress by President John F. Kennedy 25 May 1961 and was subsequently approved by the Congress. It was a program of three-man flights, leading to the landing of men on the moon. Rendezvous and docking in lunar orbit of Apollo spacecraft components were vital techniques for the intricate flight to and return from the moon.

The Apollo spacecraft consisted of the command module, serving as the crew’s quarters and flight control section; the service module, containing propulsion and spacecraft support systems; and the lunar module, carrying

ORIGINS OF NASA NAMES

two crewmen to the lunar surface, supporting them on the moon, and returning them to the command and service module in lunar orbit. Module designations came into use in 1962, when NASA made basic decisions on the flight mode (lunar orbit rendezvous), the boosters, and the spacecraft for Project Apollo. From that time until June 1966, the lunar module was called "lunar excursion module (LEM)." It was renamed by the NASA Project Designation Committee because the word "excursion" implied mobility on the moon and this vehicle did not have that capability.⁴ The later Apollo flights, beginning with *Apollo 15*, carried the lunar roving vehicle (LRV), or "Rover," to provide greater mobility for the astronauts while on the surface of the moon.

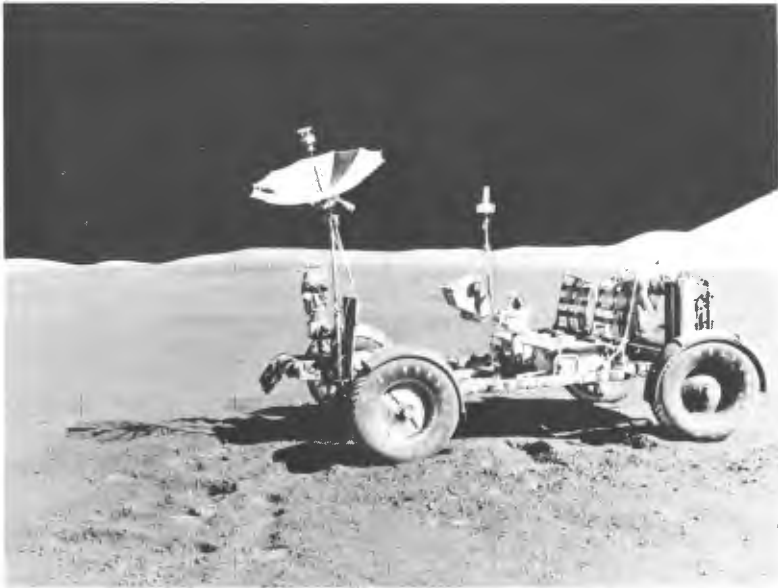
Beginning with the flight of *Apollo 9*, code names for both the command and service module (CSM) and lunar module (LM) were chosen by the astronauts who were to fly on each mission. The code names were: *Apollo 9*—"Gumdrop" (CSM), "Spider" (LM); *Apollo 10*—"Charlie Brown" (CSM), "Snoopy" (LM); *Apollo 11*—"Columbia" (CSM), "Eagle" (LM); *Apollo 12*—"Yankee Clipper" (CSM), "Intrepid" (LM); *Apollo 13*—"Odyssey" (CSM), "Aquarius" (LM); *Apollo 14*—"Kitty Hawk" (CSM), "Antares" (LM); *Apollo 15*—"Endeavour" (CSM), "Falcon" (LM); *Apollo 16*—"Casper" (CSM), "Orion" (LM); *Apollo 17*—"America" (CSM); "Challenger" (LM).

The formula for numbering Apollo missions was altered when the three astronauts scheduled for the first manned flight lost their lives in a flash fire during launch rehearsal 27 January 1967. In honor of Astronauts Virgil I. Grissom, Edward H. White II, and Roger B. Chaffee, the planned mission was given the name "Apollo 1" although it was not launched. Carrying the prelaunch designation AS-204 for the fourth launch in the Apollo Saturn IB series, the mission was officially recorded as "First manned Apollo Saturn flight—failed on ground test."

Manned Spacecraft Center Deputy Director George M. Low had urged consideration of the request from the astronauts' widows that the designation "Apollo 1"—used by the astronauts publicly and included on their insignia—be retained. NASA Headquarters Office of Manned Space Flight therefore recommended the new numbering, and the NASA Project Designation Committee announced approval 3 April 1967.

The earlier, unmanned Apollo Saturn IB missions AS-201, AS-202, and AS-203 were not given "Apollo" flight numbers and no missions were named "Apollo 2" and "Apollo 3." The next mission flown, the first Saturn V flight (AS-501, for Apollo Saturn V No. 1), skipped numbers 2

MANNED SPACE FLIGHT



Lunar Rover parked on the moon during the Apollo 15 mission.

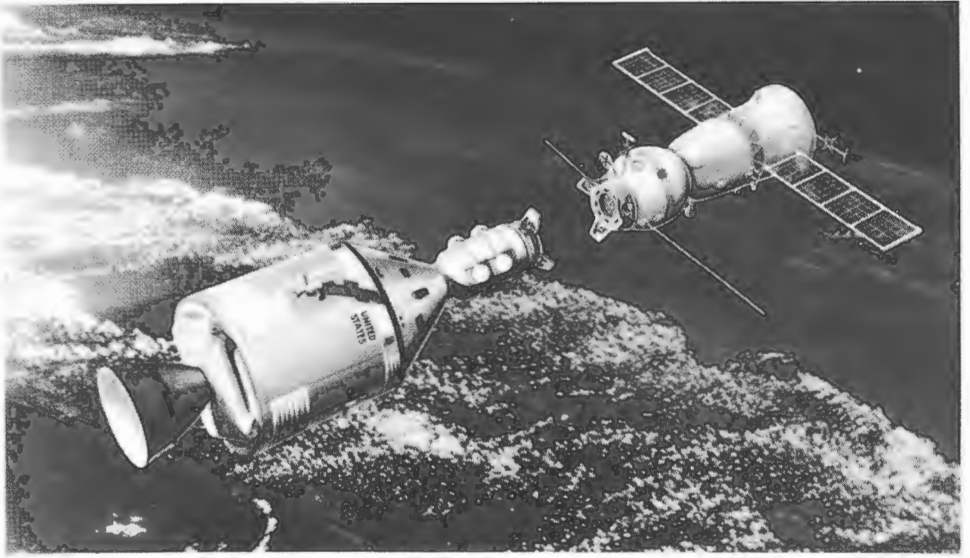
and 3 to become *Apollo 4* after launch into orbit 9 November 1967. Subsequent flights continued the sequence through 17.⁵

The Apollo program carried the first men beyond the earth's field of gravity and around the moon on *Apollo 8* in December 1968 and landed the first men on the moon in *Apollo 11* on 20 July 1969. The program concluded with *Apollo 17* in December 1972 after putting 27 men into lunar orbit and 12 of them on the surface of the moon. Data, photos, and lunar samples brought to earth by the astronauts and data from experiments they left on the moon—still transmitting data in 1974—began to give a picture of the moon's origin and nature, contributing to understanding of how the earth had evolved.

APOLLO-SOYUZ TEST PROJECT (ASTP). The first international manned space project, the joint U.S.–U.S.S.R. rendezvous and docking mission took its name from the spacecraft to be used, the American Apollo and the Soviet Soyuz.

On 15 September 1969, two months after the *Apollo 11* lunar landing mission, the President's Space Task Group made its recommendations on the future U.S. space program. One objective was broad international par-

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The Apollo spacecraft approaches the Soyuz for docking in orbit, in the artist's conception at top. Cosmonaut Aleksey A. Leonov and Astronaut Donald K. Slayton check out the docking module in a 1974 training session.

MANNED SPACE FLIGHT

ticipation, and President Nixon included this goal in his March 1970 Space Policy Statement. The President earlier had approved NASA plans for increasing international cooperation in an informal meeting with Secretary of State William P. Rogers, Presidential Assistant for National Security Affairs Henry A. Kissinger, and NASA Administrator Thomas O. Paine aboard *Air Force One* while flying to the July *Apollo 11* splashdown.¹

The United States had invited the U.S.S.R. to participate in experiments and information exchange over the past years. Now Dr. Paine sent Soviet Academy of Sciences President Mstislav V. Keldysh a copy of the U.S. post-Apollo plans and suggested exploration of cooperative programs. In April 1970 Dr. Paine suggested, in an informal meeting with Academician Anatoly A. Blagonravov in New York, that the two nations cooperate on astronaut safety, including compatible docking equipment on space stations and shuttles to permit rescue operations in space emergencies. Further discussions led to a 28 October 1970 agreement on joint efforts to design compatible docking arrangements. Three working groups were set up. Agreements on further details were reached in Houston, Texas, 21–25 June 1971 and in Moscow 29 November–6 December 1971. NASA Deputy Administrator George M. Low and a delegation met with a Soviet delegation in Moscow 4–6 April 1972 to draw up a plan for docking a U.S. Apollo spacecraft with a Russian Soyuz in earth orbit in 1975.²

Final official approval came in Moscow on 24 May 1972. U.S. President Nixon and U.S.S.R. Premier Aleksey N. Kosygin signed the Agreement Concerning Cooperation in the Exploration and Use of Outer Space for Peaceful Purposes, including development of compatible spacecraft docking systems to improve safety of manned space flight and to make joint scientific experiments possible. The first flight to test the systems was to be in 1975, with modified Apollo and Soyuz spacecraft. Beyond this mission, future manned spacecraft of the two nations would be able to dock with each other.³

During work that followed, engineers at Manned Spacecraft Center (renamed Johnson Space Center in 1973) shortened the lengthy “joint rendezvous and docking mission” to “Rendock,” as a handy project name. But the NASA Project Designation Committee in June 1972 approved the official designation as “Apollo Soyuz Test Project (ASTP),” incorporating the names of the U.S. and U.S.S.R. spacecraft. The designation was sometimes written “Apollo/Soyuz Test Project,” but the form “Apollo-Soyuz Test Project” was eventually adopted. NASA and the Soviet Academy of Sciences announced the official ASTP emblem in March 1974. The circular emblem displayed the English word “Apollo” and the Russian

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word "Soyuz" on either side of a center globe with a superimposed silhouette of the docked spacecraft.⁴

Scheduled for July 1975, the first international manned space mission would carry out experiments with astronauts and cosmonauts working together, in addition to testing the new docking systems and procedures. A three-module, two-man Soviet Soyuz was to be launched from the U.S.S.R.'s Baykonur Cosmodrome near Tyuratam on 15 July. Some hours later the modified Apollo command and service module with added docking module and a three-man crew would lift off on the Apollo-Skylab Saturn IB launch vehicle from Kennedy Space Center, to link up with the Soyuz. The cylindrical docking module would serve as an airlock for transfer of crewmen between the different atmospheres of the two spacecraft. After two days of flying joined in orbit, with crews working together, the spacecraft would undock for separate activities before returning to the earth.⁵

GEMINI. In 1961 planning was begun on an earth-orbital rendezvous program to follow the Mercury project and prepare for Apollo missions. The improved or "Advanced Mercury" concept was designated "Mercury Mark II" by Glenn F. Bailey, NASA Space Task Group Contracting Officer, and John Y. Brown of McDonnell Aircraft Corporation.¹ The two-man spacecraft was based on the one-man Mercury capsule, enlarged and made capable of longer flights. Its major purposes were to develop the technique of rendezvous in space with another spacecraft and to extend orbital flight time.

NASA Headquarters personnel were asked for proposals for an appropriate name for the project and, in a December 1961 speech at the Industrial College of the Armed Forces, Dr. Robert C. Seamans, Jr., then NASA Associate Administrator, described Mercury Mark II, adding an offer of a token reward to the person suggesting the name finally accepted. A member of the audience sent him the name "Gemini." Meanwhile, Alex P. Nagy in NASA's Office of Manned Space Flight also had proposed "Gemini." Dr. Seamans recognized both as authors of the name.²

"Gemini," meaning "twins" in Latin, was the name of the third constellation of the zodiac, made up of the twin stars Castor and Pollux. To Nagy it seemed an appropriate connotation for the two-man crew, a rendezvous mission, and the project's relationship to Mercury. Another connotation of the mythological twins was that they were considered to be the patron gods of voyagers.³ The nomination was selected from several made in NASA Headquarters, including "Diana," "Valiant," and "Orpheus"

MANNED SPACE FLIGHT



The Gemini 7 spacecraft was photographed from the window of Gemini 6 during rendezvous maneuvers 15 December 1965. Castor and Pollux, the Gemini of mythology, ride their horses through the sky (courtesy of the Library of Congress).



from the Office of Manned Space Flight. On 3 January 1962, NASA announced the Mercury Mark II project had been named "Gemini."⁴

After 12 missions—2 unmanned and 10 manned—Project Gemini ended 15 November 1966. Its achievements had included long-duration space flight, rendezvous and docking of two spacecraft in earth orbit, extravehicular activity, and precision-controlled reentry and landing of spacecraft.

The crew of the first manned Gemini mission, Astronauts Virgil I. Grissom and John W. Young, nicknamed their spacecraft "Molly Brown." The name came from the musical comedy title, *The Unsinkable Molly Brown*, and was a facetious reference to the sinking of Grissom's Mercury-

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Redstone spacecraft after splashdown in the Atlantic Ocean 21 July 1961. “Molly Brown” was the last Gemini spacecraft with a nickname; after the *Gemini 3* mission, NASA announced that “all Gemini flights should use as official spacecraft nomenclature a single easily remembered and pronounced name.”⁵

Astronaut Edward H. White II floats in space, secured to the Gemini 4 spacecraft.



MERCURY. Traditionally depicted wearing a winged cap and winged shoes, Mercury was the messenger of the gods in ancient Roman and (as Hermes) Greek mythology.¹ The symbolic associations of this name appealed to Abe Silverstein, NASA’s Director of Space Flight Development, who suggested it for the manned spaceflight project in the autumn of 1958. On 26 November 1958 Dr. T. Keith Glennan, NASA Administrator, and Dr. Hugh

MANNED SPACE FLIGHT



Full-scale mockups of the Mercury and Gemini spacecraft.

L. Dryden, Deputy Administrator, agreed upon “Mercury,” and on 17 December 1958 Dr. Glennan announced the name for the first time.²

On 9 April 1959 NASA announced selection of the seven men chosen to be the first U.S. space travelers, “astronauts.” The term followed the semantic tradition begun with “Argonauts,” the legendary Greeks who traveled far and wide in search of the Golden Fleece, and continued with “aeronauts”—pioneers of balloon flight.³ Robert R. Gilruth, head of the Space Task Group, proposed “Project Astronaut” to NASA Headquarters, but the suggestion lost out in favor of Project Mercury “largely because it [Project Astronaut] might lead to overemphasis on the personality of the man.”⁴

In Project Mercury the United States acquired its first experience in conducting manned space missions and its first scientific and engineering knowledge of man in space. After two suborbital and three orbital missions, Project Mercury ended with a fourth orbital space flight—a full-day mission by L. Gordon Cooper, Jr., 15–16 May 1963.

In each of Project Mercury’s manned space flights, the assigned astronaut chose a call sign for his spacecraft just before his mission. The choice of

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“Freedom 7” by Alan B. Shepard, Jr., established the tradition of the numeral “7,” which came to be associated with the team of seven Mercury astronauts. When Shepard chose “Freedom 7,” the numeral seemed significant to him because it appeared that “capsule No. 7 on booster No. 7 should be the first combination of a series of at least seven flights to put Americans into space.”⁵ The prime astronaut for the second manned flight, Virgil I. Grissom, named his spacecraft “Liberty Bell 7” because “the name was to Americans almost synonymous with ‘freedom’ and symbolical numerically of the continuous teamwork it represented.”⁶

John Glenn, assigned to take the Nation’s first orbital flight, named his Mercury spacecraft “Friendship 7.” Scott Carpenter chose “Aurora 7,” he said, “because I think of Project Mercury and the open manner in which we are conducting it for the benefit of all as a light in the sky. Aurora also

Astronaut John H. Glenn, Jr., is hoisted out of the Friendship 7 spacecraft after splashdown in the Atlantic 20 February 1962. The god Mercury, poised for flight, at right (courtesy of the National Gallery of Art).



MANNED SPACE FLIGHT

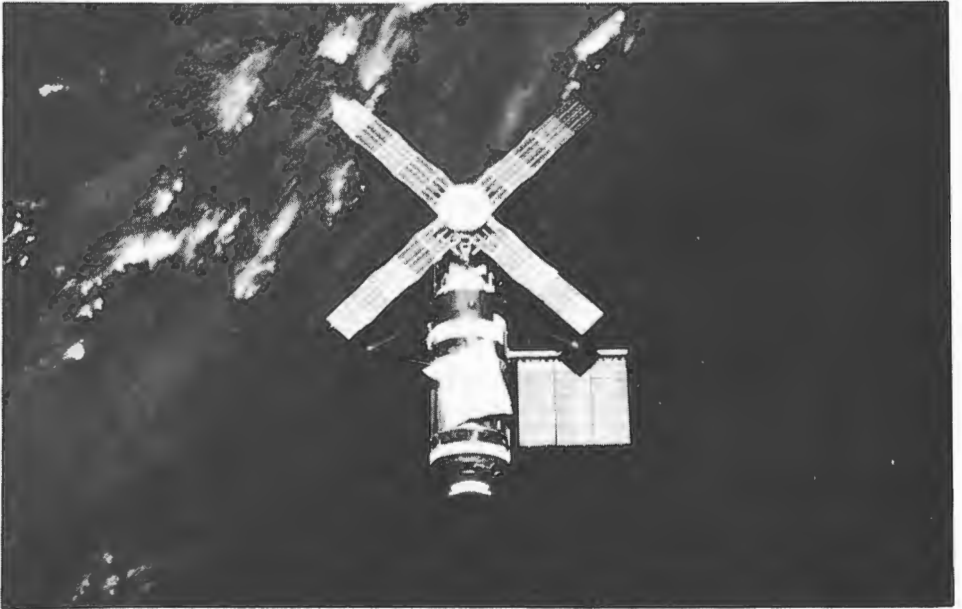
means dawn—in this case the dawn of a new age. The 7, of course, stands for the original seven astronauts.”⁷ Walter M. Schirra selected “Sigma 7” for what was primarily an engineering flight—a mission to evaluate spacecraft systems; “sigma” is an engineering symbol for summation. In selecting “sigma,” Schirra also honored “the immensity of the engineering effort behind him.”⁸ Cooper’s choice of “Faith 7” symbolized, in his words, “my trust in God, my country, and my teammates.”⁹

SKYLAB. Planning for post-Apollo manned spaceflight missions evolved directly from the capability produced by the Apollo and Saturn technologies, and Project Skylab resulted from the combination of selected program objectives. In 1964, design and feasibility studies had been initiated for missions that could use modified Apollo hardware for a number of possible lunar and earth-orbital scientific and applications missions. The study concepts were variously known as “Extended Apollo (Apollo X)” and the “Apollo Extension System (AES).”¹ In 1965 the program was coordinated under the name “Apollo Applications Program (AAP)” and by 1966 had narrowed in scope to primarily an earth-orbital concept.²

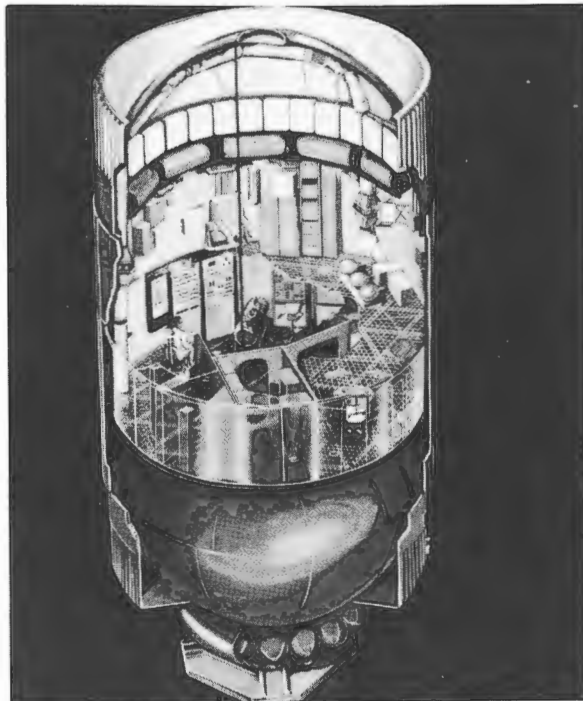
Projected AAP missions included the use of the Apollo Telescope Mount (ATM). In one plan it was to be launched separately and docked with an orbiting workshop in the “wet” workshop configuration. The wet workshop—using the spent S-IVB stage of the Saturn I launch vehicle as a workshop after purging it in orbit of excess fuel—was later dropped in favor of the “dry” configuration using the Saturn V launch vehicle. The extra fuel carried by the S-IVB when used as a third stage on the Saturn V, for moon launches, would not be required for the Skylab mission, and the stage could be completely outfitted as a workshop before launch, including the ATM.³

The name “Skylab,” a contraction connoting “laboratory in the sky,” was suggested by L/C Donald L. Steelman (USAF) while assigned to NASA. He later received a token reward for his suggestion. Although the name was proposed in mid-1968, NASA decided to postpone renaming the program because of budgetary considerations. “Skylab” was later referred to the NASA Project Designation Committee and was approved 17 February 1970.⁴

Skylab 1 (SL-1), the Orbital Workshop with its Apollo Telescope Mount, was put into orbit 14 May 1973. Dynamic forces ripped off the meteoroid shield and one solar array wing during launch, endangering the entire program, but the three astronauts launched on *Skylab 2* (SL-2)—the first manned mission to crew the Workshop—were able to repair the spacecraft and completed 28 days living and working in space before their safe return.



Skylab Orbital Workshop photographed from the Skylab 2 command module during fly-around inspection. The Workshop's remaining solar array wing, after the second wing was ripped off during launch, is deployed below the ATM's four arrays. The emergency solar parasol erected by the astronauts is visible on the lower part of the spacecraft. The cutaway drawing shows crew quarters and work areas.



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They were followed by two more three-man crews during 1973. The *Skylab 3* crew spent 59 days in space and *Skylab 4* spent 84. Each Skylab mission was the longest-duration manned space flight to that date, also setting distance-in-orbit and extravehicular records. *Skylab 4*, the final mission (16 November 1973 to 8 February 1974) recorded the longest in-orbit EVA (7 hours 1 minute), the longest cumulative orbital EVA time for one mission (22 hours 21 min in four EVAs), and the longest distance in orbit for a manned mission (55.5 million kilometers).

The Skylab missions proved that man could live and work in space for extended periods; expanded solar astronomy beyond earth-based observations, collecting new data that could revise understanding of the sun and its effects on the earth; and returned much information from surveys of earth resources with new techniques. The deactivated Workshop remained in orbit; it might be visited by a future manned flight, but was not to be inhabited again.

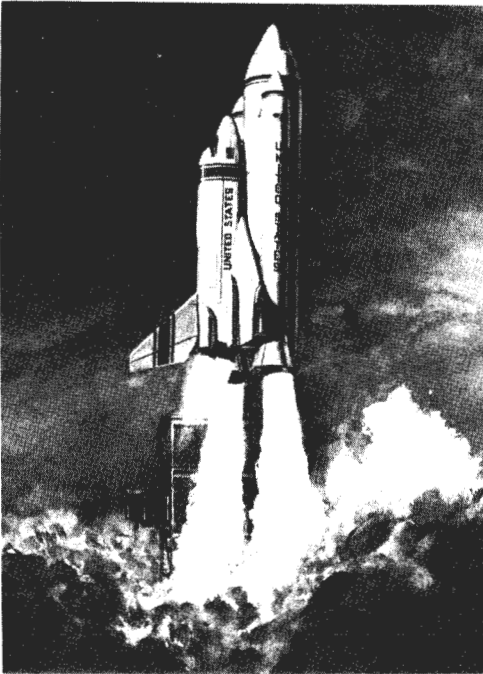
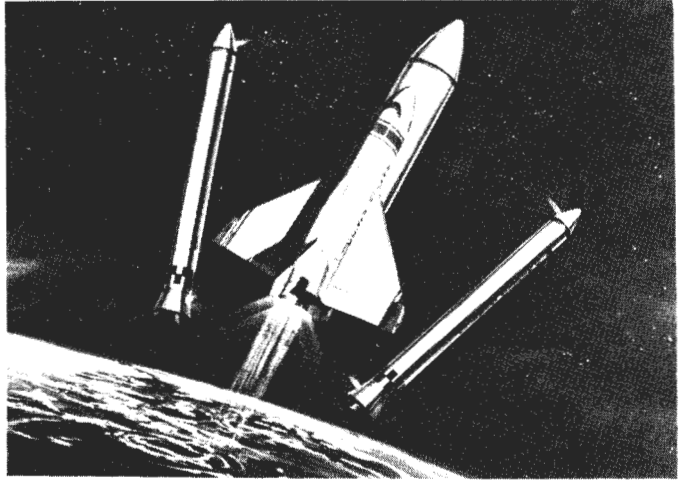
SPACE SHUTTLE. The name "Space Shuttle" evolved from descriptive references in the press, aerospace industry, and Government and gradually came into use as concepts of reusable space transportation developed. As early NASA advanced studies grew into a full program, the name came into official use.*¹

From its establishment in 1958, NASA studied aspects of reusable launch vehicles and spacecraft that could return to the earth. The predecessor National Advisory Committee for Aeronautics and then NASA cooperated with the Air Force in the X-15 rocket research aircraft program in the 1950s and 1960s and in the 1958-1963 Dyna-Soar ("Dynamic-Soaring") hypersonic boost-glide vehicle program. Beginning in 1963, NASA joined the USAF in research toward the Aerospaceplane, a manned vehicle to go into orbit and return, taking off and landing horizontally. Joint flight tests in the 1950s and 1960s of wingless lifting bodies—the M2 series, HL-10, and eventually the X-24—tested principles for future spacecraft reentering the atmosphere.

Marshall Space Flight Center sponsored studies of recovery and reuse of the Saturn V launch vehicle. MSFC Director of Future Projects Heinz H. Koelle in 1962 projected a "commercial space line to earth orbit and the

*In January 1975, NASA's Project Designation Committee was considering suggestions for a new name for the Space Shuttle, submitted by Headquarters and Center personnel and others at the request of Dr. George M. Low, NASA Deputy Administrator. Rockwell International Corporation, Shuttle prime contractor, was reported as referring to it as "Spaceplane." (Bernice M. Taylor, Administrative Assistant to Assistant Administrator for Public Affairs, NASA, telephone interview, 12 Feb. 1975; and *Aviation Week & Space Technology*, 102 [20 January 1975], 10.)

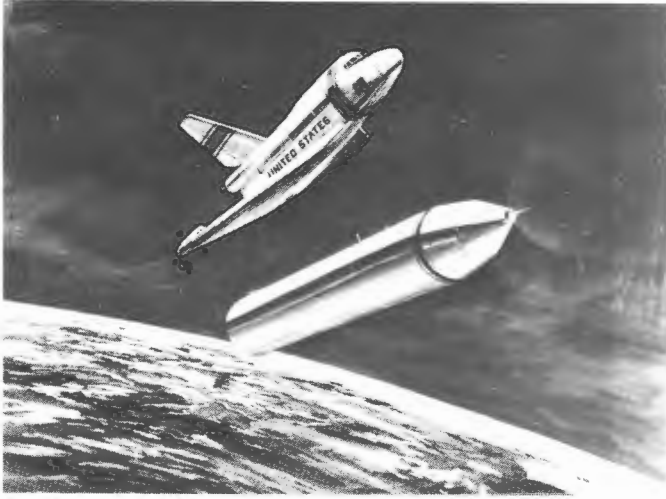
ORIGINS OF NASA NAMES



The Space Shuttle lifts off in the artist's conception of missions of the 1980s, at left, with booster jettison and tank jettison following in sequence as the orbiter heads for orbit and its mission.

moon,” for cargo transportation by 1980 or 1990. Leonard M. Tinnan of MSFC published a 1963 description of a winged, flyback Saturn V.² Other studies of “logistics spacecraft systems,” “orbital carrier vehicles,” and “reusable orbital transports” followed throughout the 1960s in NASA, the Department of Defense, and industry.

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As the Apollo program neared its goal, NASA's space program objectives widened and the need for a fully reusable, economical space transportation system for both manned and unmanned missions became more urgent. In 1966 the NASA budget briefing outlined an FY 1967 program including advanced studies of "ferry and logistics vehicles." The President's Science Advisory Committee in February 1967 recommended studies of more economical ferry systems with total recovery and rescue possibilities.³ Industry studies under NASA contracts 1969–1971 led to definition of a reusable Space Shuttle system and to a 1972 decision to develop the Shuttle.

The term "shuttle" crept into forecasts of space transportation at least as early as 1952. In a *Collier's* article, Dr. Wernher von Braun, then Director of the U.S. Army Ordnance Guided Missiles Development Group, envisioned space stations supplied by rocket ships that would enter orbit and return to earth to land "like a normal airplane," with small, rocket-powered "shuttle-craft," or "space taxis," to ferry men and materials between rocket ship and space station.⁴

In October 1959 Lockheed Aircraft Corporation and Hughes Aircraft Company reported plans for a space ferry or "commuter express," for "shuttling" men and materials between earth and outer space. In December, *Christian Science Monitor* Correspondent Courtney Sheldon wrote of the future possibility of a "man-carrying space shuttle to the nearest planets."⁵

The term reappeared occasionally in studies through the early 1960s. A 1963 NASA contract to Douglas Aircraft Company was to produce a conceptual design for Philip Bono's "Reusable Orbital Module Booster and Utility Shuttle (ROMBUS)," to orbit and return to touch down with legs

like the lunar landing module's. Jettison of eight strap-on hydrogen tanks for recovery and reuse was part of the concept.⁶ The press—in accounts of European discussions of Space Transporter proposals and in articles on the Aerospaceplane, NASA contract studies, USAF START reentry studies, and the joint lifting-body flights—referred to “shuttle” service, “reusable orbital shuttle transport,” and “space shuttle” forerunners.*

In 1965 Dr. Walter R. Dornberger, Vice President for Research of Textron Corporation's Bell Aerosystems Company, published “Space Shuttle of the Future: The Aerospaceplane” in Bell's periodical *Rendezvous*. In July Dr. Dornberger gave the main address in a University of Tennessee Space Institute short course: “The Recoverable, Reusable Space Shuttle.”⁷

NASA used the term “shuttle” for its reusable transportation concept officially in 1968. Associate Administrator for Manned Space Flight George E. Mueller briefed the British Interplanetary Society in London in August with charts and drawings of “space shuttle” operations and concepts. In November, addressing the National Space Club in Washington, D.C., Dr. Mueller declared the next major thrust in space should be the space shuttle.⁸

By 1969 “Space Shuttle” was the standard NASA designation, although some efforts were made to find another name as studies were pursued.⁹ The “Space Shuttle” was given an agency-wide code number; the Space Shuttle Steering Group and Space Shuttle Task Group were established. In September the Space Task Group appointed by President Nixon to help define post-Apollo space objectives recommended the U.S. develop a reusable, economic space transportation system including a shuttle. And in October feasibility study results were presented at a Space Shuttle Conference in Washington. Intensive design, technology, and cost studies followed in 1970 and 1971.¹⁰

*The *Defense/Space Business Daily* newsletter was persistent in referring to USAF and NASA reentry and lifting-body tests as “Space Shuttle” tests. Editor-in-Chief Norman L. Baker said the newsletter had first tried to reduce the name “Aerospaceplane” to “Spaceplane” for that project and had moved from that to “Space Shuttle” for reusable, back-and-forth space transport concepts as early as 1963. The name was suggested to him by the Washington, D.C., to New York airline shuttle flights. (Telephone interview, 22 April 1975.)

Application of the word “shuttle” to anything that moved quickly back and forth (from shuttlecock to shuttle train and the verb “to shuttle”) had arisen in the English language from the name of the weaving instrument that passed or “shot” the thread of the woof from one edge of the cloth to the other. The English word came from the Anglo-Saxon “scytel” for missile, related to the Danish “skyttel” for shuttle, the Old Norwegian “skutill” for harpoon, and the English “shoot.” (*Webster's International Dictionary*, ed. 2, unabridged.)

MANNED SPACE FLIGHT

On 5 January 1972 President Nixon announced that the United States would develop the Space Shuttle.

The Space Shuttle would be a delta-winged aircraftlike orbiter about the size of a DC-9 aircraft, mounted at launch on a large, expendable liquid-propellant tank and two recoverable and reusable solid-propellant rocket boosters (SRBs) that would drop away in flight. The Shuttle's cargo bay eventually would carry most of the Nation's civilian and military payloads. Each Shuttle was to have a lifetime of 100 space missions, carrying up to 29 500 kilograms at a time. Sixty or seventy flights a year were expected in the 1980s.

Flown by a three-man crew, the Shuttle would carry satellites to orbit, repair them in orbit, and later return them to earth for refurbishment and reuse. It would also carry up to four scientists and engineers to work in a pressurized laboratory (see Spacelab) or technicians to service satellites. After a 7- to 30-day mission, the orbiter would return to earth and land like an aircraft, for preparation for the next flight.

At the end of 1974, parts were being fabricated, assembled, and tested for flight vehicles. Horizontal tests were to begin in 1977 and orbital tests in 1979. The first manned orbital flight was scheduled for March 1979 and the complete vehicle was to be operational in 1980.

SPACE TUG. Missions to orbits higher than 800 kilometers would require an additional propulsion stage for the Space Shuttle. A reusable "Space Tug" would fit into the cargo bay to deploy and retrieve payloads beyond the orbiter's reach and to achieve earth-escape speeds for deep-space exploration. Under a NASA and Department of Defense agreement, the Air Force was to develop an interim version—the "interim upper stage (IUS)," named by the Air Force the "orbit-to-orbit stage (OOS)," to be available in 1980. NASA meanwhile continued planning and studies for a later full-capacity Space Tug.¹¹

Joseph E. McGolrick of the NASA Office of Launch Vehicles had used the term in a 1961 memorandum suggesting that, as capabilities and business in space increased, a need might arise for "a space tug—a space vehicle capable of orbital rendezvous and . . . of imparting velocities to other bodies in space." He foresaw a number of uses for such a vehicle and suggested it be considered with other concepts for the period after 1970. McGolrick thought of the space tug as an all-purpose workhorse, like the small, powerful tugboats that moved huge ocean liners and other craft. The name was used frequently in studies and proposals through the years, and in September 1969 the Presidential Space Task Group's recommendation for a

new space transportation system proposed development of a reusable, chemically propelled space tug, as well as a shuttle and a nuclear stage.¹²

LARGE SPACE TELESCOPE. Among Shuttle payloads planned—besides Spacelab and satellites like those launched in the past by expendable boosters—was the Large Space Telescope (LST), to be delivered to orbit as an international facility for in-orbit research controlled by scientists on the ground. The LST would observe the solar system and far galaxies from above the earth's atmosphere. On revisits, the Shuttle would service the orbiting telescope, exchange scientific hardware, and—several years later—return the LST to the earth.

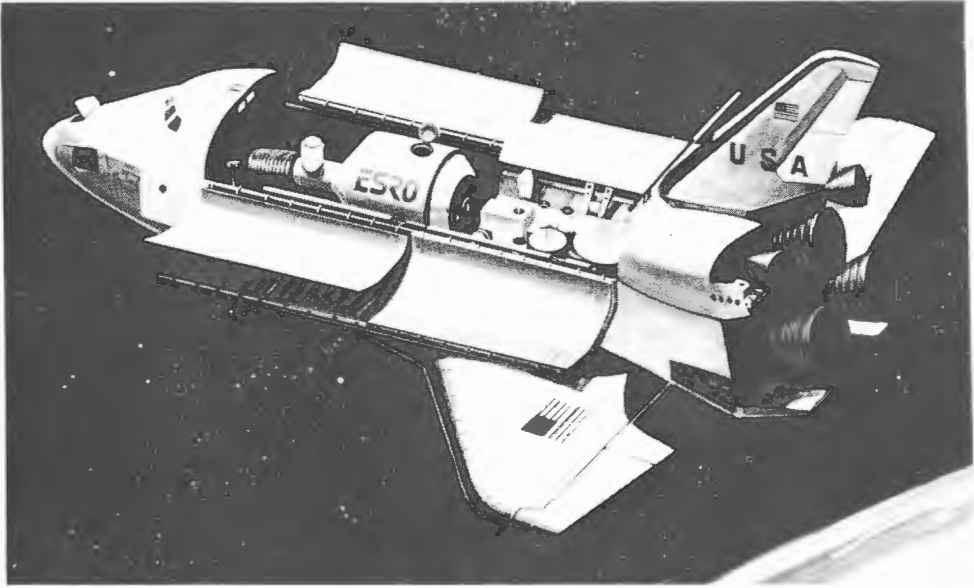
LONG-DURATION EXPOSURE FACILITY. Another payload was to be placed in orbit for research into effects of exposure to space. The unmanned, free-flying Long-Duration Exposure Facility (LDEF) would expose a variety of passive experiments in orbit and would later be retrieved for refurbishment and reuse.

SPACELAB. A new venture in space flight made possible by the Space Shuttle, Spacelab was to be a reusable “space laboratory” in which scientists and engineers could work in earth orbit without spacesuits or extensive astronaut training. The program drew the United States and Europe into closer cooperation in space efforts.

The name finally chosen for the space laboratory was that used by the European developers. It followed several earlier names used as NASA's program developed toward its 1980s operational goal. In 1971 NASA awarded a contract for preliminary design of “Research and Applications Modules” (RAMs) to fly on the Space Shuttle. A family of manned or “man-tended” payload carriers, the RAMs were to provide versatile laboratory facilities for research and applications work in earth orbit. Later modules were expected to be attached to space stations, in addition to the earlier versions operating attached to the Shuttle. The simplest RAM mode was called a “Sortie Can” at Marshall Space Flight Center. It was a low-cost, simplified, pressurized laboratory to be carried on the Shuttle orbiter for short “sortie” missions into space.¹ In June 1971 the NASA Project Designation Committee redesignated the Sortie Can the “Sortie Lab,” as a more fitting name.²

When the President's Space Task Group had originally recommended development of the Space Shuttle in 1969, it had also recommended broad international participation in the space program, and greater international cooperation was one of President Nixon's Space Policy Statement goals in March 1970. NASA Administrator Thomas O. Paine visited European

MANNED SPACE FLIGHT



A Spacelab module and pallet fill the payload bay of a scale-model Space Shuttle orbiter. The laboratory module is nearest the cabin.

capitals in October 1969 to explain Shuttle plans and invite European interest, and 43 European representatives attended a Shuttle Conference in Washington. One area of consideration for European effort was development of the Sortie Lab.³

On 20 December 1972 a European Space Council ministerial meeting formally endorsed European Space Research Organization development of Sortie Lab. An intergovernmental agreement was signed 10 August 1973 and ESRO and NASA initialed a memorandum of understanding. The memorandum was signed 24 September 1973. Ten nations—Austria, Belgium, Denmark, France, West Germany, Italy, the Netherlands, Spain, Switzerland, and the United Kingdom—would develop and manufacture the units. The first unit was to be delivered to NASA free in the cooperative program, and NASA would buy additional units. NASA would fly Spacelab on the Shuttle in cooperative missions, in U.S. missions, and for other countries with costs reimbursed.⁴

In its planning and studies, ESRO called the laboratory “Spacelab.” And when NASA and ESRO signed the September 1973 memorandum on cooperation NASA Administrator James C. Fletcher announced that NASA’s Sortie Lab program was officially renamed “Spacelab,” adopting the ESRO name.⁵

ORIGINS OF NASA NAMES

Spacelab was designed as a low-cost laboratory to be quickly available to users for a wide variety of orbital research and applications. Almost half the civilian Space Shuttle payloads were expected to fly in Spacelab in the 1980s. It was to consist of two elements, carried together or separately in the Shuttle orbiter: a pressurized laboratory, where scientists and engineers with only brief flight training could work in a normal environment, and an instrument platform, or "pallet," to support telescopes, antennas, and other equipment exposed to space.

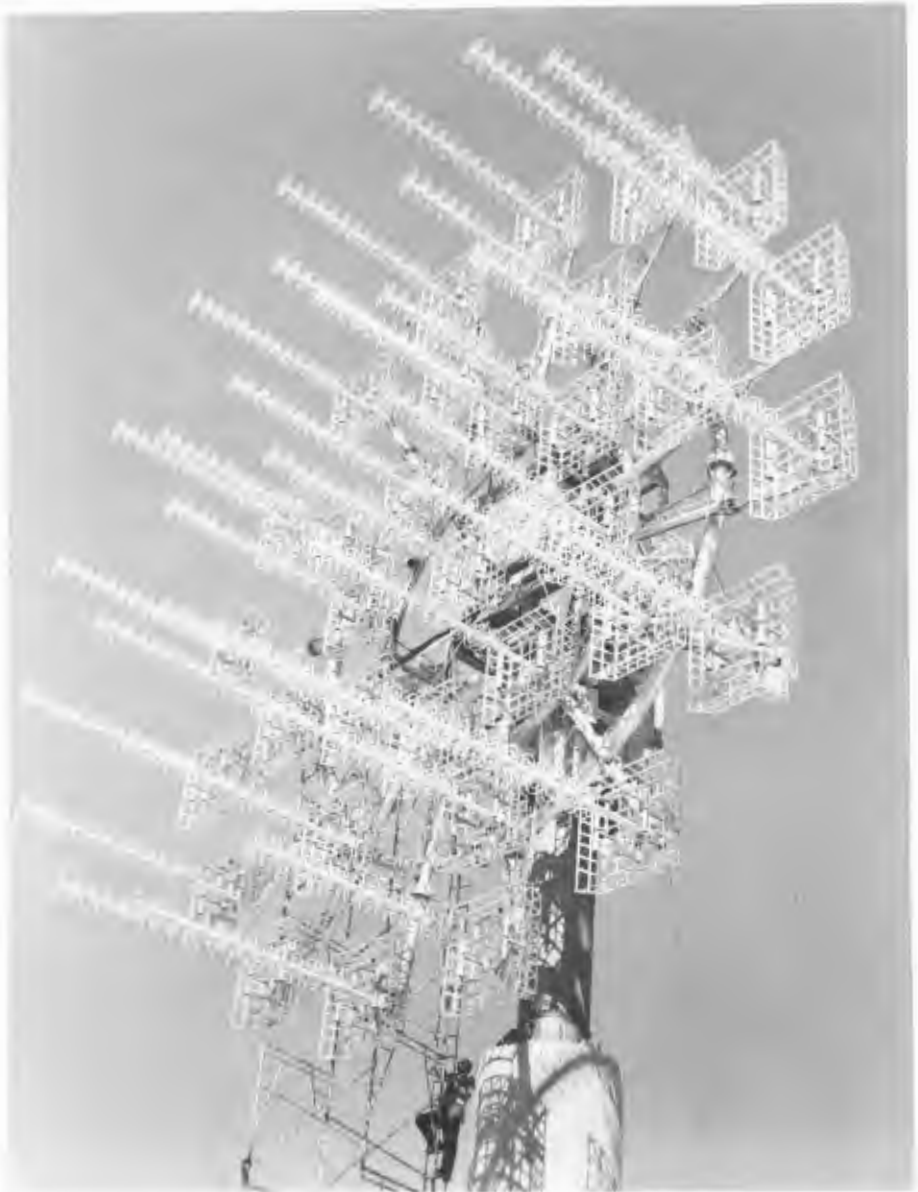
Reusable for 50 flights, the laboratory would remain in the Shuttle hold, or cargo bay, while in orbit, with the bay doors held open for experiments and observations in space. Seven-man missions, many of them joint missions with U.S. and European crew members, would include a three-man Shuttle crew and four men for Spacelab. Up to three men could work in the laboratory at one time, with missions lasting 7 to 30 days. At the end of each flight, the orbiter would make a runway landing and the laboratory would be removed and prepared for its next flight. Racks of experiments would be prepared in the home laboratories on the ground, ready for installation in Spacelab for flight and then removal on return.⁶

One of the planned payloads was NASA's AMPS (Atmospheric, Magnetospheric, and Plasmas-in-Space) laboratory, to be installed in Spacelab for missions in space.⁷

At the end of 1974, life scientists, astronomers, atmospheric physicists, and materials scientists were defining experiment payloads for Spacelab. The first qualified flight unit was due for delivery in 1979 for 1980 flight. A European might be a member of the first flight crew.⁸

V

SOUNDING ROCKETS



High-gain antenna at Wallops Flight Center receives telemetry signals from experiments launched on sounding rockets.

SOUNDING ROCKETS

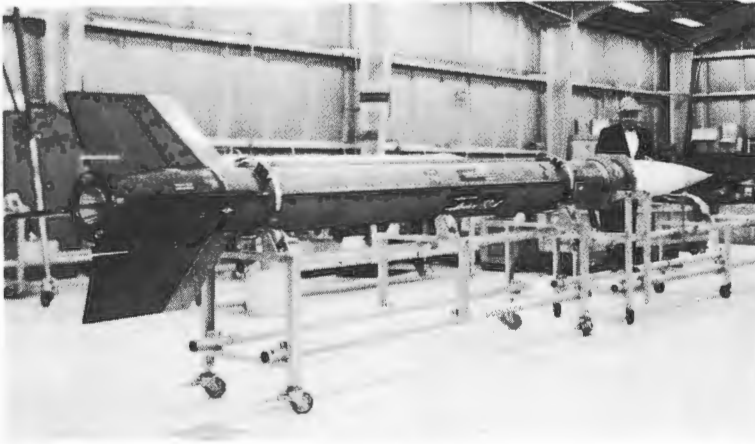
Sounding rockets are rockets that carry instruments into the upper atmosphere to investigate its nature and characteristics, gathering data from meteorological measurements at altitudes as low as 32 kilometers to data for ionospheric and cosmic physics at altitudes up to 6400 kilometers.¹ Sounding rockets also flight-test instruments to be used in satellites. The term “sounding rocket” derived from the analogy to maritime soundings made of the ocean depths.²

Sending measurement instruments into the high atmosphere was one of the principal motives for 20th century rocket development. This was the stated purpose of Dr. Robert H. Goddard in his rocket design studies as early as 1914.³ But it was not until 1945 that the first U.S. Government-sponsored sounding rocket was launched—the Wac Corporal, a project of the Jet Propulsion Laboratory and U.S. Army Ordnance.⁴

Sounding rockets played an important role in the International Geophysical Year (IGY), an 18-month period (1 July 1957 to 31 December 1958) coinciding with high solar activity. The IGY was an intensive investigation of the natural environment—the earth, the oceans, and the atmosphere—by 30 000 participants representing 66 nations. More than 300 instrumented sounding rockets launched from sites around the world made significant discoveries regarding the atmosphere, the ionosphere, cosmic radiation, auroras, and geomagnetism.⁵

The International Years of the Quiet Sun (1 January 1964 to 31 December 1965), a full-scale follow-up to the IGY, was an intensive effort of geophysical observations in a period of minimum solar activity. Instrumented sounding rockets again played a significant role in the investigation of earth-sun interactions. By the end of 1974, some 20 countries had joined NASA in cooperative projects launching more than 1700 rockets from ranges in the United States and abroad.⁶

Sounding rocket research gave rise to three new branches of astronomy—ultraviolet, x-ray, and gamma ray. Experiments launched on rockets have characterized the main features of the earth’s upper atmosphere and contributed the first recognition of the geocorona, knowledge of ionospheric chemistry, detection of electrical currents in the ionosphere, and de-



Aerobee 150A, top, in assembly area. At left below, Aerobee 350 launched on its first full flight test, 18 June 1965. At right below, Astrobee 1500 erected for its first flight test, 21 October 1964

SOUNDING ROCKETS

scription of particle flux in auroras. One of the earliest discoveries was of solar x-rays originating in the solar corona.⁷

Because higher performance sounding rockets were not economical for low-altitude experiments and lower performance rockets were not useful for high-altitude experiments, NASA used a number of rockets of varying capabilities—including Aerobee and Astrobe, Arcas, Argo D-4 (Javelin), Nike-Apache, Nike-Cajun, Nike-Hawk, Nike-Malemute, Nike-Tomahawk, Terrier-Malemute, and Black Brant. A high-performance rocket, the Aries, was under development in 1974. Vehicles could economically place 5 to 900 kilograms at altitudes up to 2200 kilometers. Highly accurate payload pointing and also payload recovery were possible when needed.⁸

AEROBEE, ASTROBEE. Development of the Aerobee liquid-propellant sounding rocket was begun in 1946 by the Aerojet Engineering Corporation (later Aerojet-General Corporation) under contract to the U.S. Navy. The Applied Physics Laboratory (APL) of Johns Hopkins University was assigned technical direction of the project. James A. Van Allen, then Director of the project at APL, proposed the name “Aerobee.” He took the “Aero” from Aerojet Engineering and the “bee” from Bumblebee, the name of the overall project to develop naval rockets¹ that APL was monitoring for the Navy. The 18-kilonewton-thrust, two-stage Aerobee was designed to carry a 68-kilogram payload to a 130-kilometer altitude.

In 1952, at the request of the Air Force and the Navy, Aerojet undertook design and development of the Aerobee-Hi, a high-performance version of the Aerobee designed expressly for research in the upper atmosphere.² An improved Aerobee-Hi became the Aerobee 150. The uprated Aerobee 150 was named “Astrobe.” Aerojet used the prefix “Aero” to designate liquid-propellant sounding rockets and “Astro” for its solid-fueled rockets.³ Some of the Aerobee and Astrobe models employed by NASA were:⁴

Sounding Rocket	Payload Weight (kg)	Nominal Altitude* (km)
Aerobee 150 and 150A**	68 227	270 110
Aerobee 170 and 170A	113.5 227	250 150
Aerobee 200 and 200A	113.5 227	310 290

ORIGINS OF NASA NAMES

Sounding Rocket	Payload Weight (kg)	Nominal Altitude* (km)
Aerobee 350	136	400
	454	210
Astrobee 1500	45	2200
	136	1200
Astrobee F.	91	500
	454	400

*Sea level launch at 85° launch elevation.

**The "A" designation indicated the rocket had four fins instead of three.

APACHE. The Apache solid-propellant rocket stage was used with the Nike first stage. Identical in appearance to the Nike-Cajun, the Nike-Apache could reach higher altitudes because the Apache propellant burning time was longer (6.4 seconds versus Cajun's 4 seconds). It could carry 34-kilogram payloads to an operating altitude of 210 kilometers or 100 kilograms to 125 kilometers.¹



Technicians ready a Nike-Apache on board the USNS Croatan, Wallops Flight Center mobile range facility.

SOUNDING ROCKETS

The name “Apache,” from the name of the American Indian tribe, followed Thiokol Chemical Corporation (later Thiokol Corporation) tradition of giving Thiokol-developed stages Indian-related names, which had begun with Cajun.²

ARCAS. A small solid-propellant sounding rocket, Arcas was named in 1959 by its producer, Atlantic Research Corporation. The name was an acronym for “All-purpose Rocket for Collecting Atmospheric Soundings.”¹ It was intentional that the first three letters, “A-R-C,” also were the initials of the Atlantic Research Corporation.² An inexpensive vehicle designed specifically for meteorological research, Arcas could carry a five-kilogram payload to an altitude of 64 kilometers.³ Later versions were the Boosted Arcas, Boosted Arcas II, and Super Arcas, all of which NASA used.

Two other sounding rockets developed by Atlantic Research were used briefly by NASA. The Arcon was named by the Corporation and the Iris was named by Eleanor Pressly of Goddard Space Flight Center, which managed the rockets.⁴



Arcas being loaded into its launch tube.

ARGO. The name of a series of sounding rockets, “Argo” was from the name of Jason’s ship in the ancient Greek myth of Jason’s travels in search of the Golden Fleece.* The first sounding rocket in this series, developed by the Aerolab Company (later a division of Atlantic Research Corporation), was called “Jason.” Subsequent vehicles in the series were given names also

* Jason named his ship after its builder, Argus. See Thomas Bulfinch, *Mythology*, Edmund Fuller, ed. (New York: Dell Publishing Co., Inc., 1959), p. 108.



Javelin in horizontal position on the launcher, for last-minute checks during prelaunch operations.



Journeyman

beginning with the letter “J”: The Argo D-4 and Argo D-8 were named “Javelin” and “Journeyman.” The “D-4” and “D-8” designations referred to the number of stages—“D” for “four”—and to the design revision—fourth and eighth.¹

SOUNDING ROCKETS

Argo D-4 (Javelin) was designed to carry 40- to 70-kilogram payloads to 800- to 1100-kilometer altitudes. Argo D-8 (Journeyman) could carry 20- to 70-kilogram payloads to 1500- to 2100-kilometer altitudes.² Javelin was still used by NASA in 1974, but Journeyman was discontinued in 1965.³ Javelin was also mated to the Nike first stage for heavier payloads.

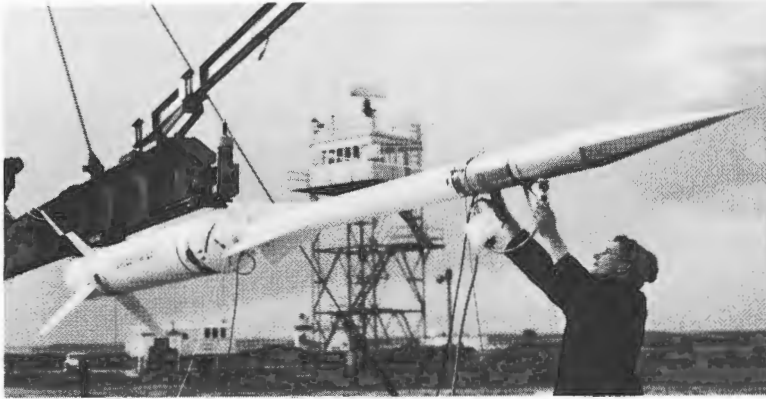
ARIES. NASA in 1974 was working with the Naval Research Laboratory, Sandia Laboratories, and West Germany to develop a new sounding rocket, the Aries, using surplus second stages from the Department of Defense Minuteman intercontinental ballistic missiles. The rocket, which had flown three test flights by December 1974, would lift larger payloads for longer flight times than other rockets—in astronomy, physics, and space processing research projects.¹

The Aries would have greater volume for carrying experiment instruments than provided by the Aerobee 350 sounding rocket and would carry 180- to 900-kilogram scientific payloads to altitudes that would permit 11 to 7 minutes viewing time above 91 440 meters, appreciably longer than the viewing time of the Aerobee 350 and the Black Brant VC. (The first test flights had carried 817 kilograms to 270.7 and 299 kilometers.)² It also was expected to give 11 to 8 minutes in weightless conditions for materials-processing-experiment payloads of 45 to 454 kilograms.³

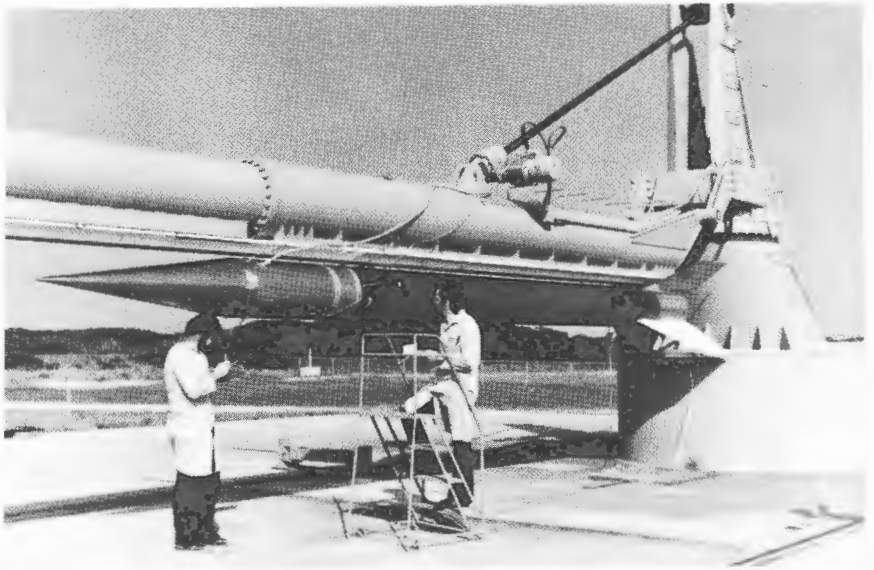
When the project was first conceived, the new vehicle was called “Fat Albert” after the television cartoon character, because its short, fat appearance contrasted with that of other rockets. The Naval Research Laboratory asked Robert D. Arritt of its Space Science Division to choose a more dignified name. Arritt and a group of his colleagues chose “Aries”; it was the name of a constellation (the rocket would be used for astronomy projects) and it was “a name that was available.” It also was Arritt’s zodiac sign.⁴

ASP. The name of the solid-propellant sounding rocket “Asp” was an acronym for “Atmospheric Sounding Projectile.” Designed to carry up to 36 kilograms of payload, the Asp was developed by Cooper Development Corporation for the Navy’s Bureau of Ships; the first prototype was launched 27 December 1955.¹ NASA used Asp as an upper stage in the Nike-Asp briefly: it was test flown several times in 1960, but a need for the vehicle did not develop.²

ORIGINS OF NASA NAMES



A scientist makes final adjustments to the Nike-Asp payload before launch from Wallops Flight Center.



Black Brant VC

BLACK BRANT. The Black Brant series of sounding rockets was developed by Bristol Aerospace Ltd. of Canada with the Canadian government. The first rocket was launched in 1939. By the end of 1974 close to 300 Black Brants

SOUNDING ROCKETS

had been launched and vehicles were in inventories of research agencies in Canada, Europe, and the United States, including the U.S. Navy, U.S. Air Force, and NASA.¹

The Canadian Armament Research and Development Establishment (CARDE) selected the name “Black Brant” for the research rocket, taking the name of a small, dark, fast-flying goose common to the northwest coast and Arctic regions of Canada. The Canadian government kept the name with the addition of numbers (I through VI by 1974) for different members of the series—rather than giving a code name to each version—to emphasize that they were sounding rockets rather than weapons.²

NASA took Black Brants into its sounding rocket inventory in 1970 and was using the Black Brant IVA and VC in 1974. The Black Brant IVA used a modified upper stage and a more powerful engine than previous models, to boost it to 900 kilometers. The Black Brant V series consisted of three 43-centimeter-diameter sounding rockets with all components interchangeable.

The Black Brant VA (or “BBVA”) used stabilizer components with the BBII’s engine and carried 136-kilogram payloads to 160 kilometers, to fill a need for that altitude range. The BBVB, using an engine giving rocket performance double that of the BBII, was designed to meet requirements for scientific investigations above 320-kilometer altitude.

The Black Brant VC was used by NASA to support the 1973–1974 Skylab Orbital Workshop missions by evaluating and calibrating Workshop instruments. The three-fin solid-fueled Black Brant VB was converted to a four-fin model suitable for launching from White Sands Missile Range and permitting recovery of the rocket payloads. The changes decreased performance somewhat but increased stability and allowed greater variations in payload length and weight on the VC. NASA launched the Black Brant VC on two flights during each of the three manned missions to the Skylab Workshop.³

The performance range of NASA’s Black Brant sounding rockets (with an 85° launch angle) in 1974 was: ⁴

Model	Gross Payload Weight (kg)	Altitude (km)
Black Brant IVA	40	900
	100	530
Black Brant VC	200	305

ORIGINS OF NASA NAMES



Nike-Cajun in launch position.



The new Hawk launched into flight.

SOUNDING ROCKETS

CAJUN. The Cajun solid-propellant rocket stage was designed and developed under the Pilotless Aircraft Research Division of the National Advisory Committee for Aeronautics' Langley Laboratory (later NASA's Langley Research Center). The project's manager, Joseph G. Thibodaux, Jr., formerly of Louisiana, suggested the new motor be named "Cajun" because of the term's Louisiana associations. It was the name of persons in that region reputed to be of mixed Acadian French and Indian or Negro blood. Allen E. Williams, Director of Engineering in Thiokol Chemical Corporation's Elkton (Md.) Division, agreed to the name, and later the Elkton Division decided to continue giving its rocket motors Indian-related names.¹

Design of the Cajun motor was based on the Deacon motor, begun during World War II by Allegany Ballistics Laboratory for the National Defense Research Council. NACA purchased Deacon propellant grains from Allegany to propel its aerodynamic research models. Deacon was used with the Nike first stage. In 1956 Langley contracted with Thiokol to develop the improved Deacon, named "Cajun."²

The Nike-Cajun, lifting 35-kilogram instrumented payloads to a 160-kilometer altitude, was one of NASA's most frequently used sounding rockets.³

HAWK. NASA was developing a low-cost sounding rocket in 1974–1975 using surplus motors from the Army's Hawk antiaircraft missiles. The research rocket inherited the Army's name, an acronym for "Homing All the Way Killer," although the new uses would be far removed from the purposes of the weapon system.¹

To be flown as a single-stage Hawk or in two-stage combination as the Nike-Hawk, for a variety of research projects, the 35.6-centimeter-diameter rocket would provide a large volume for payloads. Both stages of the Nike-Hawk would use surplus Army equipment (see also Nike). Development testing was proceeding under Wallops Flight Center management. By December 1974, two flight tests of the single-stage Hawk sounding rocket had been launched, the first one lifting off successfully 29 May 1974. The first flight test of the Nike-Hawk was planned for mid-1975.²

The single-stage Hawk could carry a 45-kilogram payload to an 80-kilometer altitude or 90 kilograms to 57 kilometers. Engineers were working toward a performance capability of 45 kilograms to 210 kilometers or 90 kilograms to 160 kilometers for the Nike-Hawk.³



Nike-Malemute lifts off.



The winged goddess Nike (courtesy of the Library of Congress).



Nike-Tomahawk poised for flight.

SOUNDING ROCKETS

MALEMUTE. The Malemute, a rocket second stage, was developed in 1974 in an interagency program with NASA, Sandia Laboratories, and the Air Force Cambridge Research Laboratories as sponsoring agencies. Designed to be flown with either the Nike or the Terrier first stage, the Malemute began flight tests in 1974. It was named for the Alaskan Eskimo people by the contractor, Thiokol Corporation, in Thiokol's tradition of using Indian-related names (see Cajun).¹

The Nike-Malemute sounding rocket would be able to lift a 90-kilogram payload to 500 kilometers; the Terrier-Malemute would lift the same payload to 700 kilometers. The new vehicles were intended to replace the Javelin and Black Brant IV rockets in the NASA inventory.²

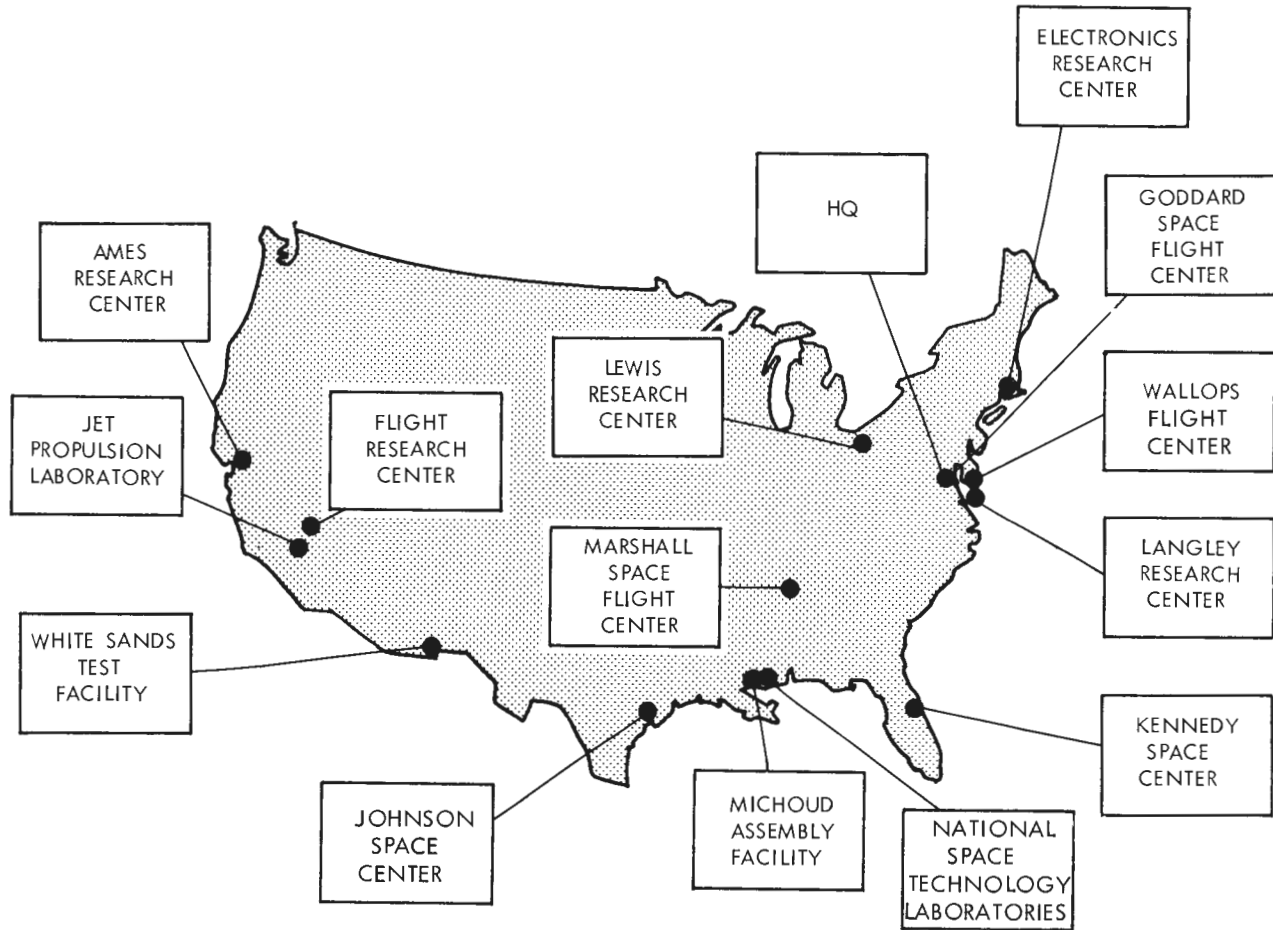
NIKE. The Nike, a solid-propellant first stage, was an adaptation of the Nike anti-aircraft missile developed, beginning in 1945, by the Hercules Powder Company for U.S. Army Ordnance.¹ The name "Nike" was taken from ancient Greek mythology: Nike was the winged goddess of victory. In NASA's sounding rocket program, Nike was used with Apache, Cajun, Tomahawk, Hawk, or Malemute upper stages, as well as with the Aerobee 170, 200, and 350.²

TERRIER. The Terrier, a rocket first stage used by NASA, was developed by Hercules Powder Company as the first stage of the Navy's Terrier anti-aircraft missile, and NASA inherited the name. NASA used it with the Malemute second stage, as the Terrier-Malemute.¹

TOMAHAWK. The Tomahawk, a sounding rocket upper stage used with the Nike booster stage, was named by Thiokol Corporation for the Indian weapon, in Thiokol's tradition of giving its motors Indian-related names (see Cajun).¹ The Nike-Tomahawk could lift 27-kilogram instrumented payloads to a 490-kilometer operating altitude or 118 kilograms to 210 kilometers.²

VI

NASA INSTALLATIONS



NASA INSTALLATIONS

The 11 NASA “field installations” and the contractor-operated Jet Propulsion Laboratory each had a unique history. Many were named for prominent Americans.

Five of the installations were existing facilities of the National Advisory Committee for Aeronautics (NACA), which in October 1958 became the nucleus of the National Aeronautics and Space Administration. These were Ames Research Center, Flight Research Center, Langley Research Center, Lewis Research Center, and Wallops Flight Center.

Three installations—Goddard Space Flight Center, Kennedy Space Center, and Marshall Space Flight Center—and the Jet Propulsion Laboratory began their association with NASA as transfers from the U.S. military space program.

Two installations were created to fill special needs of the U.S. civilian space program. Electronics Research Center joined the research Centers until 1969 and Manned Spacecraft Center, later renamed Johnson Space Center, was added to the manned spaceflight Centers. National Space Technology Laboratories, designated a permanent field installation in 1974, grew out of cooperative activities with other agencies in earth resources and environmental research at an MSFC test facility.

ORIGINS OF NASA NAMES



Aerial view of Ames Research Center, above. Dr. Joseph S. Ames at left.

NASA INSTALLATIONS

AMES RESEARCH CENTER (ARC). Congress on 9 August 1939 authorized the construction of a second National Advisory Committee for Aeronautics (NACA) laboratory for urgent research in aircraft structures, as World War II began. Ground was broken for the laboratory at Moffett Field, California, 14 September 1939. The NACA facility began operations as the Moffett Field Laboratory in early 1941.¹

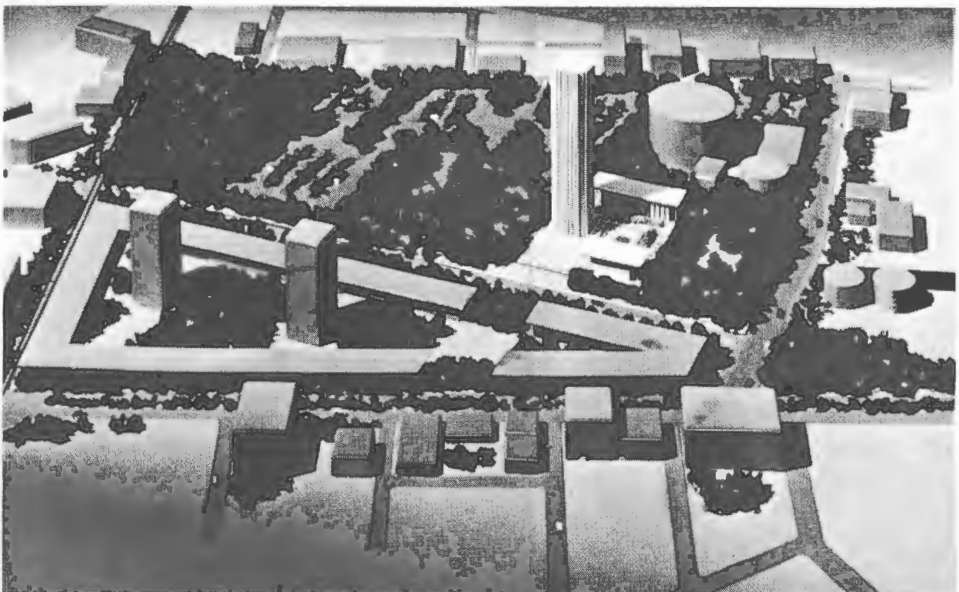
NACA named the facility "Ames Aeronautical Laboratory" in 1944 in honor of Dr. Joseph S. Ames, leading aerodynamicist and former president of Johns Hopkins University, one of the first NACA members in 1915 and serving to 1939. He was NACA Chairman from 1927 to 1939. When Dr. Ames retired as NACA Chairman, he was cited by President Roosevelt for his "inspiring leadership in the development of new research facilities and in the orderly prosecution of comprehensive research programs."²

On 1 October 1958, as a facility of the NACA, the laboratory became part of the new National Aeronautics and Space Administration and was re-named "Ames Research Center."³

Mission responsibilities of ARC focused on basic and applied research in the physical and life sciences for aeronautics and space flight. The Center managed the Pioneer and Biosatellite space projects, as well as providing scientific experiments for other missions. It contributed to development of experimental tilt-wing and fan-in-wing aircraft and solutions to high-speed atmosphere entry problems.

ELECTRONICS RESEARCH CENTER (ERC). NASA's Electronics Research Center was formally activated 1 September 1964 in Cambridge,

Model of Electronics Research Center.



ORIGINS OF NASA NAMES

Massachusetts. ERC absorbed the NASA North Eastern Office, established 14 August 1962 to administer contracts and act as liaison with industry in northeastern states.¹ The name "Electronics Research Center" reflected the installation's mission responsibility. As the focal point of nationwide research in this field, the Center organized, sponsored, and conducted comprehensive programs of basic and applied research in space and aeronautical electronics.

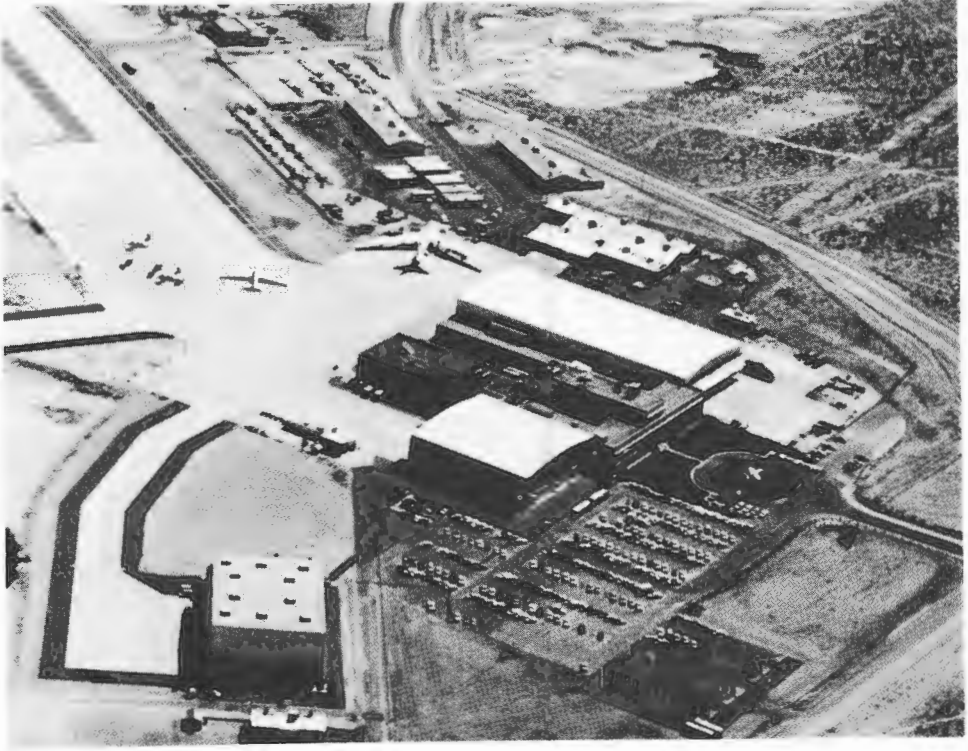
On 29 December 1969, NASA announced its decision to close ERC because of budget reductions. The facility was transferred to the Department of Transportation for use in research and development efforts and was renamed the Transportation Development Center.²

FLIGHT RESEARCH CENTER (FRC). On 30 September 1946, 13 engineers, instrument technicians, and technical observers were sent on temporary duty from the National Advisory Committee for Aeronautics' Langley Laboratory to assist in the rocket-powered X-1 flight-research program at the Air Force's Muroc, California, test facility. Called the "NACA Muroc Flight Test Unit," this group was the beginning of what was to become the Flight Research Center.¹ In 1949 NACA redesignated the unit—which in 1947 had been permanently assigned at Muroc—the "High Speed Flight Research Station." Muroc Air Force Base itself became Edwards Air Force Base after February 1950. In 1954 the NACA unit moved into new, permanent facilities on 175 acres leased from the Air Force at Edwards and its name was changed to "High Speed Flight Station."²

When the National Aeronautics and Space Administration was formed 1 October 1958, the High Speed Flight Station—as a facility of the NACA—became part of NASA. NASA renamed it "Flight Research Center" 27 September 1959,* consistent with its mission responsibilities.³ Research at the Center included investigation of all phases of aeronautical flight, reentry and landing for space flight, and problems of manned flight within and beyond the atmosphere. It was best known for its conduct of the X-15 rocket aircraft flight research program, followed by X-24 lifting-body research, supercritical wing tests, and research into other new aeronautical development.

* On 8 January 1976, NASA announced that FRC was renamed "Hugh L. Dryden Flight Research Center" in "recognition of the unique contributions" of Dr. Dryden, aeronautical research pioneer and first NASA Deputy Administrator. Dr. Dryden had been Director of NACA from May 1947 until NASA was established in October 1958; he served as NASA Deputy Administrator from 1958 to his death in December 1965. He was internationally recognized for his work in fluid mechanics and boundary layer phenomena. (NASA, Special Announcement, 8 Jan. 1956; NASA, News Release 76-7.)

NASA INSTALLATIONS



Aerial view of Flight Research Center, above, and a modified X-15 experimental aircraft with external fuel tanks.



ORIGINS OF NASA NAMES



Dr. Robert H. Goddard at work in his shop at Roswell, New Mexico, October 1935 (courtesy of Mrs. Robert H. Goddard).

GODDARD SPACE FLIGHT CENTER (GSFC). In August 1958, before NASA officially opened for business, Congress authorized construction of a NASA “space projects center” in the “vicinity of Washington, D.C.”¹ The site selected was in Maryland on land then part of the Department of Agriculture’s Beltsville Agricultural Research Center. On 15 January 1959, NASA designated four divisions of NASA Headquarters the “Beltsville Space Center.” Project Vanguard personnel, transferred by Executive Order of the President from the Naval Research Laboratory to NASA in December 1958, formed the nucleus of three of the four divisions and hence of the Center.² On 1 May 1959, NASA renamed the facility “Goddard Space

NASA INSTALLATIONS



Aerial view of Goddard Flight Research Center.

Flight Center” in honor of the father of modern rocketry, Dr. Robert H. Goddard (1882–1945).³ Rocket theorist as well as practical inventor, Dr. Goddard’s list of “firsts” in rocketry included the first launch of a liquid-propellant rocket March 1926.⁴

Goddard Space Flight Center was responsible for unmanned spacecraft and sounding rocket experiments in basic and applied research; it operated the worldwide Space Tracking and Data Acquisition Network (STADAN), which later became Spaceflight Tracking and Data Network (STDN); and it managed development and launch of the Thor-Delta launch vehicle.

GODDARD INSTITUTE FOR SPACE STUDIES (GISS). A center for theoretical research was established in 1961 as the New York office of the Theoretical Division of Goddard Space Flight Center. In July 1962 it was separated organizationally from the Theoretical Division and renamed “Goddard Institute for Space Studies.”⁵ It worked closely with academic scientists in the New York area.

JET PROPULSION LABORATORY (JPL). Students at the Guggenheim Aeronautical Laboratory of the California Institute of Technology (GALCIT), directed by Dr. Theodore von Kármán, in 1936 began design

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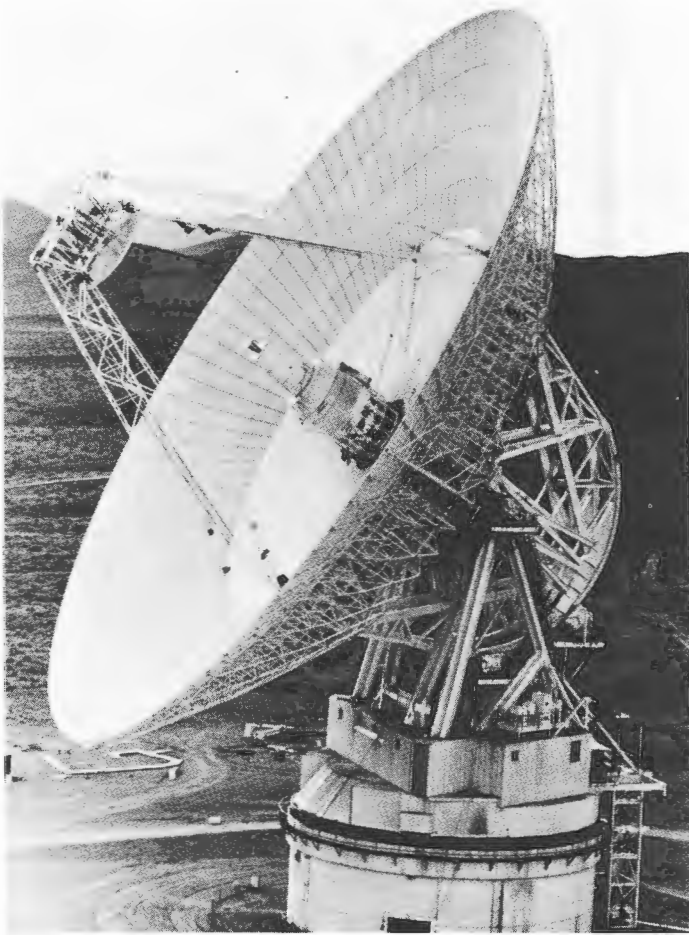
Jet Propulsion Laboratory from the air.

and experimental work with liquid-propellant rocket engines.¹ During World War II the GALCIT Rocket Research Project developed solid- and liquid-propellant units to assist the takeoff of heavily loaded aircraft and began work on high-altitude rockets. Reorganized in November 1944 under the name “Jet Propulsion Laboratory,” the facility continued postwar research and development on tactical guided missiles, aerodynamics, and broad supporting technology for U.S. Army Ordnance.²

JPL participated with the Army Ballistic Missile Agency in the development and operation of the first U.S. satellite, *Explorer 1*, the succeeding Explorer missions, and the *Pioneer 3* and *4* lunar probes. On 3 December 1958, shortly after NASA came into existence, the functions and facilities of JPL were transferred from the U.S. Army to NASA.³ Operating in Government-owned facilities, JPL remained a laboratory of Caltech under contract to NASA.* It has managed projects in NASA’s unmanned lunar

*Public Law 92-520, signed 21 October 1972, carried a rider changing the name of JPL to “H. Allen Smith Jet Propulsion Laboratory” effective 4 January 1973. The House Committee on Public Works had amended a bill for construction of a civic center as a memorial to President Dwight D. Eisenhower, adding a proposal to honor a number of members of Congress by renaming public works buildings after them, including Rep. H. Allen Smith (R-Calif.). Retiring Rep. Smith said he would request legislation to repeal the JPL name change, to avoid confusion, and Public Law 93-215, signed 28 December 1973, included an amendment restoring JPL’s name. Jet Propulsion Laboratory never used the H. Allen Smith name. (U.S. Congress, House of Representatives, *Dwight D. Eisenhower Memorial Bicentennial Civic*

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The 64-meter Goldstone antenna of the Deep Space Network.

and planetary exploration program such as Ranger, Surveyor, and the Mariner series, conducted supporting research, and founded and operated the worldwide Deep Space Network (DSN) for communication with lunar and planetary spacecraft.

Center Act, House Rpt. 92-1410, 19 Sept. 1972 [Washington: 1972], pp. 5, 9; U.S. Public Law 92-520, 86 Stat. 1022, 21 Oct. 1972, p. 4; *Wall Street Journal*, 24 Nov. 1972; Pasadena, Calif., *Star-News*, 18 Dec. 1972; Gerald J. Mossinghoff, Deputy Assistant Administrator for Legislative Affairs, NASA, memorandum for the record, 15 Jan. 1973; *Congressional Record—House*, 8 Feb. 1973, p. H932, and 3 Dec. 1973, pp. H10468-H10469; General Services Administration, National Archives and Records Service, Office of the Federal Register, *Weekly Compilation of Presidential Documents*, 10, No. 1 [7 Jan. 1974], p. 15.)

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Johnson Space Center seen from the air in the top photo, with the Mission Operations Control Room on the third day of the Apollo 8 lunar orbit mission. The television monitor shows the earth telecast from 283 000 kilometers away. President Lyndon B. Johnson at left.

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JOHNSON SPACE CENTER (JSC). On 3 January 1961 NASA's Space Task Group—an autonomous subdivision of Goddard Space Flight Center that managed Project Mercury and was housed at Langley Research Center—was made an independent NASA field installation. Following congressional endorsement of President Kennedy's decision to accelerate the U.S. manned spaceflight program, Congress in August 1961 appropriated funds for a new center for manned space flight. On 9 September 1961 NASA announced the "Manned Spacecraft Center" (MSC) would be built at Clear Lake, near Houston, Texas,¹ and on 1 November 1961 Space Task Group personnel were told that "the Space Task Group is officially redesignated the Manned Spacecraft Center."²

Known as Manned Spacecraft Center for 11½ years, the Center was responsible for design, development, and testing of manned spacecraft; selection and training of astronauts; and operation of manned space flights—including the Mercury, Gemini, Apollo, and Skylab programs and the U.S.-U.S.S.R. Apollo-Soyuz Test Project. It was lead Center for management of the Space Shuttle program.

Following the 22 January 1973 death of former President Lyndon B. Johnson, leader of support for the U.S. space program from its earliest beginnings, Senator Lloyd M. Bentsen (D-Tex.) proposed that MSC be renamed the "Lyndon B. Johnson Space Center." Senator Robert C. Byrd (D-W. Va.) introduced Senate Joint Resolution 37 on Senator Bentsen's behalf 26 January and House joint resolutions were introduced in the next few days.³ Support from NASA Headquarters and Manned Spacecraft Center was immediate.⁴ The Senate and House acted 6 and 7 February and President Nixon signed the resolution 17 February 1973.⁵

As Senator, Johnson had drafted and helped enact legislation that created NASA. As Vice President he had chaired the National Aeronautics and Space Council during the early years of the space program, when the decision was made to place a man on the moon. As President he continued strong support.⁶

Signing the resolution renaming MSC, President Nixon said, "Lyndon Johnson drew America up closer to the stars, and before he died he saw us reach the moon—the first great platform along the way."⁷

WHITE SANDS TEST FACILITY. In June 1962, Manned Spacecraft Center reached an operating agreement with the U.S. Army's White Sands Missile Range for the establishment of an Apollo propulsion development facility and NASA announced selection of the site.⁸ The facility was called "White Sands Operations." NASA renamed the facility the "White Sands Test

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A Saturn V test vehicle is transported from the Kennedy Space Center's Vehicle Assembly Building toward Launch Complex 39.



President John F. Kennedy

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Facility” 25 June 1965.⁹ White Sands was notable in U.S. rocket history as the site for test-firing the German V-2 rockets after World War II.

KENNEDY SPACE CENTER (KSC). Formally named “John F. Kennedy Space Center, NASA,” the installation at Cape Canaveral (named Cape Kennedy 1963–1973) evolved through a series of organizational changes and redesignations.

In 1951 the Experimental Missiles Firing Branch of the Army Ordnance Guided Missile Center in Huntsville, Alabama, was established to supervise test flights of the U.S. Army’s Redstone intermediate-range ballistic missile at the Long Range Proving Ground at Cape Canaveral, Florida. In January 1953, when its responsibilities were expanded, the Army facility was renamed “Missile Firing Laboratory.”¹

On 1 July 1960 the Missile Firing Laboratory became part of NASA’s Marshall Space Flight Center (MSFC)—the nucleus of which was the Laboratory’s parent organization at Huntsville—and it was absorbed organizationally into MSFC’s Launch Operations Directorate.² The other basic element of the Launch Operations Directorate was a NASA unit known as “AMROO” (Atlantic Missile Range Operations Office). AMROO had functioned as NASA’s liaison organization with the military-operated Atlantic Missile Range (formerly Long Range Proving Ground) at Cape Canaveral. Together, the Missile Firing Laboratory and AMROO formed MSFC’s Launch Operations Directorate.³

The Launch Operations Directorate was discontinued as a component of MSFC on 7 March 1962 and Launch Operations Center was established as a separate NASA field installation, officially activated 1 July 1962.⁴ On 29 November 1963, a week after the death of President John F. Kennedy, President Lyndon B. Johnson renamed the Launch Operations Center the “John F. Kennedy Space Center,” saying that President Kennedy had “lighted the imagination of our people when he set the moon as our target and man as the means to reach it” and that the Center was a “symbol of our country’s peaceful assault on space.”⁵

Adjacent to Cape Canaveral was the 324-square-kilometer Merritt Island. In the autumn of 1961 NASA had selected it for launches in the Apollo manned lunar program.⁶ On 17 January 1963 the Launch Operations Center became the executive agent for management and operation of the “Merritt Island Launch Area” (usually called “MILA”).⁷ Headquarters of Kennedy Space Center moved to new facilities on Merritt Island 26 July 1965, and NASA discontinued the “MILA” designation, calling the entire NASA complex the Kennedy Space Center.⁸ The Center was responsible for overall NASA launch operations at the Eastern Test Range (formerly Atlantic

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Missile Range), Western Test Range, and KSC itself, including launches of satellites, probes, manned space missions, and the Space Shuttle.

NASA DAYTONA BEACH OPERATIONS. The Daytona Beach facility was established at the General Electric Company in Daytona Beach, Florida, 23 June 1963 as liaison between NASA and GE; it was an integral part of the Launch Operations Center (later Kennedy Space Center).⁹

WESTERN TEST RANGE° OPERATIONS DIVISION. The WTR facility originated 27 October 1960, when NASA established the Test Support Office at the Pacific Missile Range (PMR) for liaison between NASA and the military-operated PMR. The Test Support Office came under the jurisdiction of MSFC's Launch Operations Directorate. NASA discontinued the Test Support Office 7 March 1962 and established the Pacific Launch Operations Office at PMR as an independent field installation.¹⁰ On 1 October 1965 the Pacific Launch Operations Office and the Launch Operations Division of Goddard Space Flight Center at the Western Test Range (formerly Pacific Missile Range) were combined to form the Western Test Range Operations Division of KSC.¹¹

LANGLEY RESEARCH CENTER (LaRC). Construction of NACA's first field station began at Langley Field near Hampton, Virginia, in 1917. In April 1920, President Wilson concurred with NACA's suggestion that the facility be named "Langley Memorial Aeronautical Laboratory" in honor of Dr. Samuel P. Langley (1834–1906).¹ Dr. Langley was the third Secretary of the Smithsonian Institution, "inventor, brilliantly lucid writer and lecturer on science, original investigator in astrophysics and especially of the physics of the sun, pioneer in aerodynamics." He was "all this and more." His persistent investigation of mechanical flight led to successful flights by his steam-powered, heavier-than-air "aerodromes" in 1896; on 6 May his model made two flights, each close to 1 kilometer long, and on 28 November his aerodrome achieved a flight of more than 1.2 kilometers.²

The facility was dedicated 11 July 1920, marking "the real beginning of NACA's own program of aeronautical research, conducted by its own staff in its own facilities."³ It was the only NACA laboratory until 1940. On 1 October 1958 the laboratory, as a NACA facility, became a component of the National Aeronautics and Space Administration and was renamed "Langley Research Center."⁴

The Center conducted basic research in a variety of fields for aeronautical and space flight and had management responsibility for the Lunar Orbiter and Viking projects and the Scout launch vehicles. The supercritical wing, an improved airfoil, was developed at Langley.

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Facilities of Langley Research Center



Samuel P. Langley (courtesy Smithsonian Institution)



Lewis Research Center

LEWIS RESEARCH CENTER (LeRC). Congress authorized a flight-propulsion laboratory for NACA 26 June 1940, and in 1942 the new laboratory began operations adjacent to the Cleveland, Ohio, Municipal Airport.¹ It was known as the “Aircraft Engine Research Laboratory.”² On 28 September 1948 NACA renamed it “Lewis Flight Propulsion Laboratory” in honor of Dr. George W. Lewis (1882–1948). Dr. Lewis not only was a leading aeronautical engineer, whose work in flight research has been termed “epochal contributions to aeronautics,”³ but also made his mark as an administrator, serving as NACA’s Director of Aeronautical Research from 1919 to 1947. He was responsible for the planning and building of the new flight-propulsion laboratory which was later to bear his name.⁴

Upon the formation of the National Aeronautics and Space Administration 1 October 1958, the facility became “Lewis Research Center.”⁵ The Center’s research and development responsibilities concentrated chiefly on advanced propulsion and space power systems. It had management responsibilities for the Agena and Centaur launch vehicle stages.



Dr. George W. Lewis

PLUM BROOK STATION. On Lake Erie near Sandusky, Ohio, Lewis Research Center's Plum Brook Station was a test facility for aerospace propulsion research and development. The site, formerly a U.S. Army Ordnance plant, was acquired from the Army through a gradual process beginning in 1956 and completed in 1963. The name "Plum Brook Station" derived from the Army's name of the former ordnance facility, "Plum Brook Ordnance Works," after a small stream running through the site.⁶ It had a nuclear research reactor and a wide range of propulsion test facilities.

Nuclear propulsion program cutbacks to adjust to NASA budget reductions in 1973 brought a decision to phase down most of the Plum Brook facilities. The Space Power Facility—one of the world's largest space environment simulation chambers, equipped with a solar simulation system, instrumentation, and data-acquisition facilities—was kept in operation for use by other Government agencies. The Air Force, Navy, National Oceanic and Atmospheric Administration, and Energy Research and Development Administration indicated possible interest in using the facilities.

By the end of June 1974, agencies already using the facilities at the station included the Army, Ohio National Guard, and Department of the Interior. Instrumentation for a large experimental wind generator was being installed in the cooperative NASA and National Science Foundation program to study full-scale wind-driven energy devices.⁷



Three-building headquarters complex of Marshall Space Flight Center.

MARSHALL SPACE FLIGHT CENTER (MSFC). In April 1950 the U.S. Army established its team of rocket specialists headed by Dr. Wernher von Braun as the Ordnance Guided Missile Center at Redstone Arsenal, Huntsville, Alabama. This Center was the origin of what eventually became the George C. Marshall Space Flight Center (MSFC). On 1 February 1956 the Army Ballistic Missile Agency (ABMA) was formed at Redstone Arsenal. ABMA was a merger and expansion of existing agencies there; its team of scientists formed the nucleus of the Development Operations Division.¹

NASA came into existence on 1 October 1958. Early in 1960 President Eisenhower submitted a request to Congress for the transfer of ABMA's space missions to NASA, including certain facilities and personnel, chiefly the Development Operations Division. The transfer became effective 14 March 1960 and NASA set up its "Huntsville Facility" in preparation for formal establishment of the field center later that year.² The next day, 15 March, President Eisenhower proclaimed the NASA facility would be called "George C. Marshall Space Flight Center."³ The name honored George C. Marshall, General of the Army, who was Chief of Staff during World War

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II, Secretary of State 1948–1949, and author of the Marshall Plan. General Marshall was the only professional soldier to receive the Nobel Peace Prize, awarded to him in 1954.

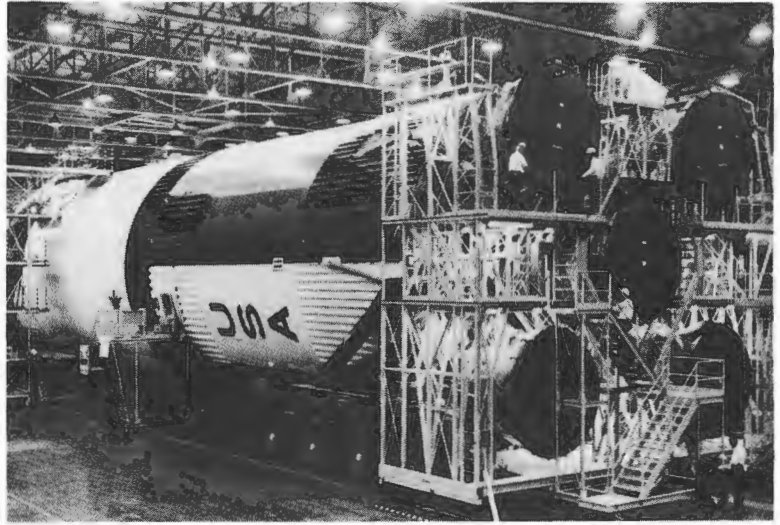
MSFC officially began operation with the formal mass transfer of personnel and facilities from ABMA 1 July 1960.⁴ The Center's primary mission responsibility was development of the Saturn family of launch vehicles, used in the Apollo manned lunar-landing program, in the Skylab experimental space station program, and in the U.S.–U.S.S.R. Apollo-Soyuz Test Project. MSFC also held responsibility for development of the Skylab Orbital Workshop and Apollo Telescope Mount, as well as integration of the Skylab cluster of components. It was responsible for three major elements of the Space Shuttle: the solid-fueled rocket booster, the Space Shuttle main engine, and the external tank.

MICHOUD ASSEMBLY FACILITY. On 7 September 1961 NASA selected the Government-owned, then-unused Michoud Ordnance Plant at Michoud, Louisiana, as the site for industrial production of Saturn launch vehicle stages under the overall direction of Marshall Space Flight Center. NASA called the site "Michoud Operations."⁵ On 1 July 1965 Michoud Operations was redesignated "Michoud Assembly Facility" to "better reflect the mission" of the facility.⁶

Following construction of the first stages of the Saturn IB and Saturn V launch vehicles for Apollo, Skylab, and ASTP missions, Michoud was

Gen. George C. Marshall receives the 1953 Nobel Peace Prize from Norwegian Nobel Prize Committee President Gunnar Jahn at Oslo University, 10 December 1953.





Final touches are added to engines of the first flight Saturn V's S-IC stage, assembled at Michoud Assembly Facility.

selected in 1972 as the site for the manufacture and final assembly of the Space Shuttle's external propellant tanks.

MISSISSIPPI TEST FACILITY (MTF). NASA announced 25 October 1961 it had selected southwestern Mississippi as the site for a large booster (Saturn) test facility under the direction of MSFC. Pending official naming of the site,* NASA encouraged use of "Mississippi Test Facility," which seemed to have been already in informal use. On 18 December 1961 the name "Mississippi Test Operations" was officially adopted, but the site was still widely called "Mississippi Test Facility," particularly by Headquarters and MSFC offices concerned in the installation's development.⁷ On 1 July 1965 MSFC announced the official redesignation, "Mississippi Test Facility."⁸ The change was said to "reflect the mission of the facility" better.**

MTF test stands were put into standby status 9 November 1970, after more than four years and the test-firing of 13 S-IC first stages and 15 S-II second stages of the Saturn V.⁹ With the close of Saturn production and the approaching end of the Apollo program, NASA had established an Earth

*For about a month there was no standardized designation and "Pearl River Test Site" was often used. See NASA, Circular 188.

**Perhaps a more accurate reason would be that this was the name most widely used; the "Mississippi Test Operations" never had stuck.

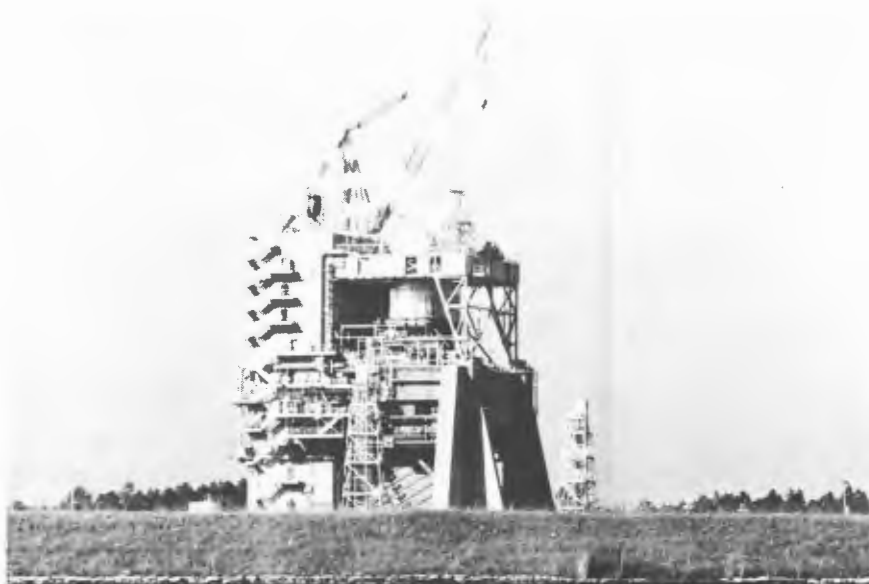
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Resources Laboratory at MTF in September 1970, stressing applications of remote-sensing data from aircraft and satellites. A number of other Government agencies, at NASA invitation, moved research activities related to resources and the environment to MTF to take advantage of its facilities.¹⁰ And on 1 March 1971 NASA announced that MTF had also been selected for sea-level testing of the Space Shuttle's main engine.¹¹

On 14 June 1974 Mississippi Test Facility was renamed "National Space Technology Laboratories" and became a permanent NASA field installation reporting directly to NASA Headquarters, "because of the growing importance of the activities at NSTL . . . and of the agencies taking advantage of NSTL capabilities."¹² (See National Space Technological Laboratories.)

NATIONAL SPACE TECHNOLOGY LABORATORIES (NSTL). Established as an independent NASA field installation 14 June 1974,¹ the National Space Technology Laboratories' varied activities had their beginnings in the Mississippi Test Facility (MTF), formed in 1961 as part of Marshall Space Flight Center to test Saturn launch vehicle stages (see Mississippi Test Facility). The facility at Bay St. Louis in Hancock County, Mississippi, tested the

Test stand A-1 at National Space Technology Laboratories was modified for testing the Space Shuttle main engine.



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Saturn V first and second stages throughout that program, qualifying them for the Apollo and Skylab missions. With the shift of emphasis in the national space program from manned exploration to practical applications after the successful *Apollo 11* landing on the moon 20 July 1969, and as the last lunar exploration missions were made 1970–1972, consideration was given to other uses for the MTF plant. Increasing awareness of the importance of the earth's natural resources and environment in those years—and sharpening focus on energy shortages in 1973—suggested that technical facilities available at MTF might be put to use in meeting some of these problems.

MTF test stands were put on standby as of 9 November 1970.² NASA had already established an Earth Resources Laboratory at the installation in September 1970 and had invited other Government agencies to use facilities on the 570-square-kilometer site for research.³ In 1971 MTF was also selected for development testing of the main engine for NASA's Space Shuttle, designed as a reusable, economical space transportation system for the 1980s.⁴

By June 1974 a number of other agencies had established one or more activities at NSTL: the Department of Commerce, Department of the Interior, Department of Transportation, Department of the Army, the U.S. Environmental Protection Agency, the State of Mississippi, and some other state and university elements from Mississippi and Louisiana. Research and technical activities were primarily related to earth resources and the environment. NASA's Earth Resources Laboratory complemented programs at Goddard Space Flight and Johnson Space Centers and emphasized applications of data gathered by remote sensing from aircraft and satellites.⁵

NASA Administrator James C. Fletcher announced the new name and status of National Space Technology Laboratories 14 June 1974, saying that the success of the experiment in collocating “mutually supporting activities” had led him to decide that “NSTL will have a permanent role in NASA's space applications and technology programs.” NASA would encourage location at NSTL of other Government activities that could use and contribute to the capabilities there.⁶

WALLOPS FLIGHT CENTER (WFC). The National Advisory Committee for Aeronautics (NACA) established a test-launching facility for its Langley Laboratory on Wallops Island, Virginia, 7 May 1945. A unit of Langley, it was named the “Auxiliary Flight Research Station.” On 10 June 1946, the unit became a division of Langley's Research Department and was named “Pilotless Aircraft Research Division (PARDD).” The phrase “pilotless air-

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Aerial view of Wallops Flight Center main base.

craft” was then used by the Navy’s Bureau of Aeronautics and the Army Air Forces to denote all guided missiles. PARD was formally organized 11 August 1946, with four sections; the Wallops facility was placed under PARD’s Operations Section and named “Pilotless Aircraft Research Station.” Its employees called the station simply “Wallops.”¹

When the National Aeronautics and Space Administration absorbed NACA in 1958, NASA continued the name long in popular use, “Wallops Station” (WS). WS first was carried on organization charts as coming under the proposed Space Flight Research Center, but on 1 May 1959 the station became an independent field installation.²

The island—and hence the installation (which in July 1959 acquired additional property on the mainland, known as Wallops Main Base³)—was named for the 17th-century surveyor John Wallop, who began patenting land on Virginia’s eastern shore in the 1660s. In 1672 he received a Crown Patent of the 13-square-kilometer island from King Charles II, and in his will John Wallop referred to “my island formerly called Keeckotank.” (It was also known as Accocomoson or Occocomoson Island.) It has borne the name “Wallops Island” for more than 260 years.⁴

Effective 26 April 1974, Wallops Station was renamed “Wallops Flight Center” as “more descriptive of the mission and operations” of the installa-

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tion. The only rocket flight-test range owned and operated by NASA, Wallops launched Scout boosters and sounding rocket experiments with instrumentation developed by scientists and engineers throughout the United States and the world. By the spring of 1974 more than 8000 launchings had taken place from WFC, including the orbiting of 17 satellites. Work also included advanced aeronautical research and participation in the Chesapeake Bay Ecological Test Program, with remote sensing of the area by aircraft and satellite.⁵

APPENDIX A

SELECTED LIST OF ABBREVIATIONS, ACRONYMS, AND TERMS

This highly selective list includes designations of flight hardware subsystems and components as well as designations of nonflight hardware used in NASA's aeronautics and space research. Many of these terms are components of the projects listed in Parts I–V of the text; others fall outside the project names. Not listed are subsystems of most launch vehicles.

ACS	Attitude control system
AD	Air density satellite (Explorer)
AE	Atmosphere Explorer satellite
AEROSAT	Joint FAA–ESRO Aeronautical Satellite
AIMP	Anchored Interplanetary Monitoring Platform (Explorer)
ALFMED	Apollo light-flash moving-emulsion detection
ALSEP	Apollo lunar surface experiments package
AM	Airlock module (Skylab spacecraft component)
AMPS	Atmospheric, Magnetospheric Plasma-in-Space laboratory (Space Shuttle payload)
AMU	Astronaut maneuvering unit
Anik	Canadian Telesat domestic telecommunications satellite
ANNA	Army-Navy-NASA geodetic satellite
APS	Ascent propulsion system (Apollo LM component); also auxiliary propulsion system
APT	Automatic picture transmission
ASTP	Apollo-Soyuz Test Project
ATDA	Augmented target docking adapter
ATM	Apollo Telescope Mount (Skylab spacecraft component)
AVCS	Advanced vidicon camera system
BBIVA, BBVC	Black Brant IVA, Black Brant VC sounding rockets
BE	Beacon Explorer satellite
BIC	Barium-ion-cloud experiment
BIOCORE	<i>Apollo 17</i> medical experiment (using mice)
BIOS	Biological Investigation of Space (suborbital flight experiment); sometimes also used as short name for Biosatellite
CAS	Cooperative Applications Satellite (CAS–A was <i>Eole</i>)
CEPE	Cylindrical Electrostatic Probe Experiment (orbital experiment attached to Delta second stage)

CM	Command module (Apollo spacecraft)
Cos	ESRO cosmic ray satellite
CRISP	Cosmic Ray Ionization Program
CSM	Command and service module (Apollo spacecraft, combination of CM and SM)
CTS	Communications Technology Satellite
DAD	Dual Air Density Explorer satellite
DFBW	Digital fly-by-wire program
DME	Direct Measurement Explorer satellite
DPS	Descent propulsion system (Apollo LM component)
DSN	Deep Space Network
EASEP	Early Apollo scientific experiments package (<i>Apollo 11</i>)
ECS'	Environmental control system
EGO	Eccentric (orbiting) Geophysical Observatory
EOPAP	Earth and ocean physics applications program
ERAP	Earth resources aircraft program
EREP	Earth resources experiment package (Skylab experiment)
EVA	Extravehicular activity
EXAMETNET	Experimental InterAmerican Meteorological Rocket Network
EXOSAT	ESRO high-energy astronomy satellite, for x-ray astronomy
FIRE	Flight Investigation of the Reentry Environment (reentry heating project)
GATV	Gemini Agena Target Vehicle
GEOS	Geodetic Satellite (Explorer); also its successor, Geodynamic Experimental Ocean Satellite, and ESRO's Geostationary Scientific Satellite
GOES	Geostationary Operational Environmental Satellite
GRS	German Research Satellite (GRS-1 was <i>Azur</i> , GRS-2-A, <i>Aeros</i>)
GTS	Geostationary Technology Satellite
HAPPE	High Altitude Particle Program Experiment
Hawkeye	Scientific satellite (Explorer; follow-on to Injun series)
HCMM	Heat Capacity Mapping Mission Explorer
HET	Health/education telecommunications experiment (on <i>ATS 6</i>)
HL-10	Lifting-body research vehicle
IE	Ionosphere Explorer
IME	Interplanetary meteoroid experiment
IMP	Interplanetary Monitoring Platform (Explorer)
Injun	Scientific satellite (Explorer)
IRLS	Interrogation, recording, and location system
ISEE	International Sun-Earth Explorer
IU	Instrument unit
IUE	International Ultraviolet Explorer
IUS	Interim upper stage for Space Shuttle (called orbit-to-orbit stage, or OOS, by Air Force; interim version of Space Tug)
Kiwi	Ground-test reactor for nuclear propulsion research
LC	Launch complex

ABBREVIATIONS, ACRONYMS

LDEF	Long-Duration Exposure Facility (satellite)
LES	Launch escape system
LEM	Lunar excursion module (renamed LM)
LLRV	Lunar landing research vehicle
LLTV	Lunar landing training vehicle
LM	Lunar module (Apollo lunar-landing spacecraft)
LOI	Lunar orbit insertion
LOR	Lunar orbit rendezvous (Apollo lunar-landing mode)
LRV	Lunar roving vehicle (Rover)
LST	Large Space Telescope (satellite)
Luster, Project	Sounding Rocket experiment to capture interplanetary particles
M2-F2	Lifting-body research vehicle
MAROTS	ESRO Maritime Orbital Test Satellite
MCC	Midcourse correction; also Mission Control Center
MDA	Multiple docking adapter (Skylab spacecraft component)
MDS	Meteoroid Detection Satellite (Explorer)
MESA	Modularized equipment stowage assembly (Apollo LM component)
METEOSAT	ESRO geostationary meteorological satellite
MET; METS	Mobile equipment transporter; modularized equipment transport system (for Apollo lunar landing missions)
MSFN	Manned Space Flight Network
MTS	Meteoroid Technology Satellite
NERV	Nuclear Emulsion Recovery Vehicle (high-altitude radiation experiment)
NERVA	Nuclear engine for rocket vehicle application
NOAA	National Oceanic and Atmospheric Administration meteorological satellite (successor to ESSA satellites)
NOMSS	National Operational Meteorological Satellite System
OOS	Orbit-to-orbit stage (see IUS)
OSCAR	Orbiting Satellite Carrying Amateur Radio
OTS	ESRO Orbital Test Satellite
OWL	Rice University scientific satellite (Explorer)
OWS	Orbital Workshop (Skylab space station)
PAET	Planetary Atmosphere Experiment Test (suborbital flight experiment)
Phoebus	Ground-test reactor for nuclear propulsion
PLACE	Position location and communications experiment (on <i>ATS 6</i>)
PLSS	Portable life support system
POGO	Polar Orbiting Geophysical Observatory
Prometheus	Sounding rocket for lightning research
PS	Payload shroud
QUESTOL	Quiet, experimental, short takeoff and landing aircraft
RAE	Radio Astronomy Explorer
RAM	Research and Applications Module (Spacelab forerunner)
RAM, Project	Radio attenuation measurement (reentry communications blackout research)
RAM C-I, etc.	Suborbital spacecraft in Project RAM

RBV	Return-beam-vidicon camera
RCS	Reaction control system
RM	Radiation/Meteoroid satellite
RMU	Remote maneuvering unit
Rover, Project	NASA-AEC research and development program of nuclear reactor propulsion for rockets
RPRV	Remotely piloted research vehicle
RTG	Radioisotope thermoelectric generator (spacecraft power system)
S-I	Saturn I booster first stage
S-IB	Saturn IB booster first stage
S-IC	Saturn V booster first stage
S-II	Saturn V second stage
S-IV	Saturn I second stage
S-IVB	Saturn IB second stage; Saturn V third stage
SAS	Small Astronomy Satellite (Explorer); also solar array system (Skylab Orbital Workshop component)
Scanner, Project	Horizon definition experiment (sounding rocket)
Scramjet	Supersonic combustion ramjet engine
SCS	Stabilization and control system
SE	Solar Explorer satellite
SERT	Space Electric Rocket Test (SERT 1 was suborbital; SERT 2 was orbited)
SEVA	Surface extravehicular activity (lunar exploration); also standup extravehicular activity
SHAPE	Supersonic High Altitude Parachute Experiment
SIM	Scientific instrument module (Apollo SM component)
SITE	Satellite instructional television experiment (on <i>ATS 6</i>)
SLA	Spacecraft-lunar module adapter; also spacecraft launch vehicle adapter
SM	Service module (Apollo spacecraft component)
SNAP	Systems for nuclear auxiliary power (nuclear-electric spacecraft power supply)
SPAN	Solar Particle Alert Network
SPANDAR	Space and range radar
SPED	Supersonic Planetary Entry Decelerator (suborbital flight test)
SPS	Service propulsion system (Apollo SM component)
SRB	Solid (fueled) rocket booster (for Space Shuttle)
SRM	Solid (fueled) rocket motor
SSME	Space Shuttle main engine
SSS	Small Scientific Satellite (Explorer)
SST	Supersonic transport aircraft
STA	Shuttle training aircraft
STADAN	Space Tracking and Data Acquisition Network (see also STDN)
STDN	Spacecraft Tracking and Data Network (formerly STADAN)
STOL	Short takeoff and landing aircraft
STS	Space transportation system
TETR	Test and Training Satellite (MSFN training satellite; see also TTS)
TLI	Translunar injection (insertion into trajectory for the moon)
TOPS	Thermoelectric outer planets spacecraft

ABBREVIATIONS, ACRONYMS

Topsi	Topside sounder satellite
TTS	Test and Training Satellite (MSFN training satellite; see also TETR)
V/STOL	Vertical or short takeoff and landing aircraft
VTOL	Vertical takeoff and landing aircraft
X-15	High-altitude, high-speed, experimental rocket research aircraft
X-24	Lifting-body research vehicle
XB-70	Experimental supersonic aircraft

APPENDIX B

INTERNATIONAL DESIGNATION OF SPACECRAFT

COPY OF THE TEXT OF A NEWS RELEASE ISSUED 31 DECEMBER 1962
BY THE NATIONAL ACADEMY OF SCIENCES-NATIONAL RESEARCH COUNCIL

Beginning on January 1, the international system for designating satellites and space probes for scientific purposes will be changed; as of the new year, Arabic numerals will supplant Greek letters in the satellite designation system.

Prior to January 1, satellites were named in the order of the letters of the Greek alphabet, beginning anew each year: the first satellite launched (Sputnik I) was 1957 Alpha, the first 1958 satellite (Explorer I) was 1958 Alpha, the second (Vanguard I) was 1958 Beta, and so on. The first satellite or space probe in 1963 will be 1963-1, the second will be 1963-2, etc. The numbering will also begin anew each year; for example, the fifth space vehicle of 1964 will be 1964-5.

Usually the launching of a satellite places more than one object in orbit. Sometimes two or more satellites are carried into space where they are separated and ejected into separate orbits. Moreover, the burned-out rocket casing also goes into orbit. The new system provides that the suffix A will identify the main satellite or space probe (i.e., the one carrying the principal scientific payload), and that B, C, etc., as needed, will be used first for any subsidiary scientific payloads in separate orbits, and then for inert components. Thus, under the old system the navigation satellite, Transit II-A, its piggyback companion, Greb, and the spent rocket which injected them into orbit, were called 1960 Eta 1, 1960 Eta 2, and 1960 Eta 3, respectively. If the new scheme had been in effect, they would have been called 1960-7A, 1960-7B, and 1960-7C, respectively.

The new system was agreed upon by all national members of the Committee on Space Research (including both satellite-launching nations) at its meeting in Washington, May 1962. The Committee on Space Research (COSPAR) was established by the International Council of Scientific Unions to facilitate international cooperation in space research. U.S. membership in COSPAR is effectuated through the National Academy of Sciences.

In the United States, the new system will be adopted by the National Aeronautics and Space Administration and the Department of Defense. It will also be used in registering U.S. satellites and space probes with the United Nations.

APPENDIX C

NASA MAJOR LAUNCH RECORD, 1958–1974

This list is a compilation of launches by NASA of (1) payloads that went into orbit or that achieved an altitude of at least 6400 kilometers and (2) major suborbital flight tests or experiments. Included are U.S. launches conducted by the Army Ballistic Missile Agency (ABMA) and the Naval Research Laboratory (NRL) before the establishment of NASA, 1 October 1958. Not listed are launch failures or sounding rocket launches.

Name	International Designation*	Launch Date**	Launch Vehicle***
<i>Explorer 1</i> (ABMA)	1958 Alpha 1	31 January 1958	Juno I
<i>Vanguard 1</i> (NRL)	1958 Beta 2	17 March 1958	Vanguard
<i>Explorer 3</i> (ABMA)	1958 Gamma 1	26 March 1958	Juno I
<i>Explorer 4</i> (ABMA)	1958 Epsilon 1	26 July 1958	Juno I
<i>Pioneer 1</i>	1958 Eta 1	11 October 1958	Thor-Able I
<i>Pioneer 3</i>	1958 Theta 1	6 December 1958	Juno II
<i>Vanguard 2</i>	1959 Alpha 1	17 February 1959	Vanguard
<i>Pioneer 4</i>	1959 Nu 1	3 March 1959	Juno II

*For simplicity, manned Apollo flights are represented in this list by single designations (lunar orbital and landing missions have separate letter designations in the international system for lunar module and S-IVB stage). Suborbital flights are not assigned international designations.

**Date given is determined by local time at the launch site.

***Thor-Delta launch vehicle configurations are abbreviated as follows: Thor-Delta (Thor-Delta, Thor-improved Delta), TAT-Delta (thrust-augmented Thor-Delta), TAID (thrust-augmented Thor-improved Delta), LTTAT-Delta (long-tank, thrust-augmented Thor-improved Delta), TAT-Agena (thrust-augmented Thor-Agena).

APPENDIX C

Name	International Designation*	Launch Date**	Launch Vehicle***
<i>Explorer 6</i>	1959 Delta 1	7 August 1959	Thor-Able III
Big Joe	(suborbital)	9 September 1959	Atlas
<i>Vanguard 3</i>	1959 Eta 1	18 September 1959	Vanguard
Little Joe 1	(suborbital)	4 October 1959	Little Joe
<i>Explorer 7</i>	1959 Iota 1	13 October 1959	Juno II
Shotput 1	(suborbital)	28 October 1959	Shotput
Little Joe 2	(suborbital)	4 November 1959	Little Joe
Little Joe 3	(suborbital)	4 December 1959	Little Joe
Shotput 2	(suborbital)	16 January 1960	Shotput
Little Joe 4	(suborbital)	21 January 1960	Little Joe
Shotput 3	(suborbital)	27 February 1960	Shotput
<i>Pioneer 5</i>	1960 Alpha 1	11 March 1960	Thor-Able IV
Shotput 4	(suborbital)	1 April 1960	Shotput
<i>Tiros 1</i>	1960 Beta 2	1 April 1960	Thor-Able
Shotput 5	(suborbital)	31 May 1960	Shotput
<i>Echo 1</i>	1960 Iota 1	12 August 1960	Thor-Delta
<i>Scout 2</i>	(suborbital)	4 October 1960	Scout
<i>Explorer 8</i>	1960 Xi 1	3 November 1960	Juno II
Little Joe 5	(suborbital)	8 November 1960	Little Joe
<i>Tiros 2</i>	1960 Pi 1	23 November 1960	Thor-Delta
Mercury-Redstone 1A	(suborbital)	19 December 1960	Redstone
Mercury-Redstone 2	(suborbital)	31 January 1961	Redstone
<i>Explorer 9</i>	1961 Delta 1	16 February 1961	Scout
Mercury-Atlas 2	(suborbital)	21 February 1961	Atlas
Little Joe 5A	(suborbital)	18 March 1961	Little Joe
Mercury-Redstone BD	(suborbital)	24 March 1961	Redstone
<i>Explorer 10</i>	1961 Kappa 1	25 March 1961	Thor-Delta
<i>Explorer 11</i>	1961 Nu 1	27 April 1961	Juno II
Little Joe 5B	(suborbital)	28 April 1961	Little Joe

NASA MAJOR LAUNCH RECORD

<u>Name</u>	<u>International Designation*</u>	<u>Launch Date**</u>	<u>Launch Vehicle***</u>
<i>Freedom 7</i> (Mercury-Redstone 3)	(suborbital)	5 May 1961	Redstone
<i>Tiros 3</i>	1961 Rho 1	12 July 1961	Thor-Delta
<i>Liberty Bell 7</i> (Mercury-Redstone 4)	(suborbital)	21 July 1961	Redstone
<i>Explorer 12</i>	1961 Upsilon 1	15 August 1961	Thor-Delta
<i>Ranger 1</i>	1961 Phi 1	23 August 1961	Atlas-Agena B
<i>Explorer 13</i>	1961 Chi 1	25 August 1961	Scout
<i>Mercury-Atlas 4</i>	1961 Alpha Alpha 1	13 September 1961	Atlas D
Probe A (P-21)	(suborbital)	19 October 1961	Scout
Saturn-Apollo 1 (SA-1)	(suborbital)	27 October 1961	Saturn I
<i>Ranger 2</i>	1961 Alpha Theta 1	18 November 1961	Atlas-Agena B
<i>Mercury-Atlas 5</i>	1961 Alpha Iota 1	29 November 1961	Atlas D
Echo (AVT-1)	(suborbital)	15 January 1962	Thor
<i>Ranger 3</i>	1962 Alpha 1	26 January 1962	Atlas-Agena B
<i>Tiros 4</i>	1962 Beta 1	8 February 1962	Thor-Delta
<i>Friendship 7</i> (Mercury-Atlas 6)	1962 Gamma 7	20 February 1962	Mercury-Atlas D
Reentry 1	(suborbital)	1 March 1962	Scout
<i>OSO 1</i>	1962 Zeta 1	7 March 1962	Thor-Delta
Probe B (P-21A)	(suborbital)	29 March 1962	Scout
<i>Ranger 4</i>	1962 Mu 1	23 April 1962	Atlas-Agena B
Saturn-Apollo 2 (SA-2)	(suborbital)	25 April 1962	Saturn I
<i>Ariel 1</i>	1962 Omicron 1	26 April 1962	Thor-Delta
<i>Aurora 7</i> (Mercury-Atlas 7)	1962 Tau 1	24 May 1962	Atlas D
<i>Tiros 5</i>	1962 Alpha Alpha	19 June 1962	Thor-Delta
<i>Telstar 1</i>	1962 Alpha Epsilon 1	10 July 1962	Thor-Delta

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Name	International Designation*	Launch Date**	Launch Vehicle***
Echo (AVT-2)	(suborbital)	18 July 1962	Thor
<i>Mariner 2</i>	1962 Alpha Rho 1	27 August 1962	Atlas-Agena B
<i>Tiros 6</i>	1962 Alpha Psi 1	18 September 1962	Thor-Delta
<i>Alouette 1</i>	1962 Beta Alpha 1	28 September 1962	Thor-Agena B
<i>Explorer 14</i>	1962 Beta Gamma 1	2 October 1962	Thor-Delta
<i>Sigma 7</i> (Mercury-Atlas 8)	1962 Beta Delta 1	3 October 1962	Atlas D
<i>Ranger 5</i>	1962 Beta Eta 1	18 October 1962	Atlas-Agena B
<i>Explorer 15</i>	1962 Beta Lambda 1	27 October 1962	Thor-Delta
Saturn-Apollo 3 (SA-3)	(suborbital)	16 November 1962	Saturn I
<i>Relay 1</i>	1962 Beta Upsilon 1	13 December 1962	Thor-Delta
<i>Explorer 16</i>	1962 Beta Chi 1	16 December 1962	Scout
<i>Syncom 1</i>	1963-4A	14 February 1963	Thor-Delta
Saturn-Apollo 4 (SA-4)	(suborbital)	28 March 1963	Saturn I
<i>Explorer 17</i>	1963-9A	2 April 1963	Thor-Delta
<i>Telstar 2</i>	1963-13A	7 May 1963	Thor-Delta
<i>Faith 7</i> (Mercury-Atlas 9)	1963-15A	15 May 1963	Atlas D
<i>Tiros 7</i>	1963-24A	19 June 1963	Thor-Delta
<i>Syncom 2</i>	1963-31A	26 July 1963	Thor-Delta
Little Joe II	(suborbital)	28 August 1963	Little Joe II
<i>Explorer 18</i>	1963-46A	26 November 1963	Thor-Delta
<i>Atlas-Centaur 2</i>	1963-47A	27 November 1963	Atlas-Centaur
<i>Explorer 19</i>	1963-53A	19 December 1963	Scout
<i>Tiros 8</i>	1963-54A	21 December 1963	Thor-Delta
<i>Relay 2</i>	1964-3A	21 January 1964	Thor-Delta
<i>Echo 2</i>	1964-4A	25 January 1964	Thor-Agena B
Saturn-Apollo 5 (SA-5)	1964-5A	29 January 1964	Saturn I

MAJOR NASA LAUNCH RECORD

Name	International Designation*	Launch Date**	Launch Vehicle***
<i>Ranger 6</i>	1964-7A	30 January 1964	Atlas-Agena B
<i>Ariel 2</i>	1964-15A	27 March 1964	Scout
<i>Gemini-Titan 1</i>	1964-18A	8 April 1964	Gemini-Titan II
FIRE 1	(suborbital)	14 April 1964	Atlas D
Apollo (A-001) Transonic Abort	(suborbital)	13 May 1964	Little Joe II
<i>Apollo-Saturn 101</i> (SA-6)	1964-25A	28 May 1964	Saturn I
Atlas-Centaur 3	(suborbital)	30 June 1964	Atlas-Centaur
SERT 1	(suborbital)	20 July 1964	Scout
<i>Ranger 7</i>	1964-41A	28 July 1964	Atlas-Agena B
Reentry 4	(suborbital)	18 August 1964	Scout
<i>Syncom 3</i>	1964-47A	19 August 1964	TAT-Delta
<i>Explorer 20</i>	1964-51A	25 August 1964	Scout
<i>Nimbus 1</i>	1964-52A	28 August 1964	Thor-Agena B
<i>OGO 1</i>	1964-54A	4 September 1964	Atlas-Agena B
<i>Apollo-Saturn 102</i> (SA-7)	1964-57A	18 September 1964	Saturn I
<i>Explorer 21</i>	1964-60A	4 October 1964	Thor-Delta
<i>Explorer 22</i>	1964-64A	9 October 1964	Scout
<i>Mariner 3</i>	1964-73A	5 November 1964	Atlas-Agena D
<i>Explorer 23</i>	1964-74A	6 November 1964	Scout
<i>Explorer 24</i> and <i>Explorer 25</i> (Injun 4)	1964-76A 1964-76B	21 November 1964	Scout
<i>Mariner 4</i>	1964-77A	28 November 1964	Atlas-Agena D
Apollo Maximum Q Abort	(suborbital)	8 December 1964	Little Joe II
<i>Atlas-Centaur 4</i>	1964-82A	11 December 1964	Atlas-Centaur
<i>San Marco 1</i>	1964-84A	15 December 1964	Scout
<i>Explorer 26</i>	1964-86A	21 December 1964	Thor-Delta

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Name	International Designation*	Launch Date**	Launch Vehicle***
Gemini-Titan 2	(suborbital)	19 January 1965	Titan II
<i>Tiros 9</i>	1965-4A	22 January 1965	Thor-Delta
<i>OSO 2</i>	1965-7A	3 February 1965	Thor-Delta
<i>Pegasus 1</i>	1965-9A	16 February 1965	Saturn I
and <i>Apollo-Saturn 103</i> (SA-9)	1965-9B		
<i>Ranger 8</i>	1965-10A	17 February 1965	Atlas-Agena B
<i>Ranger 9</i>	1965-23A	21 March 1965	Atlas-Agena B
<i>Gemini 3</i> (Gemini-Titan 3)	1965-24A	23 March 1965	Titan II
<i>Early Bird 1</i>	1965-28A	6 April 1965	TAT-Delta
<i>Explorer 27</i>	1965-32A	29 April 1965	Scout
<i>FIRE 2</i>	(suborbital)	22 May 1965	Atlas D
<i>Pegasus 2</i>	1965-39A	25 May 1965	Saturn I
and <i>Apollo-Saturn 104</i> (SA-8)	1965-39B		
<i>Explorer 28</i>	1965-42A	29 May 1965	Thor-Delta
<i>Gemini 4</i> (Gemini-Titan 4)	1965-43A	3 June 1965	Titan II
<i>Tiros 10</i>	1965-51A	2 July 1965	TAT-Delta
<i>Pegasus 3</i>	1965-60A	30 July 1965	Saturn I
and <i>Apollo-Saturn 105</i> (SA-10)	1965-60B		
<i>Scout</i> (SEV-A)	1965-63A	10 August 1965	Scout
<i>Centaur-Surveyor</i> (Atlas-Centaur 6)	1965-64A	11 August 1965	Atlas-Centaur
<i>Gemini 5</i> (Gemini-Titan 5)	1965-68A	21 August 1965	Titan II
<i>OGO 2</i>	1965-81A	14 October 1965	TAT-Agena D
<i>Explorer 29</i> (<i>GEOS 1</i>)	1965-89A	6 November 1965	TAID

NASA MAJOR LAUNCH RECORD

Name	International Designation*	Launch Date**	Launch Vehicle***
<i>Explorer 30</i>	1965-93A	18 November 1965	Scout
<i>Alouette 2</i> and <i>Explorer 31</i>	1965-98A 1965-98B	28 November 1965	Thor-Agena B
<i>Gemini 7</i> (Gemini-Titan 7)	1965-100A	4 December 1965	Titan II
<i>FR-1</i>	1965-101A	6 December 1965	Scout
<i>Gemini 6</i> (Gemini-Titan 6)	1965-104A	15 December 1965	Titan II
<i>Pioneer 6</i>	1965-105A	16 December 1965	TAID
Apollo (A-004) Intermediate Altitude Abort	(suborbital)	20 January 1966	Little Joe II
<i>ESSA 1</i>	1966-8A	3 February 1966	Thor-Delta
Reentry 5	(suborbital)	9 February 1966	Scout
Apollo-Saturn 201	(suborbital)	26 February 1966	Saturn IB
<i>ESSA 2</i>	1966-16A	28 February 1966	TAID
<i>Gemini-Agena</i> <i>Target Vehicle 8</i>	1966-19A	16 March 1966	Atlas-Agena D
<i>Gemini 8</i> (Gemini-Titan 8)	1966-20A	16 March 1966	Titan II
<i>Centaur-Surveyor</i> (Atlas-Centaur 8)	1966-30A	7 April 1966	Atlas-Centaur
<i>OA O 1</i>	1966-31A	8 April 1966	Atlas-Agena D
<i>Nimbus 2</i>	1966-40A	15 May 1966	TAT-Agena B
<i>Explorer 32</i>	1966-44A	25 May 1966	Thor-Delta
<i>Surveyor 1</i>	1966-45A	30 May 1966	Atlas-Centaur
<i>Augmented Target</i> <i>Docking Adapter</i>	1966-46A	1 June 1966	Atlas D
<i>Gemini 9</i> (Gemini-Titan 9)	1966-47A	3 June 1966	Titan II
<i>OGO 3</i>	1966-49A	6 June 1966	Atlas-Agena B
<i>PAGEOS 1</i>	1966-56A	23 June 1966	TAT-Agena D
<i>Explorer 33</i>	1966-58A	1 July 1966	TAID

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Name	International Designation*	Launch Date**	Launch Vehicle***
<i>Apollo-Saturn 203</i>	1966-59A	5 July 1966	Saturn IB
<i>Gemini-Agena Target Vehicle 10</i>	1966-65A	18 July 1966	Atlas-Agena D
<i>Gemini 10 (Gemini-Titan 10)</i>	1966-66A	18 July 1966	Titan II
<i>Lunar Orbiter 1</i>	1966-73A	10 August 1966	Atlas-Agena D
<i>Pioneer 7</i>	1966-75A	17 August 1966	TAID
<i>Apollo-Saturn 202</i>	(suborbital)	25 August 1966	Saturn IB
<i>Gemini-Agena Target Vehicle 11</i>	1966-80A	12 September 1966	Atlas-Agena D
<i>Gemini 11 (Gemini-Titan 11)</i>	1966-81A	12 September 1966	Titan II
<i>Surveyor 2</i>	1966-84A	20 September 1966	Atlas-Centaur
<i>ESSA 3</i>	1966-87A	2 October 1966	TAID
<i>Centaur-Surveyor (Atlas-Centaur 9)</i>	1966-95A	25 October 1966	Atlas-Centaur
<i>Intelsat-II F-1 (Intelsat II-A)</i>	1966-96A	27 October 1966	TAID
<i>Lunar Orbiter 2</i>	1966-100A	6 November 1966	Atlas-Agena D
<i>Gemini-Agena Target Vehicle 12</i>	1966-103A	11 November 1966	Atlas-Agena D
<i>Gemini 12 (Gemini-Titan 12)</i>	1966-104A	11 November 1966	Titan II
<i>ATS 1</i>	1966-110A	6 December 1966	Atlas-Agena D
<i>Biosatellite 1</i>	1966-114A	14 December 1966	TAID
<i>Intelsat-II F-2</i>	1967-1A	11 January 1967	TAID
<i>ESSA 4</i>	1967-6A	26 January 1967	TAID
<i>Lunar Orbiter 3</i>	1967-8A	4 February 1967	Atlas-Agena D
<i>OSO 3</i>	1967-20A	8 March 1967	Thor-Delta
<i>Intelsat-II F-3</i>	1967-26A	22 March 1967	TAID
<i>ATS 2</i>	1967-31A	5 April 1967	Atlas-Agena D
<i>Surveyor 3</i>	1967-35A	17 April 1967	Atlas-Centaur

NASA MAJOR LAUNCH RECORD

<u>Name</u>	<u>International Designation*</u>	<u>Launch Date**</u>	<u>Launch Vehicle***</u>
<i>ESSA 5</i>	1967-36A	20 April 1967	TAID
<i>San Marco 2</i>	1967-38A	26 April 1967	Scout
<i>Lunar Orbiter 4</i>	1967-41A	4 May 1967	Atlas-Agena D
<i>Ariel 3</i>	1967-42A	5 May 1967	Scout
<i>Explorer 34</i>	1967-51A	24 May 1967	TAID
<i>Mariner 5</i>	1967-60A	14 June 1967	Atlas-Agena D
<i>Surveyor 4</i>	1967-68A	14 July 1967	Atlas-Centaur
<i>Explorer 35</i>	1967-70A	19 July 1967	TAID
<i>OGO 4</i>	1967-73A	28 July 1967	TAT-Agena D
<i>Lunar Orbiter 5</i>	1967-75A	1 August 1967	Atlas-Agena D
<i>Biosatellite 2</i>	1967-83A	7 September 1967	TAID
<i>Surveyor 5</i>	1967-84A	8 September 1967	Atlas-Centaur
<i>Intelsat-II F-4</i>	1967-94A	27 September 1967	TAID
<i>OSO 4</i>	1967-100A	18 October 1967	Thor-Delta
RAM C-1	(suborbital)	19 October 1967	Scout
<i>ATS 3</i>	1967-111A	5 November 1967	Atlas-Agena D
<i>Surveyor 6</i>	1967-112A	7 November 1967	Atlas-Centaur
<i>Apollo 4</i> (Apollo-Saturn 501)	1967-113A	9 November 1967	Saturn V
<i>ESSA 6</i>	1967-114A	10 November 1967	TAID
<i>Pioneer 8</i> and <i>TTS 1</i>	1967-123A	13 December 1967	TAID
<i>Surveyor 7</i>	1968-1A	7 January 1968	Atlas-Centaur
<i>Explorer 36</i> (<i>GEOS 2</i>)	1968-2A	11 January 1968	TAID
<i>Apollo 5</i> (Apollo-Saturn 204)	1968-7A	22 January 1968	Saturn IB
<i>OGO 5</i>	1968-14A	4 March 1968	Atlas-Agena D
<i>Explorer 37</i>	1968-17A	5 March 1968	Scout
<i>Apollo 6</i> (Apollo-Saturn 502)	1968-25A	4 April 1968	Saturn V

APPENDIX C

Name	International Designation*	Launch Date**	Launch Vehicle***
Reentry 6	(suborbital)	27 April 1968	Scout
<i>IRIS 1</i>	1968-41A	16 May 1968	Scout
<i>Explorer 38</i>	1968-55A	4 July 1968	TAID
<i>Explorer 39</i> and <i>Explorer 40</i> (<i>Injun 5</i>)	1968-66A 1968-66B	8 August 1968	Scout
<i>ATS 4</i>	1968-68A	10 August 1968	Atlas-Centaur
<i>ESSA 7</i>	1968-69A	16 August 1968	LTTAT-Delta
RAM C-2	(suborbital)	22 August 1968	Scout
<i>Aurorae</i>	1968-84A	3 October 1968	Scout
<i>Apollo 7</i> (Apollo-Saturn 205)	1968-89A	11 October 1968	Saturn IB
<i>Pioneer 9</i> and <i>TETR 2</i>	1968-100A 1968-100B	8 November 1968	TAID
<i>HEOS 1</i>	1968-109A	5 December 1968	TAID
<i>OAO 2</i>	1968-110A	7 December 1968	Atlas-Centaur
<i>ESSA 8</i>	1968-114A	15 December 1968	LTTAT-Delta
<i>Intelsat-III F-2</i>	1968-116A	18 December 1968	LTTAT-Delta
<i>Apollo 8</i> (Apollo-Saturn 503)	1968-118A	21 December 1968	Saturn V
<i>OSO 5</i>	1969-6A	22 January 1969	Thor-Delta
<i>ISIS 1</i>	1969-9A	30 January 1969	TAID
<i>Intelsat-III F-3</i>	1969-11A	5 February 1969	LTTAT-Delta
<i>Mariner 6</i>	1969-14A	24 February 1969	Atlas-Centaur
<i>ESSA 9</i>	1969-16A	26 February 1969	TAID
<i>Apollo 9</i> (Apollo-Saturn 504)	1969-18A	3 March 1969	Saturn V
<i>Mariner 7</i>	1969-30A	27 March 1969	Atlas-Centaur
<i>Nimbus 3</i>	1969-37A	14 April 1969	LTTAT-Agena D

NASA MAJOR LAUNCH RECORD

Name	International Designation*	Launch Date**	Launch Vehicle***
<i>Apollo 10</i> (Apollo-Saturn 505)	1969-43A	18 May 1969	Saturn V
<i>Intelsat-III F-4</i>	1969-45A	21 May 1969	LTTAT-Delta
<i>OGO 6</i>	1969-51A	5 June 1969	LTTAT-Agena D
<i>Explorer 41</i>	1969-53A	21 June 1969	TAID
<i>Biosatellite 3</i>	1969-56A	28 June 1969	LTTAT-Delta
<i>Apollo 11</i> (Apollo-Saturn 506)	1969-59A	16 July 1969	Saturn V
<i>Intelsat-III F-5</i>	1969-64A	25 July 1969	LTTAT-Delta
<i>OSO 6</i> and <i>PAC</i>	1969-68A 1969-68B	9 August 1969	LTTAT-Delta
<i>ATS 5</i>	1969-69A	12 August 1969	Atlas-Centaur
<i>Boreas</i>	1969-83A	1 October 1969	Scout
<i>Azur</i>	1969-97A	7 November 1969	Scout
<i>Apollo 12</i> (Apollo-Saturn 507)	1969-99A	14 November 1969	Saturn V
<i>Skynet A</i>	1969-101A	21 November 1969	LTTAT-Delta
<i>Intelsat-III F-6</i>	1970-3A	14 January 1970	LTTAT-Delta
<i>ITOS 1</i> and	1970-8A	23 January 1970	LTTAT-Delta
<i>OSCAR 5</i>	1970-8B		
<i>SERT 2</i>	1970-9A	3 February 1970	LTTAT-Agena D
<i>NATOSAT 1</i>	1970-21A	20 March 1970	LTTAT-Delta
<i>Nimbus 4</i>	1970-25A	8 April 1970	LTTAT-Agena D
<i>Apollo 13</i> (Apollo-Saturn 508)	1970-29A	11 April 1970	Saturn V
<i>Intelsat-III F-7</i>	1970-32A	22 April 1970	LTTAT-Delta
<i>Intelsat-III F-8</i>	1970-55A	23 July 1970	LTTAT-Delta
<i>Skynet B</i>	1970-62A	19 August 1970	LTTAT-Delta
RAM C-3 (suborbital)		30 September 1970	Scout

APPENDIX C

Name	International Designation*	Launch Date**	Launch Vehicle***
<i>OFO</i>	1970-94A	9 November 1970	Scout
and <i>RM</i>	1970-94B		
<i>NOAA 1</i>	1970-106A	11 December 1970	LTTAT-Delta
and <i>CEPE</i>	1970-106B		
<i>Explorer 42</i>	1970-107A	12 December 1970	Scout
<i>Intelsat-IV F-2</i>	1971-6A	25 January 1971	Atlas-Centaur
<i>Apollo 14</i> (Apollo-Saturn 509)	1971-8A	31 January 1971	Saturn V
<i>NATOSAT 2</i>	1971-9A	2 February 1971	LTTAT-Delta
<i>Explorer 43</i>	1971-19A	13 March 1971	TAID
<i>ISIS 2</i>	1971-24A	31 March 1971	TAID
<i>San Marco 3</i>	1971-36A	24 April 1971	Scout
<i>Mariner 9</i>	1971-51A	30 May 1971	Atlas-Centaur
PAET	(suborbital)	20 June 1971	Scout
<i>Explorer 44</i>	1971-58A	8 July 1971	Scout
<i>Apollo 15</i> (Apollo-Saturn 510)	1971-63A	26 July 1971	Saturn V
<i>Eole</i>	1971-71A	16 August 1971	Scout
<i>OSO 7</i>	1971-83A	29 September 1971	LTTAT-Delta
and <i>TETR 3</i>	1971-83B		
<i>Explorer 45</i>	1971-96A	15 November 1971	Scout
<i>Ariel 4</i>	1971-109A	11 December 1971	Scout
<i>Intelsat-IV F-3</i>	1971-116A	19 December 1971	Atlas-Centaur
<i>Intelsat-IV F-4</i>	1972-3A	22 January 1972	Atlas-Centaur
<i>HEOS 2</i>	1972-5A	31 January 1972	LTTAT-Delta
<i>Pioneer 10</i>	1972-12A	2 March 1972	Atlas-Centaur- TE-M-364-4
<i>TD-1A</i>	1972-14A	11 March 1972	LTTAT-Delta
<i>Apollo 16</i> (Apollo-Saturn 511)	1972-31A	16 April 1972	Saturn V

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Name	International Designation*	Launch Date**	Launch Vehicle***
<i>Intelsat-IV F-5</i>	1972-41A	13 June 1972	Atlas-Centaur
<i>ERTS 1</i>	1972-58A	23 July 1972	LTTAT-Delta
<i>Explorer 46</i>	1972-61A	13 August 1972	Scout
<i>OAO 3</i>	1972-65A	21 August 1972	Atlas-Centaur
<i>Triad OI-1X</i>	1972-69A	2 September 1972	Scout
<i>Explorer 47</i>	1972-73A	22 September 1972	LTTAT-Delta
<i>NOAA 2</i>	1972-82A	15 October 1972	LTTAT-Delta
and <i>OSCAR 6</i>	1972-82B		
<i>Anik 1</i>	1972-90A	9 November 1972	LTTAT-Delta
<i>Explorer 48</i>	1972-91A	16 November 1972	Scout
<i>ESRO 4</i>	1972-92A	21 November 1972	Scout
<i>Apollo 17</i> (AS-512)	1972-96A	7 December 1972	Saturn V
<i>Nimbus 5</i>	1972-97A	10 December 1972	LTTAT-Delta
<i>Aeros</i>	1972-100A	16 December 1972	Scout
<i>Pioneer 11</i>	1973-19A	5 April 1973	Atlas-Centaur- TE-M-364-4
<i>Anik 2</i>	1973-23A	20 April 1973	LTTAT-Delta
<i>Skylab 1</i>	1973-27A	14 May 1973	Saturn V
<i>Skylab 2</i>	1973-32A	25 May 1973	Saturn IB
<i>Explorer 49</i>	1973-39A	10 June 1973	LTTAT-Delta
<i>Skylab 3</i>	1973-50A	28 July 1973	Saturn IB
<i>Intelsat-IV F-7</i>	1973-58A	23 August 1973	Atlas-Centaur
<i>Explorer 50</i>	1973-78A	25 October 1973	LTTAT-Delta
<i>NNSS O-20</i>	1973-81A	29 October 1973	Scout
<i>Mariner 10</i>	1973-85A	3 November 1973	Atlas-Centaur
<i>NOAA 3</i>	1973-86A	6 November 1973	LTTAT-Delta
<i>Skylab 4</i>	1973-90A	16 November 1973	Saturn IB
<i>Explorer 51</i>	1973-101A	15 December 1973	LTTAT-Delta
<i>Skynet IIA</i>	1974-2A	18 January 1974	LTTAT-Delta

APPENDIX C

Name	International Designation*	Launch Date**	Launch Vehicle***
<i>San Marco 4</i>	1974-9A	18 February 1974	Scout
<i>Miranda (UK-X4)</i>	1974-13A	8 March 1974	Scout
<i>Westar 1</i>	1974-22A	13 April 1974	LTTAT-Delta
<i>SMS 1</i>	1974-33A	17 May 1974	LTTAT-Delta
<i>ATS 6</i>	1974-39A	30 May 1974	Titan IIIC
<i>Hawkeye 1 (Explorer 52)</i>	1974-40A	3 June 1974	Scout
<i>Aeros 2</i>	1974-55A	16 July 1974	Scout
<i>ANS</i>	1974-70A	30 August 1974	Scout
<i>Westar 2</i>	1974-75A	10 October 1974	LTTAT-Delta
<i>Ariel 5 (UK-5)</i>	1974-77A	15 October 1974	Scout
<i>NOAA 4</i> and <i>OSCAR 7</i> and <i>INTASAT</i>	1974-89A 1974-89B 1974-89C	15 November 1974	LTTAT-Delta
<i>Intelsat-IV F-8</i>	1974-93A	21 November 1974	Atlas-Centaur
<i>Skynet IIB</i>	1974-94A	23 November 1974	LTTAT-Delta
<i>Helios 1</i>	1974-97A	10 December 1974	Titan IIIE-Centaur- TE-M-364-4
<i>Symphonie 1</i>	1974-101A	18 December 1974	LTTAT-Delta

APPENDIX D

NASA NAMING COMMITTEES

The first “naming committee” established within NASA Headquarters was the Ad Hoc Committee to Name Space Projects and Objects. Meeting informally during 1960, the Committee sought to establish procedures for submitting and selecting names and proposed specific mission categories as a step toward defining a clear-cut pattern of NASA names. Precedent had been set for the continuation of a “series approach” to names by Explorer and Pioneer spacecraft. The Committee emphasized that flight names should be suggestive of the mission and reflect the series of which they were a part. This emphasis was the basis for the decision to use the “Cortright” system for naming space probes, as described in the introductory section on space probes in the text (Part III).

On 9 January 1961, NASA Management Instruction 4-3-1, by the Committee, prescribed policy and procedure for assigning names to major NASA projects. A new committee, the Project Designation Committee, would be appointed to review and recommend specific project names. The NMI stated in part:

Each project name will be a simple euphonic word that will not duplicate or be confused with other NASA or non-NASA project titles. When possible and if appropriate, names will be chosen to reflect NASA’s mission. Project names will be serialized when appropriate, thus limiting the number of different names in use at any one time; however, serialization will be used only after successful flight or accomplishment has been achieved.

The Project Designation Committee met to consider specific names and solicited suggestions from NASA field centers as categories for future mission names were defined. Names chosen were “reserved” for the appropriate missions. The committee recommendations were not always approved and the selection of a name for a particular mission occasionally was postponed for lack of an acceptable substitute. Many approved names were never used, as the projects themselves were redesigned or later canceled.

The influence of the committee waned after 1963 as some projects were deferred or canceled and ongoing series required no new names. Fewer new

APPENDIX D

projects were approved and recommendation and approval of project names often came after the fact; names already in common use by program offices were adopted. Revived in 1970, the committee meets only to consider specific requests for official project names.

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Juno, in the Uffizi Gallery, Florence. From the Library of Congress Prints and Photographs Department.

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Thor, statue by B. E. Fogelberg. Reproduced by the Library of Congress from Donald A. MacKenzie, *Teutonic Myth and Legend* (New York: William H. Wise & Co., 1934).

Ocean, a Titan. Reproduced from de Montfaucon.

Apollo, fourth century sculpture in the Vatican Museum, Rome. Photograph from George Washington University Department of Art.

Castor and Pollux, the Gemini, in the Museum of Fine Arts, Boston, Mass. Reproduced from the collections of the Library of Congress.

Mercury, bronze by Giovanni Bologna in the Mellon Collection, National Gallery of Art, Washington, D.C. Photograph from the National Gallery.

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