

Man and Space



RCA



TRANSEARTH EVA—Apollo 17
Astronaut Ronald E. Evans retrieves
film cassettes from the Lunar Sounder,
Mapping Camera, and Panoramic Camera.

Foreword

Man and Space has been prepared by RCA Government and Commercial Systems to provide a brief summary of the U.S. space program.

Because the U.S. space program is a national effort involving virtually every industry and the technology of hundreds of professions, references to specific companies in this publication have been kept to a minimum.

Man and Space was prepared from the most current information available, and

the assistance of the National Aeronautics and Space Administration (NASA) is gratefully acknowledged.

Spacecraft, space systems and programs in which RCA has been involved are listed on the last page of this booklet. Additional information on the role of RCA in the national space program may be obtained from the Public Affairs Department, RCA Government and Commercial Systems, Moorestown, N.J. 08057.

Why Go into Space ?

The fascination of the Moon, the stars and the other planets in our solar system has captured man's imagination since the beginning of time. His desire to know what lies beyond, to break free of earth's gravity and explore the Moon and outer space has motivated him with a sense of urgency similar to his desire for survival.

Manned exploration of the Moon signaled not only our attainment of a centuries old desire, but established historical and technological milestones equal to the invention of the wheel and the first powered flight.

Most importantly, man's venture into space will continue to bring him new knowledge of the heavens, of his own planet and of himself. In meeting the requirements of space flight he has made hundreds of advances in technology that already provide practical benefits for mankind.

Because of the United States space effort, new breakthroughs in fabrics, metallurgy, electronics, food processing, communications, ceramics, medicine and other fields have made life more enjoyable for many people.

Advances in computer technology demanded by unmanned space missions to Mars and Venus have brought nearer the day when school students will be taught by computer-assisted instruction methods.

Thus the Moon, the stars and the planets have beckoned man into the universe with the promise of a better life on Earth—a life enriched through scientific discovery.



The Earth rising over the Moon as seen by the Apollo 8 astronauts.

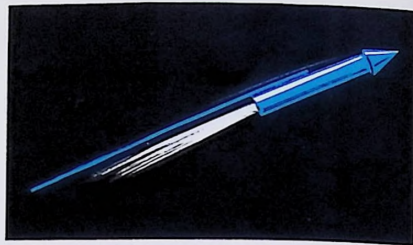
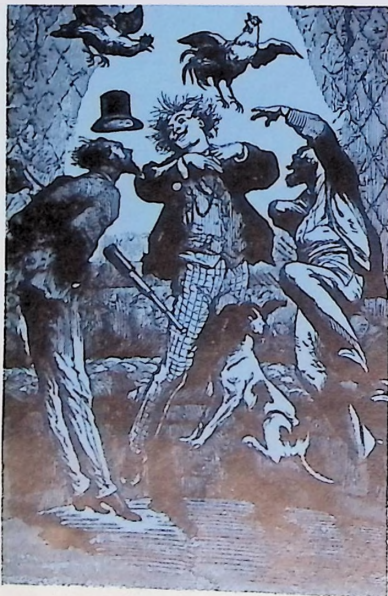
Beginning Ideas

The first man to dream of leaving the Earth and traveling to a distant star may never be known. He is lost among the millions of men who have inhabited the Earth since the beginning of time.

It is safe to assume however, that the idea of leaving the Earth developed as understanding of the universe and the solar system evolved, in which case the first Moon landing culminated a 2,000 year old dream.

In 160 A.D. the first story concerning a flight to the Moon appeared written by Lucien of Greece. For centuries no other stories of space travel appeared in recorded history and it wasn't until the renaissance of science after 1600 A.D. that writers such as Kepler, Voltaire,

Weightlessness as portrayed in 1865 Jules Verne's "From the Earth to the Moon".

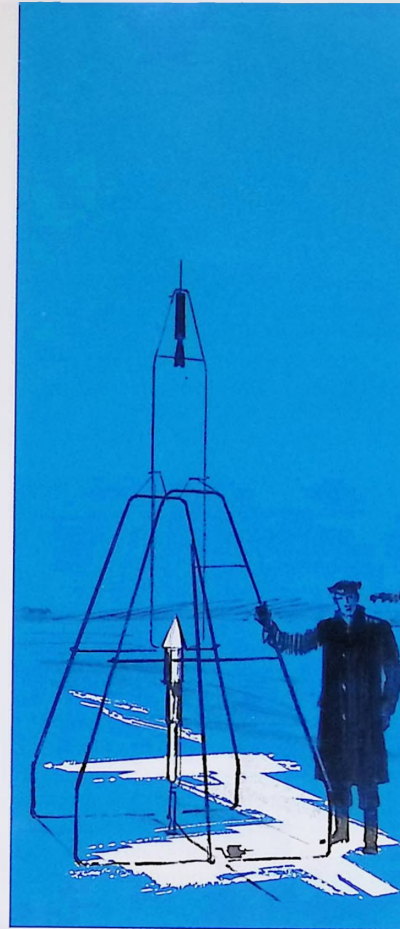


Jules Verne, Edgar Allan Poe and H. G. Wells filled the pages of literature with imaginative tales of space flight. To get their fictional explorers into space these writers used animal power, firecrackers, balloons, catapults, cannons and other inventive means.

The first known presentation on the injection of a man-made satellite into Earth orbit was made in 1869 by novelist Edward E. Hale. His work also discussed weather, communications and navigation satellites, all of which have become a reality.

Closely tied to the beginning ideas of space flight is the development of the rocket, first used by the Chinese in the early 13th Century. Originally conceived as a weapon of war, it was not until the early 1900s that the rocket was seriously considered as a method for propulsion in space.

In 1903 a Russian school teacher, Constantin Tsiolkovsky, published the first treatise on space travel which advocated the use of liquid-fueled rockets. His ideas lay in obscurity however and it wasn't until 1923 that Hermann Oberth, a Rumanian-German, and Robert Goddard, an American, seriously considered the idea of developing a liquid-fueled rocket.



Dr. Robert Goddard with his early rocket experiments.

Performing experiments at Clark University in Massachusetts, the increasing noise and size of Dr. Goddard's rockets caused his neighbors no small amount of concern. He soon was forced to leave New England and travel to the Southwestern United States where he could conduct his work in the open space of the desert.

With continued improvement, his rockets reached 7,500 feet altitude and speeds of over 700 miles per hour. By the late 1930s Dr. Goddard was recognized in professional circles as the world's foremost rocket scientist.

But most Americans did not realize the potential of Dr. Goddard's liquid-fueled rocket for space travel and a general lack of interest by the scientific community provided little encouragement to his research and development efforts.

German scientists were inspired by the work of Goddard and they soon organized the German Society for Space Travel. Dr. Goddard's ideas were well known within this society and it was from these ideas that a family of German rockets were developed in the early 1940s.

One of the leading scientists in early German rocket development was Dr. Wernher Von Braun, who later became a top NASA official. After migrating to the United States, he became a leading scientist in the United States Space Program and was instrumental in development of the Saturn IB and V rockets.

Thus from Oberth and Goddard, German rocket developments led to atmospheric probes launched by small sounding rockets and the world famous launchings of Sputnik I and Explorer I.

The Space Age Begins

According to the writings of Jules Verne, a spacecraft was a giant aluminum bullet fired toward the Moon from a large cannon buried in Florida soil, not too distant from Cape Kennedy. Indeed the United States and Canada had at one time seriously considered launching small satellites with the help of a rebored 16-inch naval cannon.

But when the U.S. decided to launch a small research satellite during the International Geophysical Year in 1957-58, engineers did not think in terms of Verne's huge projectile. Instead they followed a logical course into space—by extending sounding rocket technology.

While engineers and scientists began investigating the problems of heat created by re-entry and shapes suitable for space flight, the Russians orbited the first man-made satellite of the Earth on October 4, 1957.

The American people, and all the people of the world, had been introduced to the "Space Age" in the form of a 184 lb. satellite that was little more than a radio with a self-contained power source. Its repetitive "beep-beep" radio signal enmeshed in static was to prove the rallying force behind an American space effort that would lead men to the surface of the Moon and perhaps beyond.

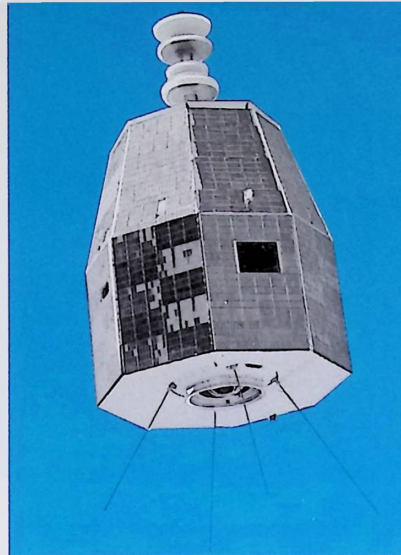
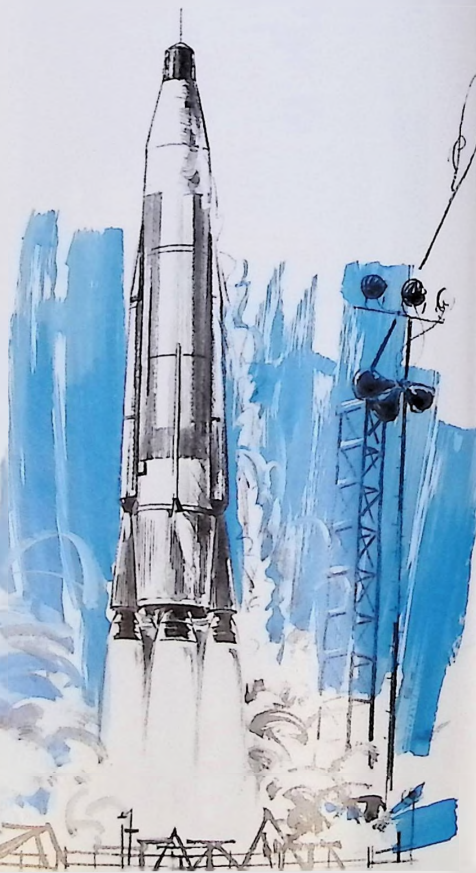
Communications Satellites

The possibility of global communications via satellites was first described in 1945 by the British writer Arthur C. Clarke who published an article entitled "Extraterrestrial Relays".

As is often the case of a science fiction writer, Clarke was before his time, but only by about 15 years.

Since that time, Clark has produced an extraordinary film titled "2001—A Space Odyssey," and in conjunction with members of the aerospace industry is producing a film showing the benefits of the space program in areas such as health, medicine, education, transportation and communications.

Although passive metalized balloons were the first method used to bounce radio signals from one point on Earth to another, the really first communications satellite was the Moon. During the 1950s, the U.S. Army used the Moon to establish a long range communications link between Washington, D.C. and Hawaii. Known as Communication by Moon



Relay I communications satellite.

Relay (CMR), the system became the world's first operational space communications system.

Passive satellites such as the Moon and metalized balloons like ECHO I and II had their disadvantages however, and as technology improved they were abandoned in favor of active-repeater type communications satellites.

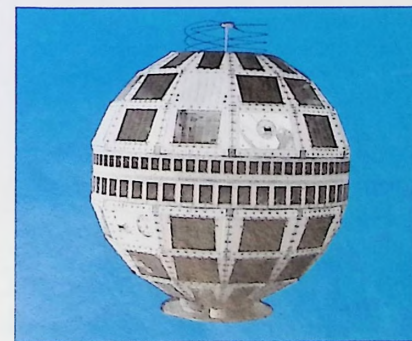
The first active-repeater type communications satellite was SCORE. Launched December 18, 1958, SCORE relayed voice conversations, code, and teletype messages. Also aboard the spacecraft was a tape recorder which carried a Christmas message of peace from the late President Dwight D. Eisenhower. Operative for twelve days, SCORE proved the feasibility and desirability of active-repeater communications satellites. With these satellites space had begun to provide practical benefits for all men and manned space flight was still three years away.

Refinements in active communications satellites continued building upon the knowledge received from SCORE, COURIER IB and TELSTAR. Based on

this background scientists and engineers built the RELAY communications satellite, launched December 13, 1962. Operational for more than two years, the satellite demonstrated the feasibility of intercontinental and transoceanic transmission of telephone, television, teletype, and facsimile radio signals via a medium-altitude active-repeater satellite.

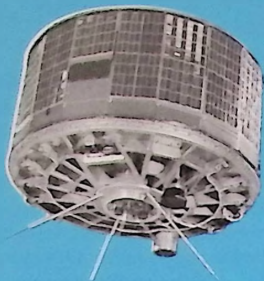
Both RELAY I and RELAY II, established a standard for reliability and long life. In more than four years of operation, these satellites successfully performed some 5,000 television, voice, teletype and facsimile transmission experiments.

During the last several years, many more communications satellites have been placed into orbit. Among them are the INTELSAT series (International Telecommunications Satellite Consortium). The satellites are owned and operated by INTELSAT, an organization of more than 60 countries which use the satellites to relay voice, telephone, and television signals between America and Europe, and America and the Far East.

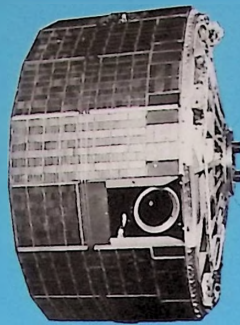


Telstar—An early communications satellite.

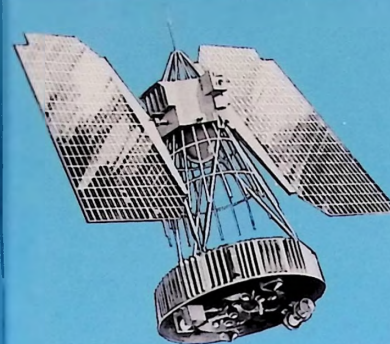
Weather Satellites



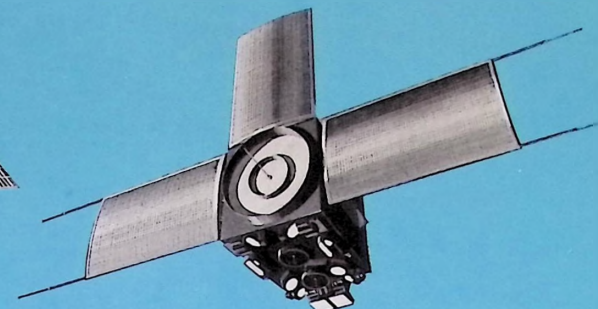
TIROS I-VIII (Standard Mode) Carrying two television camera systems, these first operational weather satellites provided meteorologists their first satellite pictures of the Earth's weather conditions.



TIROS/ESSA (Wheel Mode) An advanced model of the earlier Tiros Weather satellites, these spacecraft are maneuvered to roll in orbit around the world, like a drum rolling down a hill. Over 1,000,000 weather photos have been transmitted by the TIROS/ESSA series spacecraft.



NIMBUS I and II experimental meteorological satellites were first launched during the mid 1960s. The spacecraft provided a test bed for development of advanced weather satellite sensors.



ITOS—A new generation weather satellite designed to provide greater coverage of the Earth's weather at less cost. The first operational spacecraft, ITOS-1, was launched January 23, 1970. A second ITOS spacecraft, NOAA-1, was launched on December 11, 1970; and NOAA-2 was put into orbit on October 15, 1972.

Before the space age began, sounding rockets were providing information about the Earth's upper atmosphere. This information was helpful to weathermen, but it remained for the Earth Weather Satellite to be the most valuable meteorological tool contributed by the space program.

RCA, under direction of the National Aeronautics and Space Administration, developed the first weather satellite. It was called TIROS for Television Infrared Observation Satellite. TIROS I was launched April 1, 1960.

The TIROS series of satellites continually provide weather pictures that aid meteorologists in forecasting global and local weather conditions. By mid 1969, nineteen TIROS Satellites and TIROS Operational System (TOS) Satellites had been launched. Drum shaped and covered with hundreds of solar cells to power the satellite's television cameras, these spacecraft have transmitted more than one-and-one-half million weather pictures.

As a further development of the Improved TIROS Operational System (ITOS)—a new generation weather satellite, ITOS-1, was placed into orbit in January, 1970. This three-axis stabilized spacecraft was designed to provide more frequent coverage

of global weather phenomena than previous meteorological satellites.

The second in the ITOS series of meteorological satellites was launched December 1970. Operated by the newly formed National Oceanic and Atmospheric Administration (NOAA), NOAA-1 was designed to take both day and night pictures of earth's cloud cover to provide meteorologists with a global view of the weather every 12 hours.

To expand the data available from meteorological satellites, NOAA-2 was placed in orbit in October 1972. It is the first operational satellite to provide three-dimensional information on the world's weather.

NOAA-2 is the first satellite to be entirely equipped with operational heat-sensing infrared instruments for obtaining global environmental data. Three environmental instruments supply both daytime and nighttime views of the earth's cloud cover in addition to vertical temperature readings of the atmosphere and the oceans.

These remote sensing instruments include a Very High Resolution Radiometer (VHRR), a Vertical Temperature Profile Radiometer (VTPR) and Scanning Radiometer (SR).

A total of 22 TIROS and ITOS series weather satellites have been success-

fully launched, and additional ITOS operational spacecraft are slated for launch through the mid 1970's.

While the first TIROS satellites were proving the everyday value of the weather spacecraft, NASA developed the Nimbus Technology Satellite aimed at improving the instruments and spacecraft components used on operational weather satellites.

Nimbus Satellites are large automated research and development spacecraft. NIMBUS I, launched August 28, 1964, tested the basic spacecraft design and carried a new high-resolution TV cloud-mapping system (the Advanced Vidicon Camera System), plus an Automatic Picture Transmission System (APT) that allowed local weather stations to receive weather pictures directly from the satellite.

As a result of this experimental satellite, the AVCS and APT systems were successfully incorporated into the TIROS Operational Satellites. NIMBUS II, launched May 15, 1966, contained equipment not only for providing day and night pictures of the Earth and its clouds, but also for measuring the Earth's heat balance.

NIMBUS III was launched April 14 1969 and contained instruments for seven research projects. The 1,269

pound butterfly-shaped satellite had equipment designed to locate objects on which small radio transmitters had been placed, including an elk in Yellowstone National Park, ocean buoys, aircraft and balloons.

On April 8, 1970 NIMBUS IV was launched. It is a weather satellite that is investigating phenomena in the infrared, ultraviolet, microwave and radio frequency regions.

NIMBUS V was launched on December 11, 1972. Sensors aboard the spacecraft make measurements of the oceans, atmosphere and the Earth's surface.

Other NIMBUS satellites are scheduled for launch later in the 1970's.



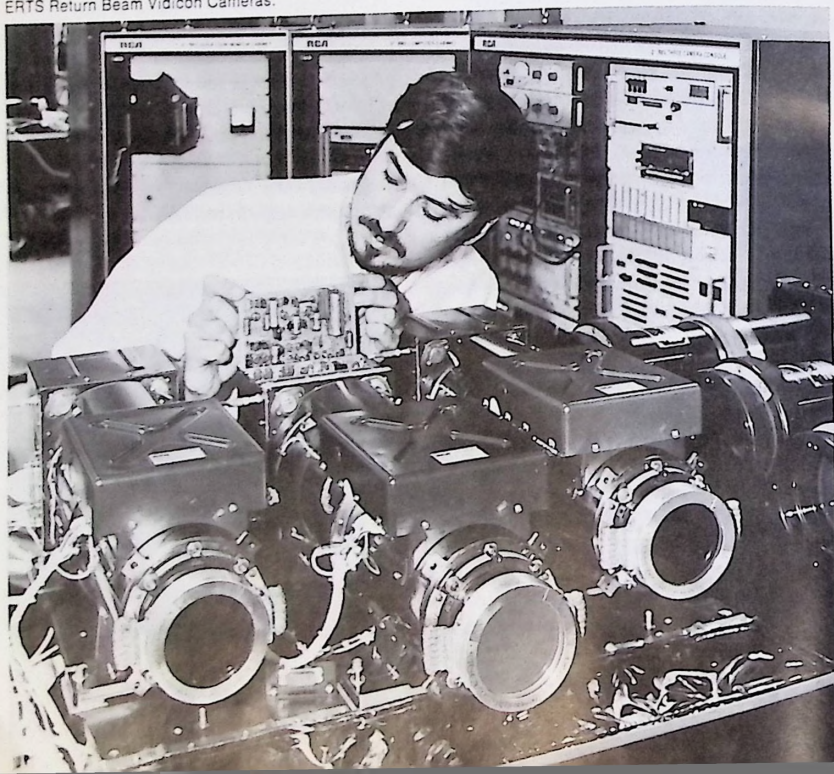
Unmanned Spacecraft

Short of manned landing, unmanned instrumented spacecraft are the best means of obtaining information about planets and the Moon. Through soft landings, flybys and orbits, unmanned spacecraft can provide Earth scientists with vast amounts of information concerning a planet's atmosphere, gravitational pull, soil composition, and other factors that are used in preparation for manned landing.

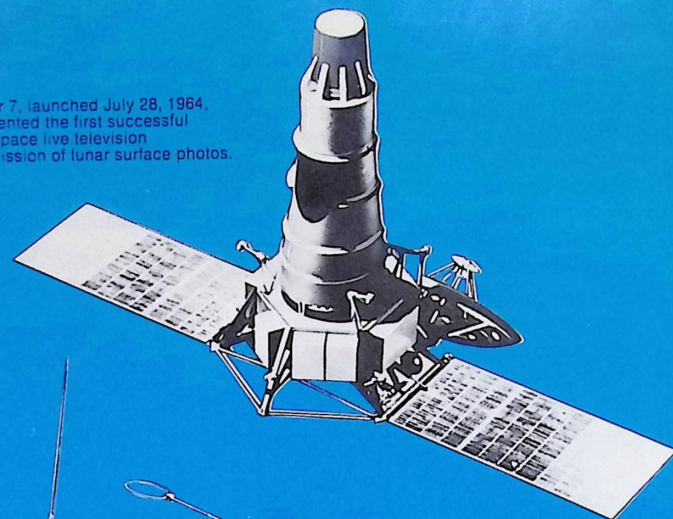
Outer space also provides man with an opportunity to see other planets and galaxies unhindered by the Earth's atmosphere. Already the bits of scientific data and the pictures acquired by means of NASA's PIONEER and MARINER spacecraft have tremendously increased our knowledge of the Moon, Venus, and Mars. Some of the more significant unmanned programs are:

- **ATS: Applications Technology**
Satellites are intended to test new space instruments and spacecraft components, such as communications and meteorological equipment, particularly those employed in stationary orbit satellites.
- **ERTS: The first Earth Resources**
Technology Satellite was launched on July 23, 1972. The satellite employs an imaging system capable of producing pictures of extremely high resolution. Equipped with a Return Beam Vidicon TV Camera System operating in three different spectral bands, the satellite is providing information on food supplies, natural resources, water and air pollution, and crop diseases.

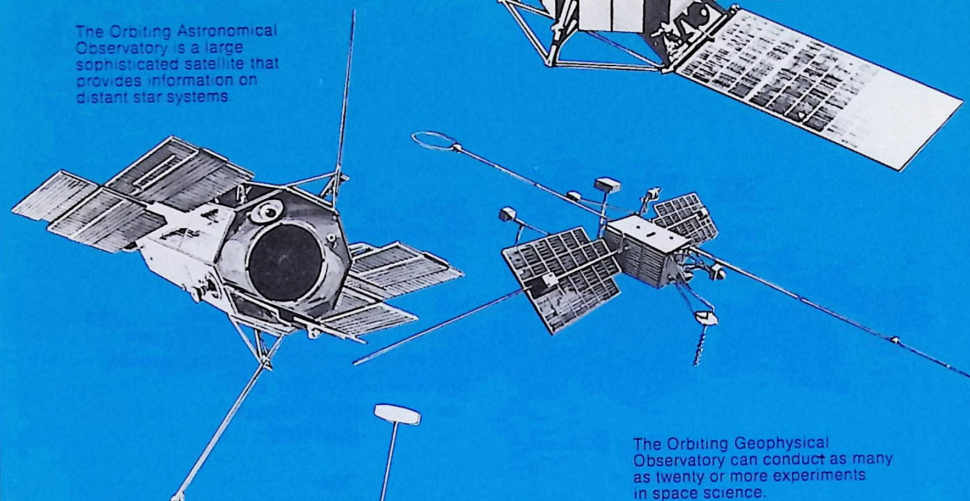
ERTS Return Beam Vidicon Cameras.



Ranger 7, launched July 28, 1964, represented the first successful deep space live television transmission of lunar surface photos.

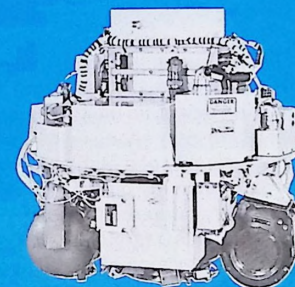
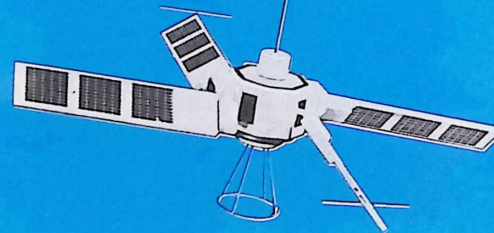


The Orbiting Astronomical Observatory is a large sophisticated satellite that provides information on distant star systems.



The Orbiting Geophysical Observatory can conduct as many as twenty or more experiments in space science.

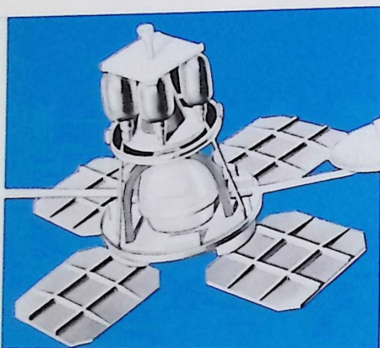
Artist's concept of U.S. Navy Navigation Satellite



SERT (Space Electric Rocket Test) was the first operation of an ion engine in space. A program of NASA's Langley Research Center, SERT was launched July 20, 1964 and was so successful that a second spacecraft scheduled for the program was cancelled.

- **EXPLORER:** A long series of scientific satellites that began before NASA was established. The Army Explorer 1 was the first U. S. Satellite to be launched, on January 31, 1958. Explorers 2, 3 and 4 were also Army satellites; the rest—Explorers 5-45 were launched by NASA. (Explorers 42 and 45 were launched for NASA by Italian launch crews.)

- **LUNAR ORBITER:** Five lunar probes placed in orbit around the Moon designed to return close-up pictures and other information about the Earth's only natural satellite. Following their photographic missions, the spacecraft performed useful functions by sending back scientific data on lunar gravity and micrometeoroid activity in addition to being tracking targets for NASA's Manned Space Flight Network Tracking Stations.



LUNAR ORBITER

- **MARINER:** A family of planetary probes designed to investigate Mars and Venus, making scientific measurements in interplanetary space on the way. In the vicinity of a planet, the Mariner probes scan the planet with instruments and carry out radio frequency experiments. Mariner spacecraft 6 and 7 carried television cameras to give scientists detailed close up views of Mars polar and equatorial regions. Mariner 8 was unsuccessful due to launch vehicle failure. Mariner 9 is in orbit around Mars and is taking pictures and returning environmental data from the planet.

- **NAVSAT:** Originally developed for use by Polaris submarines, NAVSAT provides highly accurate position information to ships at sea. The system has three principal elements; ground tracking stations, the satellites and shipboard user equipment.

- **OAO:** The Orbiting Astronomical Observatory is a large sophisticated satellite designed for studying stars and carrying out associated experiments in space science. Launched April 8, 1966, the first OAO I spacecraft was unsuccessful due to a power failure. A second Orbiting Astronomical Observatory (OAO II) launched December 7, 1968 provided valuable data on distant stars.

- **OGO:** NASA built a family of six Orbiting Geophysical Observatories to conduct as many as twenty or more experiments in the fields of geophysics, space physics and astronomy. Like other Space Observatories, OGOS were large and relatively sophisticated, weighing between 1000 and 1300 pounds. Some of the OGOS were injected into polar orbits and were called POGOS.

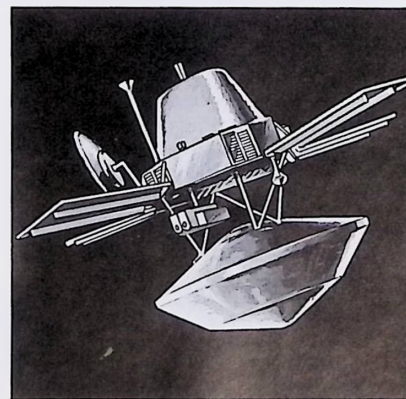
- **OSO:** The first six Orbiting Solar Observatories were the smallest of the Observatory class and carried fewer experiments. Weights varied between 450 and 650 pounds. OSO-7, and the next three scheduled, weigh 1400 pounds. The satellites have provided considerable information about our Sun.

- **PIONEER:** The first five Pioneer probes were aimed to fly in the general direction of the Moon, but not to hit it. They either fell back to Earth, or continued into solar orbit. The second series, beginning with PIONEER VI, were aimed at deep-space exploration. These later Pioneers carry magnetometers, solar wind instruments, radiation counters and other scientific instruments.

- **RANGER:** The first two spacecraft of this series were intended to test techniques for use on lunar and planetary spacecraft as well as measure the particles and fields present in interplanetary space. The next three Rangers were to "rough land" a seismometer package on the lunar surface and the final four Rangers were designed to take closeup pictures of the lunar surface before crash landing. Ranger VII, VIII and IX spacecraft telecast to Earth over 17,000 closeups of the Moon, information that provided data for planning the lunar landing of Apollo astronauts.

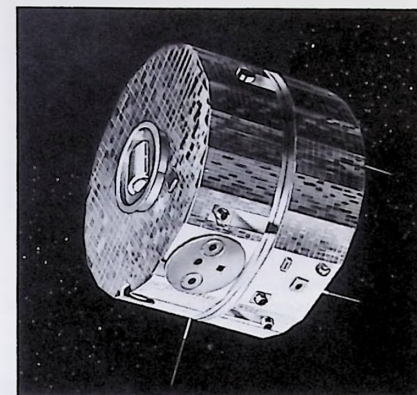
- **SURVEYOR:** A series of seven soft-landing lunar probes built to reconnoiter the Moon's surface in preparation for the Apollo manned landing. The first Surveyors were primarily picture-taking spacecraft, but later models added experiments for soil mechanics and analysis of the Moon's surface composition.

- **VIKING:** In 1975-76 two unmanned spacecraft called Vikings, each composed of orbiter and lander sections, will traverse some 460 million miles from Earth, destined for orbit and soft landings on Mars. Viking will perform scientific investigations of Mars, both from orbit and on the surface of the planet. The primary purpose of the program is to search for life on Mars.



VIKING

- **VANGUARD:** Project Vanguard was inaugurated as part of the American program for the International Geophysical Year (IGY). The first Vanguard satellite was placed into orbit March 17, 1958. Among the valuable data acquired from this satellite was information about the relatively slight but significant distortion referred to as the "pear shape" of the Earth.



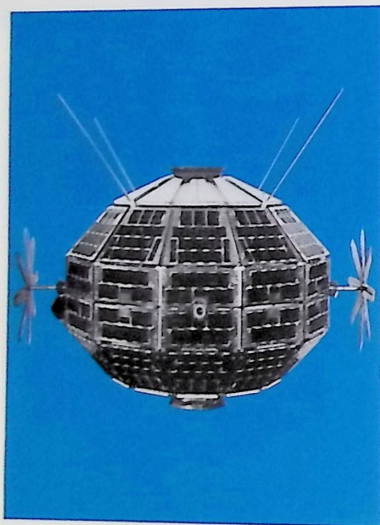
ATMOSPHERE EXPLORER

- **ATMOSPHERE EXPLORER:** Scheduled for first launch in 1973, Atmosphere Explorer, a 1400 lb. satellite, will investigate the chemical processes and energy transfer mechanisms which control the structure and behavior of the Earth's atmosphere and ionosphere through the region of high solar absorption. It will fly an extremely elliptical orbit, enabling it to acquire data in the Thermosphere. Additional AE satellites are scheduled for launch in 1974 and 1975.

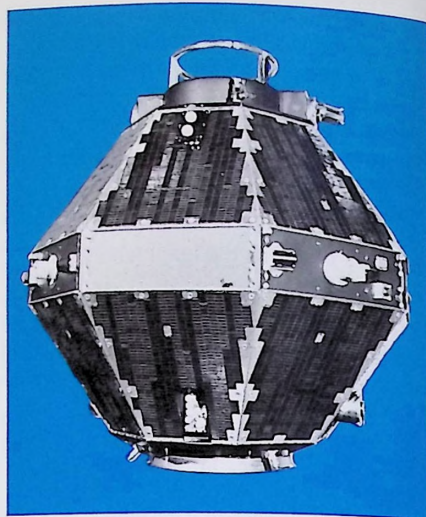
Canadian Space Program

The first satellite to be designed and constructed in Canada was named Alouette I. It is a scientific satellite containing four experiments: an ionospheric sounder, a VLF receiver, and instruments to measure cosmic noise and energetic particles. The spacecraft was launched from the Western Test Range, California on September 29, 1962 as part of a joint space program between NASA and Canada's Defense Research Board. The satellite is now the oldest active vehicle in space, and still transmits data back to earth on command.

Alouette II was launched into orbit on November 29, 1965, also from the Western Test Range. A fifth experiment was added to Alouette II—a langmuir probe for measuring electron density and electron temperature.



ALOUETTE II



ISIS II

Canada's third space satellite, designated ISIS for International Satellite for Ionospheric Studies, was launched from the Western Test Range on January 30, 1969. The spacecraft contains ten experiments designed to measure most of the important ionospheric parameters at the same time and in the same place.

ISIS II was placed into orbit on April 1, 1971. The satellite is instrumented with twelve experiments including two to observe optical phenomena.

These first four Canadian satellites were designed and constructed by the Communications Research Centre of the Department of Communications, RCA Limited-Canada, and Spar Aerospace Products Limited. The satellites continue to be tracked and commanded by Canadian and United States satellite telemetry/tracking stations.

Canada's first domestic communications satellite, ANIC I (an Eskimo name for brother), was launched from Cape Kennedy in December 1972.

Mercury/Gemini

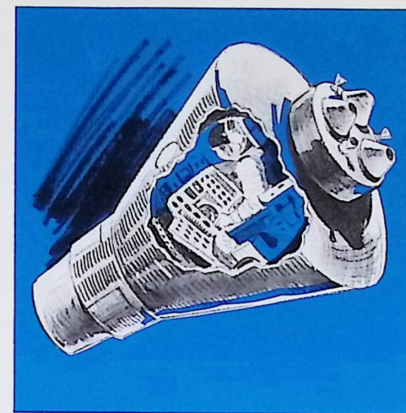
Project Mercury was the first NASA manned space flight program designed to orbit a manned spacecraft, investigate man's ability and reaction to space flight, and recover both man and spacecraft.

Astronaut Alan B. Shepard, Jr. was the first American to rocket into space on May 5, 1961. His 302 mile flight from Cape Kennedy lasted slightly more than 15 minutes and reached an altitude of about 115 miles. The one-man Mercury spacecraft subsequently carried astronauts Virgil I. Grissom, John H. Glenn, M. Scott Carpenter, Walter M. Schirra and L. Gordon Cooper into space for missions lasting up to 34 hours.

Following the six missions of the Mercury Program (two sub-orbital and four orbital), America's manned space flight program moved into Project Gemini.

Experience obtained with the Mercury spacecraft as well as high altitude flights of the X-15 rocket plane enabled NASA scientists and engineers to design the Gemini spacecraft that would orbit two astronauts for as long as two weeks. An important modification to the Gemini spacecraft was the addition of a docking apparatus for joining another vehicle in space—an essential operation for any flight to the Moon.

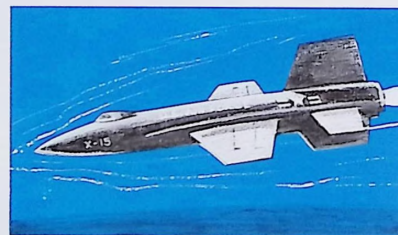
Gemini was the first maneuverable spacecraft and the first space vehicle to



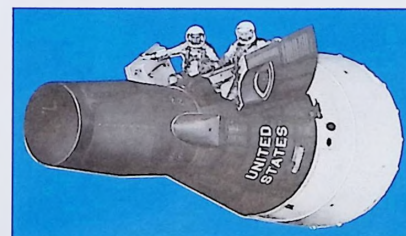
The Mercury spacecraft.

change its orbit (Gemini III). From the Gemini missions, techniques were developed for rendezvous and docking that were used in later Apollo flights. Other accomplishments of Project Gemini were: The first walk in space by man (Astronaut Ed White on Gemini 4), the first space rendezvous with another vehicle (Gemini 7-6), the first docking with another spacecraft (accomplished by civilian Neil Armstrong and Lt. Col. David Scott on Gemini 8), the longest space flight (Gemini 7—two weeks), and the longest space walk—a 129 minute maneuver outside his spacecraft by Lt. Col. Edwin E. Aldrin on Gemini 12.

X-15 Rocket Plane.



GEMINI



Apollo



"I believe this nation should commit itself to achieving the goal, before this decade is out, of landing a man on the Moon and returning him safely to Earth."

*President John F. Kennedy
May 25, 1961*

This pledge by President Kennedy was made when the U.S. had not even been able to place a tiny, unmanned space probe closer than 20,000 miles to the lunar surface. It was not even quite clear just how the U.S. would manage the moon voyage—by flying one enormous spaceship directly to the moon as envisioned by Jules Verne, or by assembling two large parts of the

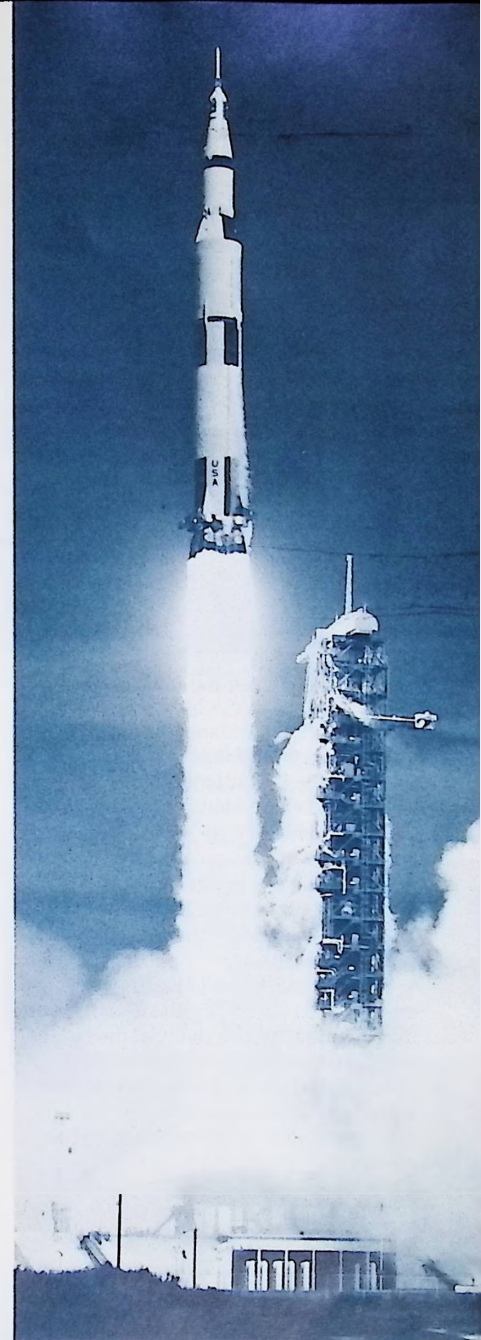
moonship together in Earth orbit and then setting off for the Moon. As it turned out, a third method, that of lunar orbit rendezvous was chosen.

The Apollo spaceship consists of three modules or sections. The Command Module is designed to accommodate three astronauts in a "shirtsleeve" environment. It contains all of the life-supporting necessities such as food, air and waste disposal together with the navigational, propulsion and communications equipment required for deep space travel. The Command Module, like the Pilot's compartment of an airliner, has windows, and contains controls and instruments which enable the astronauts to pilot their craft.

As the Command Module is the only one of the three parts of the spaceship which will return to Earth, it is built to survive the tremendous deceleration forces and intense heat caused by entry into the atmosphere at 25,000 miles per hour. Weighing five tons, the Command Module is 11 feet tall and has a base diameter of approximately 13 feet.

Behind the Command Module is the Service Module which contains the rocket engines, fuel supplies and electronics equipment. The Service Module weighs 24 tons, is 23 feet long and 13 feet in diameter.

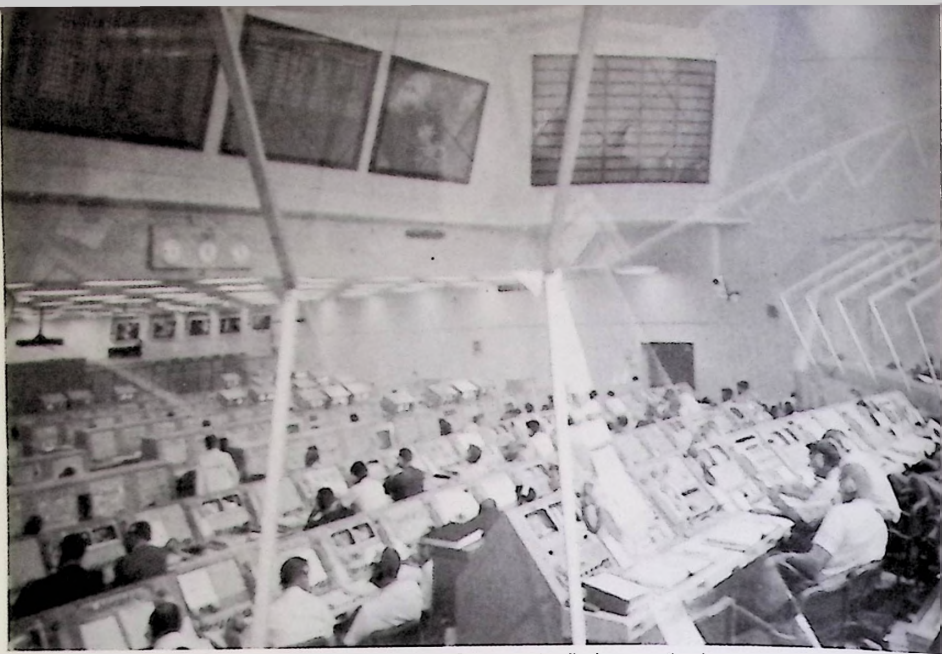
The Lunar Module is the spacecraft that takes two Apollo astronauts down to the Moon, carries them from the Moon's surface into lunar orbit, to rendezvous with the Apollo Command and Service Modules in lunar orbit. Among the LM's equipment is a rocket for slowing down the ship before landing on the Moon, a rocket for launch from the surface of the Moon and for maneuvering into orbit, and four spindle-like legs that are extended to support the spacecraft on the Moon's surface. During the launch



Apollo/Saturn V space vehicle lifts off from Kennedy Space Center



Four Apollo/Saturn V Moon rockets, each towering 363 feet, can be assembled at once in one of the largest—by volume—buildings in the world, the Vehicle Assembly Building (VAB).



Engineers working in a Launch Control Center Firing Room monitor final preparation for an Apollo launch. These personnel operate 450 consoles within the firing room.

from Earth, the LM is stored in the spacecraft—LM Adapter.

After the most intensive ground testing program in history, NASA started flight testing Apollo spacecraft equipment in 1963. For the first space flights, the Saturn 1B launch vehicle, smaller of the two rockets built for the manned program, was used.

The first three Apollo flights were unmanned, suborbital missions to demonstrate the capability of the launch vehicle and its compatibility with the spacecraft. They also provided the first test of the Apollo heat shield at temperatures it would encounter when re-entering the atmosphere from Earth orbit.

The fourth Apollo flight, also unmanned, made a complete checkout of the Saturn 1B rocket to demonstrate the ability of the launch vehicle's second stage S-IVB engine to re-start in space—a must for the lunar mission.

A fifth unmanned suborbital flight gave a second check on the Apollo heat shield performance as well as a check on the launch vehicle's performance and spacecraft compatibility. The Lunar Module flew for the first time on Apollo 5, January 22, 1968, during which mission the craft's systems were checked, including a firing of the LM's engines to simulate a landing on the Moon.

The sixth Apollo mission checked the up-rated Saturn 1B and the Saturn V rocket while exposing the spacecraft systems to the environment of deep space.

First Manned Apollo Mission

APOLLO 7—October 11–22, 1968. First manned Apollo flight demonstrated the spacecraft, crew and support elements. All performed as required.



Lift off: 10/11/68 — Splashdown: 10/22/68 — Flight Time: 260:8:45
Astronauts: Donn Eisele, Walter H. Schirra, Walter Cunningham

Manned Apollo Missions began October 11, 1968 when Astronauts Walter M. Schirra, Jr., Lt. Col. Donn F. Eisele, and Civilian Walter Cunningham flew a near perfect 11-day mission. Apollo 7 also provided the first live

television pictures to home sets from inside a manned U.S. spacecraft. Using an RCA developed 4½ pound Hand-Held Camera, the astronauts sent the American public their first view of life in an orbiting space vehicle.

TV FROM SPACE—This view of Apollo 7 Command Module pilot Donn F. Eisele was transmitted by a 4½ pound camera as the spacecraft orbited more than 125 miles above the Earth.



Around the Moon and Back

APOLLO 8—December 21–27, 1968. History's first manned flight to the vicinity of another celestial body.



Lift off: 12/21/68 — Splashdown: 12/27/68 — Flight Time: 147:00:41
Astronauts: James A. Lovell, Jr., William Anders, Frank Borman

Apollo 7 however, was only a prelude to the missions to follow. On December 21, 1968, riding the most powerful rocket in history, a Saturn V producing 7,600,000 pounds of thrust, Astronauts James A. Lovell, William A. Anders and Frank Borman were rocketed into a 103-mile-high orbit to prepare for a flight to the Moon. Approximately three-quarters through the spacecraft's second revolution of the Earth, the 225,000 pound S-IVB Third Stage Engine was re-ignited to burn for about five minutes. This increased the spacecraft's speed from 17,500 miles per hour to over 24,000 miles per hour, sending the Apollo Command Module toward the Moon.

As the spacecraft traveled through space, the astronauts began a slow rotating of the spacecraft to prevent its systems from boiling under the direct rays of the sun or freezing in the airless, extreme cold of outer space. Maneuvering their spacecraft through a

series of Service Module Rocket Firings, Apollo 8 achieved a 60 to 70 mile orbit of the Moon on December 24 and 25, 1968.

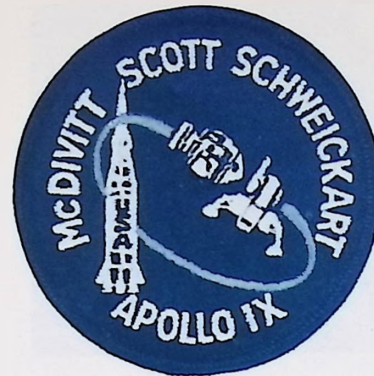
With a duplicate of the Hand-Held Camera carried aboard Apollo 7, the astronauts were able to send television pictures of the lunar surface a quarter of a million miles to the American public on Christmas Eve, 1968.

Completing ten orbits of the Moon, the astronauts again fired their Service Module Rocket Motor to escape the gravity of the Moon and begin their journey home. As the spacecraft left the Moon its pilots, aided by an on-board computer, took aim on a narrow re-entry corridor—a 40 mile wide keyhole in the Earth's atmosphere 230,000 miles away.

Apollo 8 proved that man had the equipment and the ability to leave his own planet, navigate through the vast uncharted ocean of space, rendezvous and orbit the Moon, and then find his way safely home.

Lunar Module Ready

APOLLO 9—March 3–13, 1969. First all-up manned Apollo flight (with Saturn V and Command, Service, and Lunar Modules). First Apollo EVA. First docking of CSM with LM.



Lift off: 3/3/69 — Splashdown: 3/13/69 — Flight Time: 241:00:53
Astronauts: James A. McDivitt, David R. Scott, Russell L. Schweickart
Command Module: Gumdrop — Lunar Module: Spider

Apollo 9 tested the complete Lunar Module in Earth orbit. Sent into space by the 363 foot Saturn V, the LM and Command Module were tested as a complete system. Astronauts James A. McDivitt and Russell L. Schweickart entered the LM through a tunnel in the

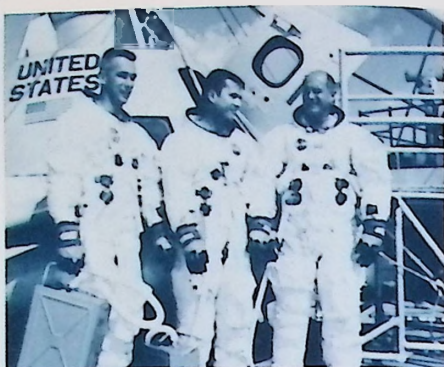
Command Module, separated from the Command Module and practiced rendezvous and docking maneuvers in space. Apollo 9 also included the first walk in space since Project Gemini ended in 1966.

During Apollo 9 (Checkout of the Lunar Module in Earth orbit), Astronaut David R. Scott emerges from the hatch of the Command Module as the spacecraft passes over the Mississippi Valley.



Final Dress Rehearsal

APOLLO 10—May 18–26, 1969. Apollo LM descended to within 9 miles of Moon and later rejoined CSM. First rehearsal in lunar environment.



Lift off: 5/18/69 — Splashdown: 5/26/69 — Flight Time: 192:03:23
Astronauts: Eugene A. Cernan, John W. Young, Thomas P. Stafford
Command Module: Charley Brown — **Lunar Module:** Snoopy

Before the flight of Apollo 9 was over, Apollo 10 was moved from the Vehicle Assembly Building at Cape Kennedy to the launching pad in preparation for launching in May. Apollo 10 completed a full dress rehearsal of the lunar landing flight that followed almost every step in the Moon landing sequence. But once in lunar orbit, Apollo 10 went a very dramatic step further. The Lunar Module actually separated from the Command/Service Module, descended to 50,000 feet above the lunar surface, then using the power of its ascent engine, returned to a rendezvous with the Command Module in lunar orbit.

Apollo 10 confirmed the operational performance, stability and reliability of the Command/Service Module/Lunar Module configuration during translunar coast, lunar orbit insertion, and lunar

module separation and descent. The latter maneuver involved employing all but the final minutes of the techniques for use in an actual lunar landing. The mission also completed critical evaluations of the lunar module propulsion systems and rendezvous and landing radar devices in the rendezvous and redocking maneuvers.

In addition to demonstrating that man could navigate safely and accurately in the Moon's gravitational fields, Apollo 10 photographed and mapped tentative landing sites for future missions.

"That's one small step for a man"...

APOLLO 11—July 16–24, 1969. First landing of men on the Moon. Total stay time: 21 hrs., 36 min.



Lift off: 7/16/69 — Splashdown: 7/24/69 — Flight Time: 195:18:35
Astronauts: Neil A. Armstrong, Michael Collins, Edwin E. Aldrin, Jr.
Command Module: Columbia — **Lunar Module:** Eagle

And now Man was ready. After more than 2,000 years of waiting, after many false starts, frustrations and disappointments, three men were at last preparing to leave the only known inhabited planet in our solar system and set foot on another terrestrial body.

It was precisely 9:32 a.m. EDT July 16, 1969 that civilian Commander Neil A. Armstrong, Air Force Colonel Edwin E. Aldrin, Jr. and Air Force Lt. Colonel Michael Collins began their journey atop the powerful Saturn V rocket.

Creating one of the loudest sounds man has ever heard, the five F-1 first stage engines burned 15 tons of fuel per second to develop the 7.7 million pounds of thrust needed to send the three men and their Lunar Module to the surface of the Moon. After the engines were ignited, the roaring giant thundered on its launching pad for 8.9 seconds while computers made certain all engines were performing properly. Once the computers sensed every one of the rocket's more than fifteen million parts were working flawlessly, they



The Space Vehicle for Apollo 11 is rolled out of the Vehicle Assembly Building down the 3.5 mile Crawlerway to Launch Complex 39-A at a speed of one mile per hour.

commanded four 40,000 pound restraining arms to release the Saturn V and its spacemen.

As the mighty rocket hurtled through the Earth's atmosphere, down-range space tracking stations and radar ships constantly monitored and relayed to Mission Control the spacecraft's flight path, the condition of the astronauts and their spaceship.

Approximately twelve minutes after leaving Pad A at Launch Complex 39 of the John F. Kennedy Space Center, the three astronauts entered an Earth "parking" orbit. There all the systems of the Saturn V's third stage, the rocket that would launch them out of Earth orbit and on their way to the Moon, was minutely checked by the spacemen with the help of computers on Earth.

It required a little less than three hours to verify that all spacecraft systems were indeed performing well and that the Lunar Module, named "Eagle", and the Command Module called "Columbia", were ready for their historic flight.

This completed, the Saturn V's third stage engine was ignited for approximately six minutes to propel Columbia and Eagle toward the Moon at 24,200 miles per hour. During the next several hours, the astronauts completed a series of vital maneuvers.

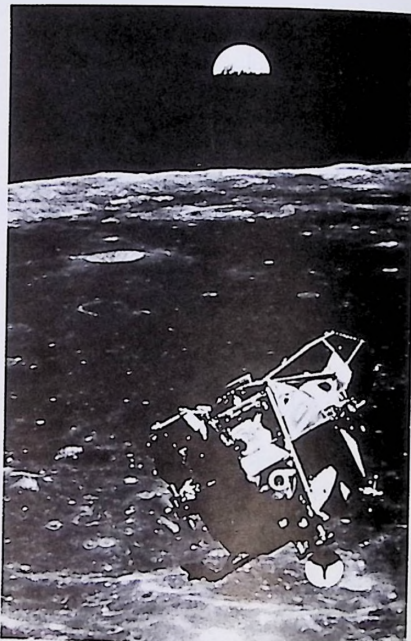
First, the Apollo Command/Service Module separated from the third stage and Commander Armstrong turned the spacecraft around to dock with the Lunar Module in its adapter. Following this maneuver, the Command/Service Module with the Lunar Module attached separated from the third stage of the Saturn V.

For the three Apollo 11 astronauts the 71½ hour journey to the vicinity of the Moon and insertion into Lunar orbit was almost routine and the spacecraft's

course on this historic mission was so accurate that only one out of a possible four mid-course corrections was necessary.

By midnight of the first day the Apollo 11 spaceship was 75,000 miles away from Earth and 170,000 miles from the Moon. Its speed had dropped from a peak of 24,200 miles per hour as they broke out of Earth orbit to slightly less than 5,000 miles per hour as the Earth's gravity continued to drag on the Apollo craft.

While the astronauts slept, their spaceship hurtled toward a so-called "Twilight Zone" where the gravitational pull of the Earth and Moon is about equal. Then on July 18 at 11:22 p.m. E.D.T. the Apollo spaceship came within the full grip of the Moon's gravity and its speed increased from about 2,000 to 5,700 miles



The Apollo 11 Lunar Module ascent stage photographed from the Command and Service Module during rendezvous in lunar orbit.

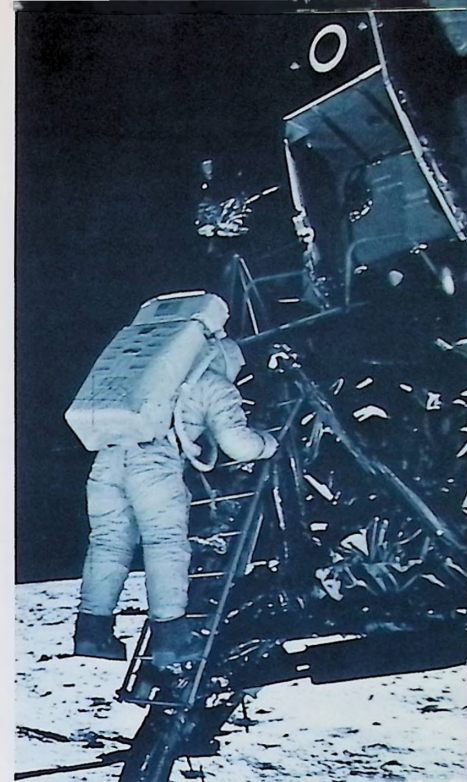
per hour as the spacecraft began its sweep toward the backside of the Moon.

Before the spacecraft reached the backside of the Moon, Astronauts Armstrong and Aldrin wriggled through a tunnel connecting the Command Module with the Lunar Module to check the systems of the spindly-legged lander. During the following two hours, both men carefully checked the craft to assure that it was ready for its flight to the lunar surface.

It was 1:28 p.m. E.D.T. Saturday, July 19, when the Apollo spaceship weighing 48 tons and traveling at a speed of 5,225 miles per hour zoomed over the left edge of the Moon. Once behind the solar body, the astronauts headed for a climactic moment in the mission when they fired the Service Module's engine to place them in a precise orbit above the lunar surface.

Firing the Service Module's engine for six minutes, Commander Armstrong placed the Apollo spaceship in a 61 by 169 mile high orbit of the lunar terrain. The astronauts had the option of cancelling the firing had they detected anything wrong, but without this maneuver the spaceship would have looped once behind the Moon and headed back to Earth.

On the spacecraft's second revolution of the Moon, the astronauts sent 34 minutes of televised views of the lunar surface from 90 miles up—including a guided television sweep of the approach which the lander "Eagle" was to take the following day. In the third orbit, Astronaut Collins, in command of the Service Module rocket controls fired its engine for 17 seconds to change the spacecraft's orbit from 61 by 169 miles to 66 and 54 miles above the Moon. After the orbit was altered, Astronaut Aldrin crawled into the Lunar Module for some



In this photograph taken by Armstrong, Aldrin is shown as he descends LM ladder.

final equipment tests.

Tests completed, he returned to the Command Module where the three Moon explorers had supper and a nights rest in preparation for the next day's activities.

That historic Sunday began for the astronauts at about 9:00 a.m. E.D.T. when Armstrong and Aldrin again squirmed into the Lunar Module for a series of equipment checks that lasted until 1:20 p.m. E.D.T. Unlocking from "Columbia", the "Eagle" circled the Command Module for 20 minutes. Then, Astronaut Collins piloted his command ship a half-mile below and two miles ahead of the LM as it prepared to swoop down onto the lunar surface.

At 3:12 p.m. E.D.T. Commander Armstrong fired the LM's descent engine to lower the ship to an orbit that would take it within 50,000 feet of the Moon's

The foreground shows clear footprints of Apollo 11 Commander Neil A. Armstrong, the first man to set foot on the Moon, as Astronaut Edwin E. Aldrin contemplates the U.S. flag.

surface. From there he began firing the engine continuously for the remaining 12 minutes until touchdown. Dodging a rock strewn crater in the last few seconds, Astronaut Armstrong piloted the Lunar Module to a landing on the Sea of Tranquility at exactly 4:18 p.m. E.D.T., Sunday, July 20, 1969.

With the establishment of "Tranquillity Base" two U.S. astronauts had fulfilled mankind's dreams of journeying to the Moon, and technically had achieved the national goal established eight years before by President John F. Kennedy. But in landing on the Moon, Apollo 11 had completed only half of its mission. Lunar exploration was yet ahead of the two spacemen.

After depressurization of the LM, Astronaut Neil A. Armstrong crawled onto the craft's front porch and into the airless vacuum of the Moon. He carefully climbed down the lunar lander's steps, placed his right foot into the spaceship's landing pad and at 10:56 p.m. E.D.T. July 20, 1969 stepped from the Lunar Module to become the first earthling to ever set foot on the Moon. His movements were seen all over the world through the eyes of a television camera mounted on the LM and the people of the Earth shared his glory, when using an RCA developed communications system, he said: "That's one small step for a man, one giant leap for mankind."

He described the surface as "fine and powdery" and it clung to his boots like fine charcoal dust.

During the next two hours and 31 minutes, Commander Armstrong walked the lunar surface, joined by Astronaut Aldrin for one hour and 50 minutes. They spoke with the President of the United States and planted an American Flag that will remain for all time. Then Aldrin set out experiments to detect

solar winds and Moon quakes and placed a laser reflector on the lunar surface that would enable scientists to accurately determine the distance of the solar body from Earth. The astronauts also collected over 50 pounds of lunar rocks and soil, cavorted about the terrain in a demonstration of how Man can move freely on the Moon's surface where his weight is one sixth that on Earth, left a ceremonial plaque, and deposited a small disc containing messages from world leaders.

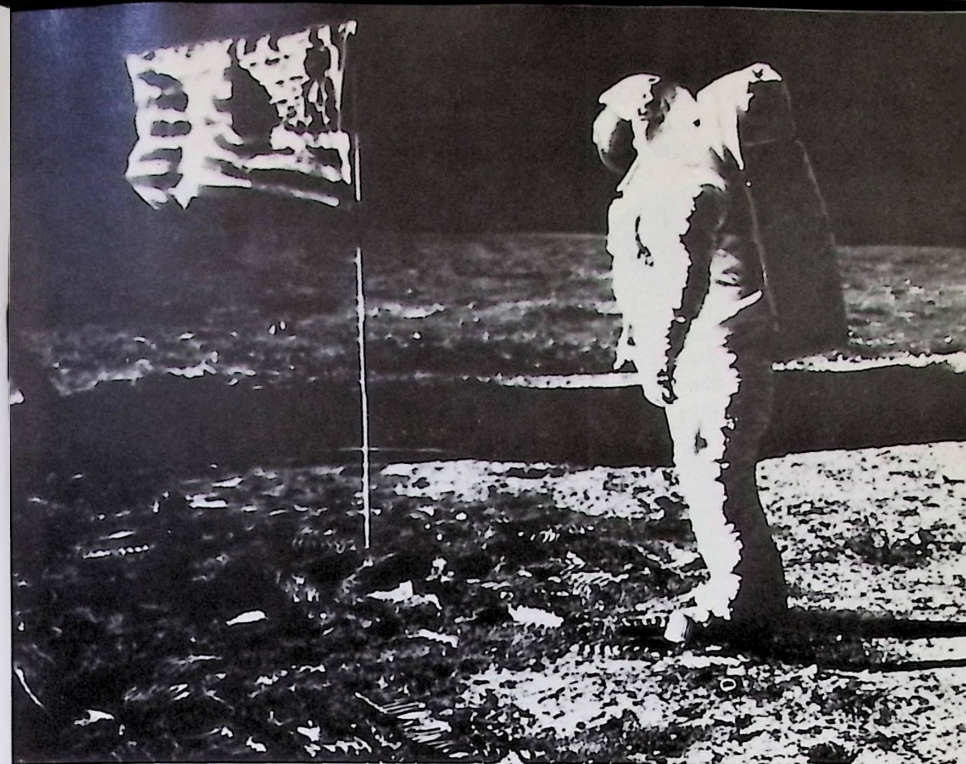
While obtaining core samples of the Moon's surface, and setting out a seismometer, the two men used RCA communications equipment to carry on a continuous description of the lunar environment immediately around them.

Their precious time on the surface of the Moon was drawing rapidly to a close. Commander Armstrong picked up as many pieces of Moon Rock as rapidly as he could while Mission Control on Earth prodded Astronaut Aldrin into returning to the Lunar Module.

With Aldrin inside, the two spacemen began the task of raising the lunar samples into the ascent stage of the LM by means of a hoist inside the Eagle and a loosely-swung double line of tape.

Then, at exactly 1:11 a.m. E.D.T. July 21, 1969 Man's first exploration of the Moon came to an end as Commander Neil Armstrong ascended the Lunar Module's ladder, and sealed closed the LM's hatch. By about 3:00 a.m. E.D.T. the astronauts had finished preparing to jettison the excess equipment they were to leave on the Moon.

At 4:25 a.m. E.D.T. both astronauts and Michael Collins, who had continued to orbit the Moon in the Command Module, were given the o.k. to rest. The "Eagle" had been completely checked to assure its blast off from the Moon, for on its



ability to rise from the lunar surface rested the return of mankind's first Moon explorers. Should the ascent stage engine for any reason fail to fire, the two astronauts would have been stranded forever without hope of rescue, and Astronaut Collins in the Command Module would have been forced to return to Earth alone. Such a disaster did not occur.

At 1:54 p.m. E.D.T., Monday, July 21, Commander Armstrong fired the LM's ascent stage engine and the two astronauts blasted from their Moon base in the Sea of Tranquility to end the 21 hours and 36 minute stay on the lunar surface. After several orbits of the Moon, the Lunar Module linked up at 5:35 p.m. E.D.T. with the Command Module for the return to Earth.

Once the rendezvous and docking of the two spacecraft was completed, the

astronauts began transferring the boxes of lunar samples from the Lunar Module to the Command Module. This completed, the "Eagle" was abandoned in a solitary lunar orbit.

A final burn by the Service Module's 20,500 pound-thrust engine—again while Apollo was behind the Moon—pushed the spacecraft's speed from 3,600 miles per hour to the 6,188 miles per hour required to free the Apollo craft from the Moon's gravitational pull.

At 12:55 a.m. E.D.T. Tuesday, July 22, the three astronauts began their quarter of a million mile journey home to Earth and splashdown in the Pacific Ocean. Thus, Man's dream had been realized—he had walked on the surface of the Moon and now he was returning to Earth, a planet that would be enriched for centuries to come as a result of his exploration of the Moon.

Broadening Horizons

APOLLO 12—November 14–24, 1969. Second manned exploration of the Moon. Total stay time: 31 hrs., 31 min.



Lift off: 11/14/69 — Splashdown: 11/24/69 — Flight Time: 244:36:25
Astronauts: Charles Conrad, Jr., Richard F. Gordon, Jr., Alan L. Bean
Command Module: Yankee Clipper — Lunar Module: Intrepid

While Apollo 11 demonstrated man's capability to leave Earth, land on the Moon and return home, Apollo 12 ushered in a new era of broadening of the horizons of science.

At 11:22 a.m. on November 14, 1969 Apollo 12 lifted off with its all-Navy crew—Spacecraft Commander Captain Charles Conrad, Captain Alan L. Bean, pilot of the Lunar Module Intrepid, and Captain Richard Gordon, pilot of the Command Module Yankee Clipper.

Although overcast skies and rain threatened to delay the launch, the lift-off proceeded on schedule. As the Saturn V space vehicle entered the clouds, a bolt of lightning arcing between the rocket and the ground caused overloading of the electrical system. The backup battery system took over, however, and within three minutes the crew had all circuits back in operation. The rest of the journey to the Moon went smoothly.

One of the major objectives of the mission was to establish the capability for a pinpoint landing, needed for future

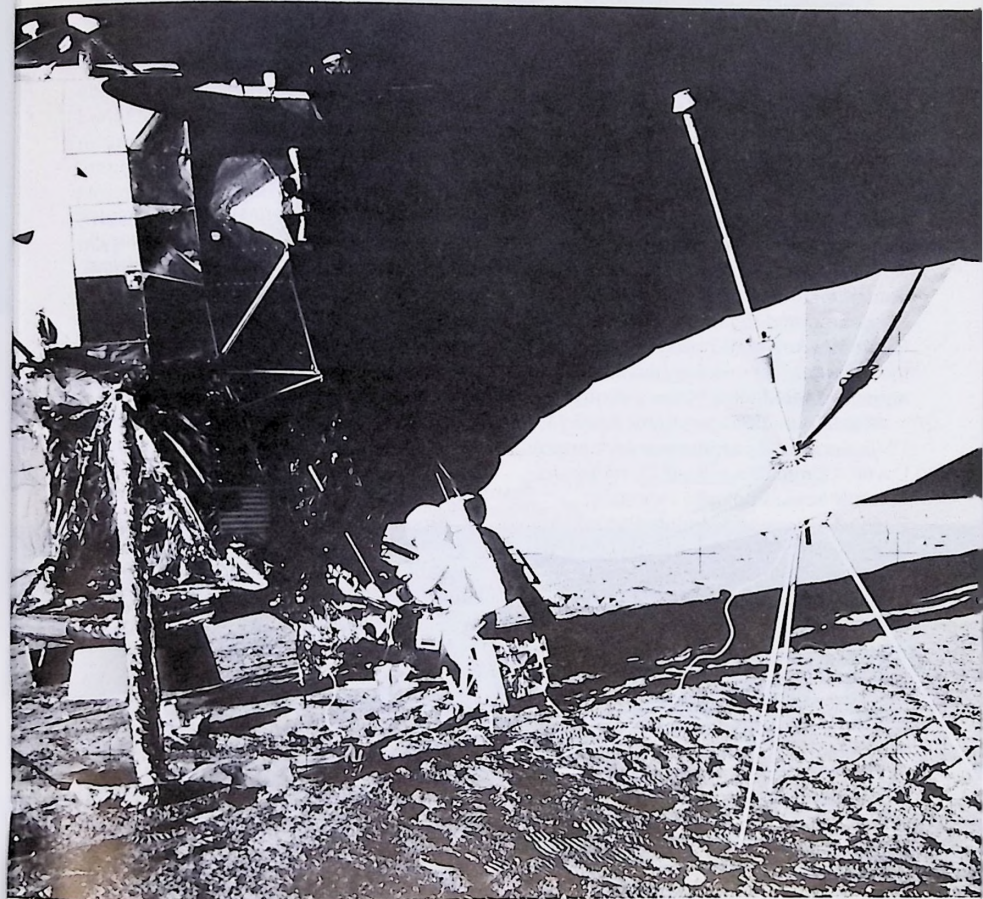
missions which were targeted for rough Moon terrain landings. The target was Surveyor 3, an unmanned spacecraft that landed on the Moon in April, 1967. Spacecraft Commander Charles Conrad manipulated the Lunar Module Intrepid to a pinpoint landing 600 feet from Surveyor 3 in the "Ocean of Storms."

A significant part of the Apollo 12 mission were the ALSEP (Apollo Lunar Surface Experiments Package) instruments deployed by the astronauts. The power for the ALSEP was provided by a device unique in space history—a nuclear power source fueled by a rod of uranium 238. Included among the ALSEP instruments were:

- A seismometer for recording shock waves on the Moon
- A surface magnetometer designed to determine the existence of and measure a lunar magnetic field.
- A lunar atmosphere detector which measured the density of the very attenuated lunar atmosphere.
- An ionosphere detector to measure the lunar ionosphere.

Astronauts Conrad and Bean were described as "real rockhounds" by the geologists monitoring their activities. During their two walks on the Moon, the astronauts gathered rocks from varied areas of the lunar terrain while providing the geologists a running commentary on the specific locations and samples. A total of about 75 pounds of samples were returned by Apollo 12.

After lift-off from the Moon and a smooth docking with the Command Module Yankee Clipper, the astronauts headed home. Two mid-course corrections put the spacecraft on target for splashdown on November 24, only 3.5 nautical miles from the prime recovery ship, Hornet.



RCA's S-band erectable antenna deployed by the astronauts to augment their radio signal strength.

"We've Got a Problem"

APOLLO 13—April 11–17, 1970. Mission aborted because of Service Module oxygen tank failure.



Lift off 4/11/70 — Splashdown: 4/17/70 — Flight Time: 142:54:41
Astronauts: James A. Lovell, Jr., John L. Swigert, Jr., Fred W. Haise, Jr.
Command Module: Odyssey — Lunar Module: Aquarius

From lift off to splashdown, only a thin strand connects the astronauts of the Apollo Program to Earth—the communications link between the spacecraft and the Mission Control Center in Houston. During Apollo 13, the communications link became an all-important life line to the astronauts.

At 2:13 p.m. EST, Saturday, April 11, 1970, Apollo 13 and its team of James A. Lovell, Commander, Fred W. Haise, Jr., Lunar Module Pilot and John L. Swigert, Command Module Pilot, were launched from Kennedy Space Center, Florida. The mission continued on schedule and as planned until Monday evening. The Command/Service Module was linked to the Lunar Module and the joined spacecraft were 207,000 miles from Earth, speeding toward the Moon. Lovell and Haise had entered the Lunar Module, named Aquarius, for a series of checks and had telecasted their activities back to Earth. Haise was still in Aquarius. Lovell was in the tunnel between Aquarius and the Command/Service Module, called Odyssey. Swigert was in Odyssey.

Suddenly they were startled by a loud bang. In Odyssey, the instrument panel indicated that one of the main electrical systems of Apollo 13 was deteriorating. Just before 10:10 p.m., Swigert calmly radioed these words: "Hey, we've got a problem here."

With that first indication of serious trouble for Apollo 13, a dramatic rescue operation began involving hundreds of ground controllers and thousands of technicians and scientists.

Housed in the Service Module, high pressure oxygen tanks and hydrogen tanks feed three fuel cells that generate the spacecraft's electrical current, provide breathing oxygen and produce water. An apparent rupture of one of the high pressure oxygen tanks crippled the spacecraft Odyssey. Three days from home, the spacecraft now had electricity for only 15 minutes operation under normal procedures.

The Lunar Module became a lifeboat for the three astronauts, and the RCA Communications System in the LM became their life line to Earth. The Lunar Module was powered up and the

Command Module was shut down to save its batteries, oxygen, and cooling water in hope they could ultimately be used for reentry and landing.

The Moon still lay 50,000 miles and 20 hours ahead. And, although the current trajectory would take the crippled spacecraft around the Moon and back toward Earth, the returning ship would miss the Earth by 250 miles and pass on by, beyond hope of survival.

After many alternatives were prepared and analyzed by trajectory planners, Mission Control decided on a two-step abort of the mission: a short burn of the Lunar Module engine to assure free return of the spacecraft to Earth, and a longer burn after looping around the Moon to speed the return and pinpoint the target area in the mid Pacific where the prime recovery forces waited.

The first burn was successful and the spacecraft headed for the far side of the Moon. On Earth, meanwhile, possible future maneuvers were tried out in flight simulators: the big burn to get quicker return, attitude control, maneuvering to drop the Service Module and others. Engineers conferred with

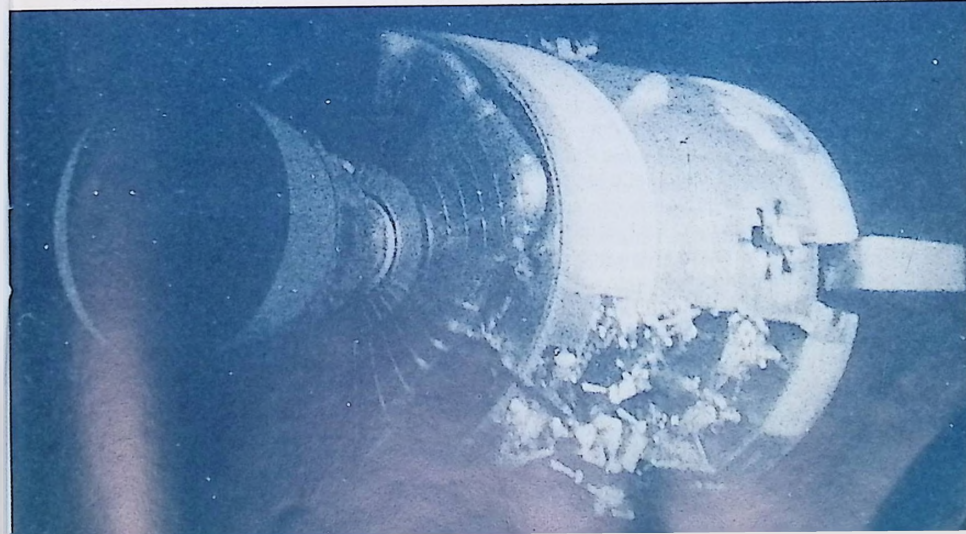
experts on the Command/Service Module, Lunar Module and guidance systems and ran emergency problems through computers.

At 7:49 p.m. Tuesday, the spacecraft emerged from its swing around the Moon and headed home. The long burn of the descent engine of the Lunar Module took place on schedule to shorten the return flight by 10 hours and put the spacecraft on target for splashdown. A mid-course correction was later necessary to put Apollo 13 within the reentry corridor.

Several delicate maneuvers remained for the crew of Apollo 13. First, the Service Module had to be jettisoned. The astronauts then abandoned their lifeboat, the Lunar Module, and entered the Command Module. Finally, the Lunar Module was jettisoned. The Command Module then plunged into the atmosphere, and at 1:08 p.m. Friday, April 17, 1970, the three astronauts splashed down only four miles from the prime recovery ship, the USS Iwo Jima.

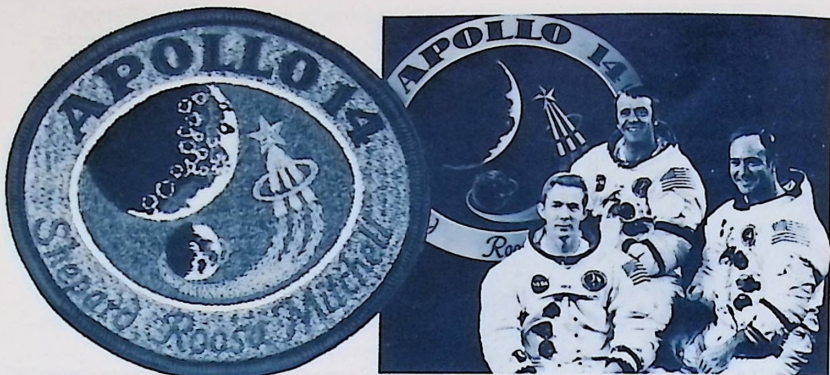
Through closely linked teamwork on the ground and in the crippled spacecraft, Apollo 13 was brought safely home.

View of the damaged Service Module photographed from the Lunar Module/Command Module following jettison of the SM.



Mission to Fra Mauro

APOLLO 14—January 31–February 9, 1971. First manned landing in an exploration of lunar highlands. Total stay time: 33 hrs., 31 min.



Lift off: 1/31/71 — Splashdown: 2/9/71 — Flight Time: 216:01:59
Astronauts: Stuart A. Roosa, Alan B. Shepard, Jr., Edgar D. Mitchell
Command Module: Kitty Hawk — Lunar Module: Antares

Apollo 14, man's third successful landing on the Moon, had as its prime objective the scientific exploration at Fra Mauro. This lunar area is quite different from those of the Apollo 11 and 12 missions. Fra Mauro is an upland or foothill region, as compared with the flat plains or lunar mare areas visited earlier. Apollo 14 was the most ambitious attempt at lunar scientific exploration up to that time, and all prime mission objectives were accomplished.

The three-man crew consisted of Alan B. Shepard, Jr., Commander; Edgar D. Mitchell, Lunar Module Pilot; and Stuart A. Roosa, Command Module Pilot. Apollo 14 was launched into an overcast sky at 4:03 p.m., EST, Sunday, January 31, 1971 from the Kennedy Space Center, Florida. Because of weather conditions, the liftoff was

delayed for 40 minutes, the first launch delay in the Apollo Program.

Three and one-half days later, the three astronauts arrived in the vicinity of the Moon and inserted their craft into Moon orbit. Roosa remained alone in the command ship, Kitty Hawk, while Shepard and Mitchell in the Lunar Module, Antares, made a perfect touchdown on the Moon within a few yards of the planned landing point.

During their first Moon walk, lasting four hours and 50 minutes, the astronauts collected more than 40 pounds of rocks and set up the ALSEP (Apollo Lunar Surface Experiments Package) and other experiments.

Included in the experiments were such instruments as:

- Seismometer for sensing tremors on the Moon.
- Charged Particle Lunar Environment Experiment (CPLEE) for measuring energies of particles (solar electrons and protons) which bombard the lunar surface.
- Suprathermal Ion Detector (SIDE) for detecting lower energy positive ions and high energy solar wind flux of positive ions.
- Cold Cathode Ionization Gauge for measuring minute quantities of gas above the lunar surface.
- Solar Wind Composition experiment which trapped solar wind particles for return to Earth for analysis.
- Laser Ranging Retro-Reflector for reflecting a laser beam from Earth to allow scientists to make precise distance measurements between Earth and Moon, and between points on Earth.

The second Moon walk was almost entirely devoted to the longest Moon traverse made by man to that time. The walk took the astronauts nearly 4,000 feet from Antares. During that trip, the men collected approximately 50 pounds of rocks, took measurements of the Moon's magnetic field, dug a shallow trench to test soil, described lunar topography, and became the first humans to climb lunar hills.

Another first of Apollo 14 was the Modularized Equipment Transporter (MET), a small two-wheeled cart loaded with instruments and geological tools. It made the first tire tracks on the Moon's surface, but not the last, as Apollo 15 would soon demonstrate.



Astronaut Mitchell during extravehicular activity.

After 33 hours and 32 minutes on the Moon, Shepard and Mitchell ignited Antares' ascent engine and launched themselves off the lunar surface. After linking up with Kitty Hawk and Roosa, the astronauts headed home for a splashdown in the Pacific Ocean at 4:05 p.m., EST, February 9, 1971.

Man Must Explore

APOLLO 15—July 26–August 7, 1971. First use of lunar roving vehicle to transport astronauts over Moon's surface. Ground-commanded color television system showed first live TV coverage of LM lift off from Moon. Total EVA time: 19 hrs., 9 min. Total lunar stay time: 66 hrs., 55 min.



Lift off: 7/26/71 — Splashdown: 8/7/71 — Flight Time: 295:12
Astronauts: James B. Irwin, David R. Scott, Alfred M. Worden
Command Module: Endeavour — Lunar Module: Falcon

At 6:15 p.m., EDT on July 30, 1971 the lunar landing craft of Apollo 15 alighted on the lunar plain called Palus Putredinis (Marsh of Decay). USAF Colonel David R. Scott, Mission Commander, and USAF Lieutenant Colonel James B. Irwin, Lunar Module Pilot, had landed on the Moon between the lunar Apennine Mountains towering 15,000 feet above the flatlands, and the mile-wide Hadley Rille, which ranges from 600 to 1200 feet in depth. This landing site enabled the Apollo 15 expedition to study three different types of lunar topography—a mare basin (plain), lunar rille (gorge), and mountain front.

The ability of the Apollo 15 astronauts to explore was greatly enhanced by the use of a Lunar Roving Vehicle (LRV) which provided Scott and Irwin history's first drive on the Moon.

During three separate motor trips, they explored the rim of Hadley Rille, the edges of deep craters, and the slopes of the Apennine Mountains.

A feature of the Lunar Rover, as the

LRV was called, was RCA's earth-controlled color television camera which enabled viewers throughout the world to observe the varied terrain of the Moon explored by the astronauts.

On their second lunar trip, the astronauts discovered a unique crystalline stone perched on a rock that was lying on an Apennine slope. The sample, which has been called the "genesis rock," is believed to have been formed more than four billion years ago.

During their lunar expeditions, Scott and Irwin gathered about 170 pounds of lunar rock samples, many unlike any brought back by previous missions. The astronauts also conducted many scientific experiments including: taking core samples as deep as 7 feet 9 inches from the lunar plain; placing heat sensors into the bored holes to determine internal temperatures of the Moon; and setting up the Apollo Lunar Surface Experiment Package containing instruments to report on Moonquakes and meteorite impacts, the lunar magnetic field, the solar wind, the nearly

nonexistent wisps of lunar atmosphere, and any heat escaping from beneath the Moon's surface.

While Scott and Irwin were working on the Moon's surface, USAF Major Alfred M. Worden in the Command Module, Endeavour, was collecting pictures and other science data from orbit. Among the scientific instruments in the Scientific Instrument Module (SIM) aboard the Command/Service Module were:

- An X-ray detector, for picking up secondary X-rays resulting when solar X-rays strike minerals on the Moon, indicating distribution of minerals.
- A magnetometer which detected a weak lunar magnetic field.
- A gamma ray spectrometer which detected radioactive hotspots on the Moon.
- A laser altimeter which operated in conjunction with a mapping camera to provide precise determination of the Moon's geographical and topographical characteristics.

At 1:11 p.m., EDT, August 2, Scott and Irwin launched the Lunar Module,

Falcon, from the Moon to link up with Endeavour. This launch was the first at which mankind could be a spectator.

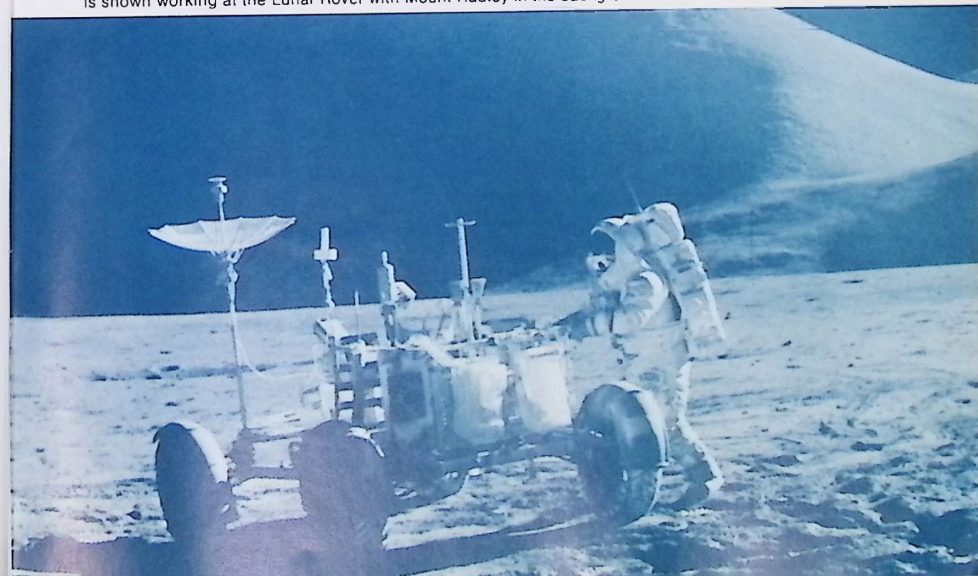
The TV camera on the Lunar Rover, which was left behind, telecast the lift-off of Falcon for all the world to see.

Before leaving lunar orbit, the crew of Endeavour launched a 78½-pound scientific subsatellite which is providing new details on lunar gravity, the Moon's space environment, and on the weak localized lunar magnetic fields.

On August 5, still about 197,000 miles away from home, astronaut Worden performed the first walk in deep space to pick up cassettes of film from the SIM Bay.

Then at 4:46 p.m., EDT, August 7, Endeavour splashed down in the mid-Pacific. During the mission, Commander Scott had expressed the feelings of other explorers, past and future: "As I stand out here in the wonders of the unknown at Hadley, I try to realize there is a fundamental truth to our nature. Man must explore. And this is exploration at its greatest."

RCA's Ground-Commanded Color Television Assembly provided live television pictures of the areas explored by the Apollo 15 astronauts. Astronaut Scott is shown working at the Lunar Rover with Mount Hadley in the background.



Moon Mountains

APOLLO 16—April 16–27, 1972. Fifth manned exploration of the Moon. Lunar roving vehicle and ground-commanded color television system again used to enhance scientific expeditions on lunar surface. Lunar EVA time: 20 hrs., 14 min. Total lunar stay time: 71 hrs., 14 min.



Lift off: 4/16/72 — Splashdown: 4/27/72 — Flight Time: 265:51
Astronauts: John W. Young, Thomas K. Mattingly, II, Charles M. Duke, Jr.
Command Module: Casper — Lunar Module: Orion

The lunar highlands are believed by some scientists to be the oldest region on the Moon. The mission of Apollo 16 was to explore and collect rocks and soil samples in the highland regions of the Moon near the crater Descartes.

On April 16 at 12:45 p.m. EST, Apollo 16 lifted off from Pad A of Launch Complex 39, Kennedy Space Center—carrying Astronauts John W. Young, Spacecraft Commander; Thomas K. Mattingly II, Command Module Pilot; and Charles M. Duke, Jr., Lunar Module Pilot.

Apollo 16's code names were "Casper" for the Command Module (after the friendly ghost) and "Orion" for the Lunar Module (after the constellation also known as "The Hunter").

Each Apollo mission provided new information and some surprises about the Moon, and Apollo 16 was no exception. The Apollo 16 astronauts recorded the strongest magnetic forces yet discovered on the Moon, indicating a lunar history of faster spinning and/or a hotter core than theories hold. Mattingly,

observing from lunar orbit, sighted what appeared to be the cooled remains of a lava flow on the wall of a crater, providing additional evidence of past volcanic action on the Moon.

Although a problem in the control system for the thrust controls of the Command Module shortened the duration of the Apollo 16 flight by about one day, all but one of the 33 major experiments of the mission were accomplished.

Among the achievements of the Apollo 16 astronauts: the longest times up to then spent on the Moon (71 hours, 2 minutes), and in surface extravehicular activities (total of three EVA's was 20 hours, 14 minutes), and the largest amount of lunar rock and soil samples (about 213 pounds) ever returned to Earth.

Astronauts Young and Duke also made the first use of the Moon as an astronomical observatory. They set up two instruments to scan the lunar sky: a far ultraviolet camera/spectrograph that photographed emissions or absorption

of energy from hydrogen atoms; and a cosmic ray detector which provided new information on sources of highly energetic particles which streak from the Sun and other stars.

On April 27, 1972 the three main parachutes billowed from the spacecraft as it came down in the Pacific Ocean, only three-fifths of a nautical mile off target.

Apollo 16, like the earlier flights, brought back information about the Moon that is relevant to the study of the origins of the Earth and the solar system. The vast treasure of lunar data from Apollo has contributed more to man's knowledge of the Moon and the Earth than centuries of theorizing and Earth observations.

With Stone Mountain as a background, Astronaut John W. Young leaps from the lunar surface as he salutes the U.S. flag at the Descartes landing site.



Final Apollo Flight

APOLLO 17—December 7–19, 1972. Sixth and final expedition planned in the Apollo program. Longest mission and lunar stay time of the program. One space and three lunar EVAs. Lunar EVA time: 22 hrs. Total lunar stay time: 75 hrs.



Lift off: 12/7/72 — Splashdown: 12/19/72 — Flight Time: 301:51
Astronauts: Harrison H. Schmitt, Ronald E. Evans, Eugene A. Cernan
Command Module: America — Lunar Module: Challenger

"We'll expect engine ignition at 8.9 seconds . . . 10 . . . 9 . . . 8 . . . 7 . . . ignition sequence started—all engines are started—we have ignition 2, 1, zero—we have a lift off. We have a lift off and it's lighting up the area, it's just like daylight here at Kennedy Space Center as the Saturn V is moving off the pad. It has now cleared the tower."

These words from launch control describe the lift off of Apollo 17 from Pad 39-A at 12:33 a.m. EST, on December 7, 1972. The last of the Apollo missions, Apollo 17 was the first night launch.

The Lunar Module "Challenger" touched down on the Taurus-Littrow lunar landing site at 1:55 p.m., December 11, with USN Captain Eugene A. Cernan, Apollo 17 Commander, and Dr. Harrison H. Schmitt, Lunar Module Pilot, aboard. This sixth manned lunar landing began man's longest stay on the surface of the Moon—74 hours, 59 minutes, 38

seconds. During their stay on the lunar surface, while conducting scientific experiments and collecting samples of lunar rocks and soil, the Apollo 17 astronauts also set other new records: the longest single lunar surface EVA time (7 hours, 37 minutes, 21 seconds); the longest total lunar surface EVA time (22:05:06); the longest lunar distance traversed with the Lunar Roving Vehicle on one EVA (19 kilometers); and the longest total distance traversed with the LRV (35 kilometers). They also returned to Earth the most lunar samples (250 pounds).

While Cernan and Schmitt were exploring the lunar surface, USN Captain Ronald E. Evans, Command Module Pilot, was orbiting the Moon in the Command/Service Module "America". Evans operated a complex array of scientific instruments and lunar mapping and panoramic cameras.

Included in the equipment aboard the Service Module was a new experiment carried for the first time on Apollo 17—the Lunar Sounder. As part of the system, a powerful radar penetrated three-fourths of a mile below the Moon's crust to map subsurface layers and detect any water or mineral deposits existing there.

The successful Pacific Ocean splashdown of Apollo 17 at 2:24 p.m., December 19, marked the end of an era of manned lunar exploration. The knowledge and scientific and technological advances created by the Apollo program, however, will continue to be of ever-increasing benefit to all mankind.

The Apollo 17 space vehicle illuminates the night sky as it lifts off for the final lunar expedition in the Apollo Program.



Apollo Systems by RCA

Perhaps equally as significant as man's landing on the Moon are the systems which enable him to go there. Among them are the most complex and sophisticated electronics and communications devices yet developed.

Virtually every RCA electronic system on the Lunar Module is a major technological achievement. For example, the RCA control assembly to throttle the LM descent engine so the spacecraft can touch down gently on the Moon could fit into a shoebox with room to spare.

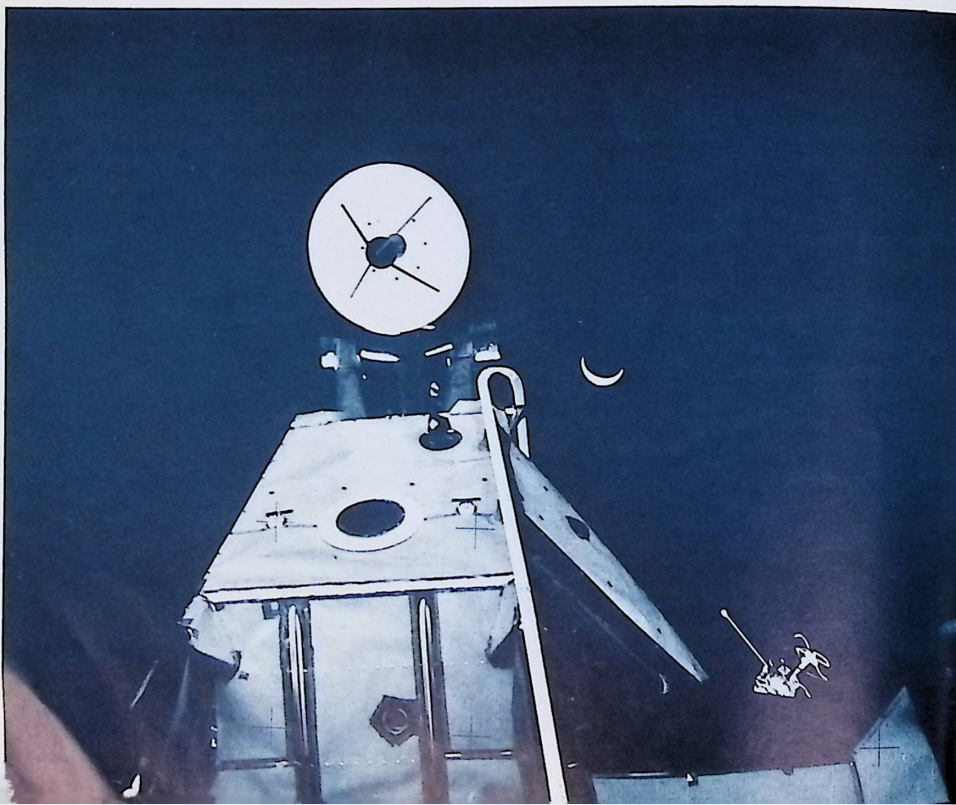
Other equipment includes the landing radar for the LM that measures the spacecraft's velocity and altitude with respect to the Moon. This information is then combined with information from

other LM sensors, computers and control systems to produce a soft, safe lunar landing.

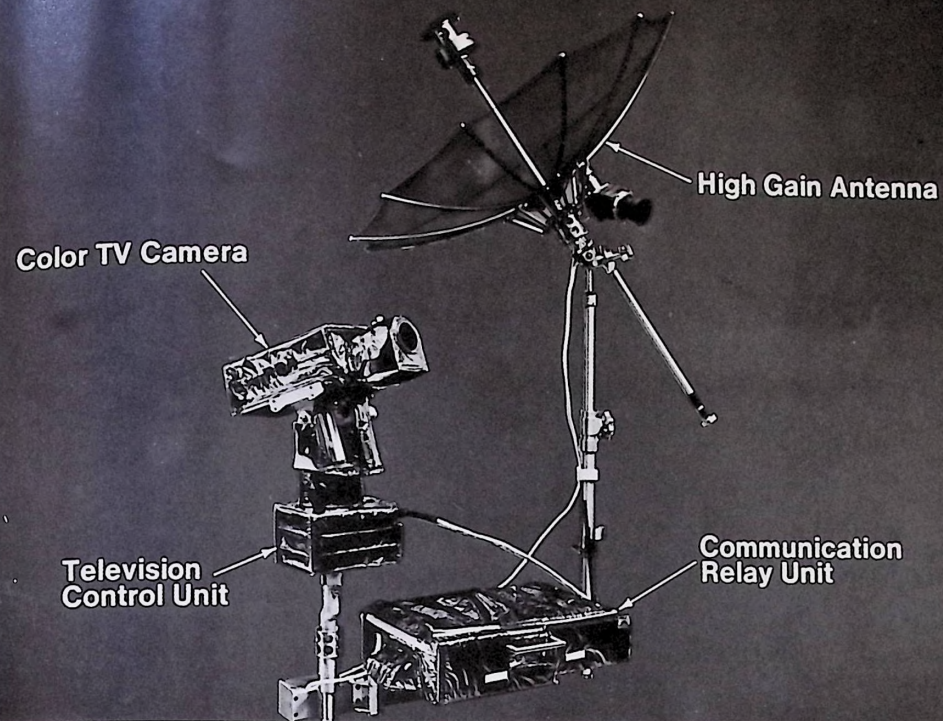
As the LM prepares to leave the Moon, its RCA-built rendezvous radar tracks the Command Service Module in lunar orbit to determine the proper time for lift off. When the LM rises, the radar continues to track the CSM so the Moon-landing astronauts can maneuver back to the mother ship for the trip home.

Throughout the complex mission, the LM astronauts talk to the CSM and to mission controllers on Earth by one of the most elaborate communications systems ever developed. The RCA system can transmit everything from live television showing the astronauts

Apollo 14 astronauts shot this picture from the bottom of the ladder of their Lunar Module. RCA's Rendezvous Radar antenna is shown on top of the LM, with the crescent-shaped Earth in the background.



Lunar Communication/TV System



exploring the Moon, to the spacemen's pulse rates. In addition, the system can compute the range between the CM and LM when the two vehicles are separated.

Even before the Saturn V rocket lifts our astronauts from the launch pad, two advanced RCA computers check over 3,000 factors of the giant launch vehicle to assure its perfect performance.

And once our astronauts are on their way to the Moon, the attitude and control of the Lunar Module is determined by two highly complex RCA-built engine control systems. They are the Attitude and Translation Control Assembly and the Descent Control Assembly. These systems determine the sequence for firing of 16 reaction control jets for spacecraft attitude and to shift its position side-to-side and front-to-rear. The Descent Engine Control Assembly

is a small electronic device which can throttle the LM engine from as little as 10 per cent power to full thrust. It also allows the engine to be gimbaled so its direction of thrust is properly aligned with the spacecraft's center of gravity.

There is also an Extra-Vehicular Communications System built by RCA that allows both astronauts piloting the Lunar Module to leave the spacecraft and simultaneously explore the lunar surface. Carried by the astronauts as part of their Extra-Vehicular Activity Backpack, the communications units are approximately the size of a cigar box.

For live television transmission from the Moon's surface, an expandable antenna that was contained in a cylinder, 10 inches in diameter and 39 inches long, was developed by RCA. Mounted on a tripod, the antenna was deployed by the

Apollo 12 and 14 astronauts to a 10 foot diameter and was used for communications and television transmissions between the Moon and Earth.

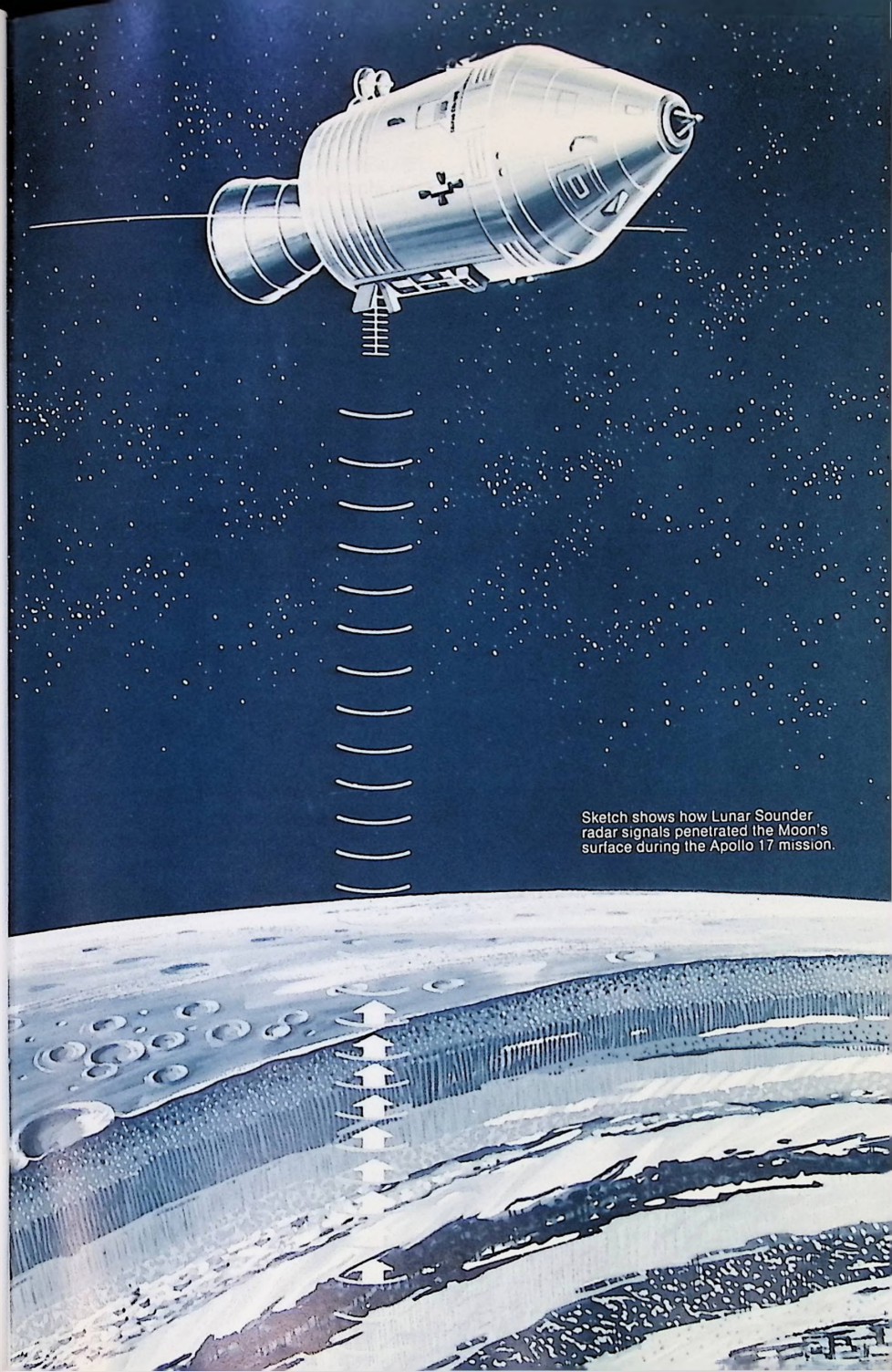
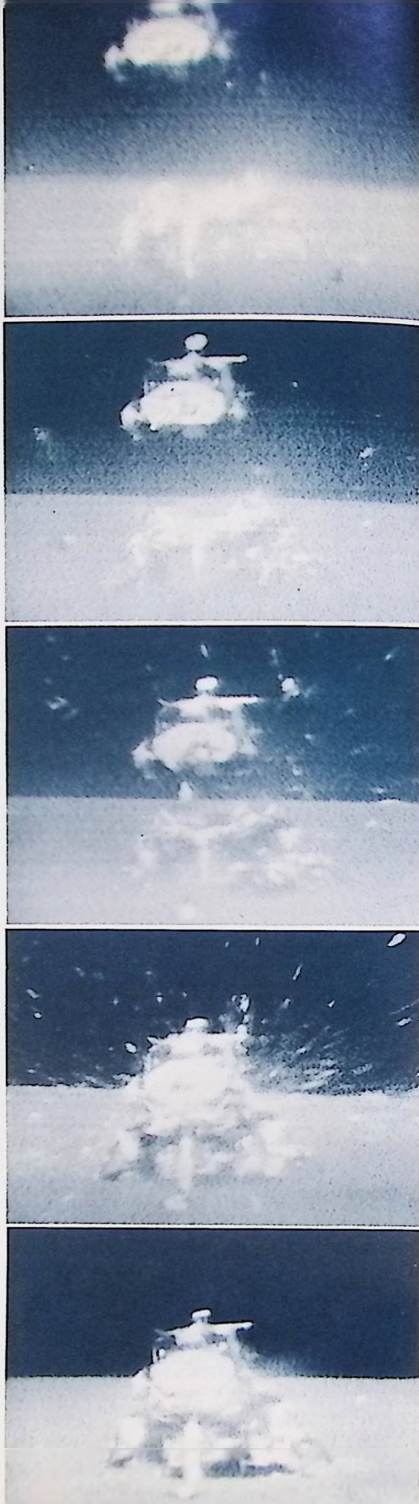
Used for the first time on Apollo 15, RCA's Ground Commanded Color Television Assembly (GCTA) consists of a space color TV camera, and a control unit which allows controllers at the Manned Spacecraft Center in Houston to operate the camera. Mounted on the Lunar Rover, the GCTA provided live television pictures from all of the areas explored by the astronauts, as well as the first live TV coverage of a Lunar Module lift off from the Moon.

Also mounted on the Lunar Rover of Apollo 15 was RCA's Lunar Communications Relay Unit which transmitted voice, telemetry and the color television pictures from the Moon and received transmissions directly from Earth.

The Command/Service Module also had a new addition for Apollo 15—RCA's Laser Altimeter. Operated in conjunction with a mapping camera, this laser altimeter was used to provide precise determination of the Moon's geographical and topographical characteristics, measuring the altitude of the C/S Module with an accuracy to within one meter.

During the Apollo 17 mission, the Lunar Sounder was used to map subsurface features of the Moon and detect any water or mineral deposits there. As a part of the system, RCA's powerful radar was able to distinguish echoes varying in strength by as much as a million to one. The Sounder was operated from the Command/Service Module orbiting the Moon at about 69 miles.

First live TV coverage of a Lunar Module lift off from the Moon, at the moment of launch.



Sketch shows how Lunar Sounder radar signals penetrated the Moon's surface during the Apollo 17 mission.

Skylab

Skylab will be the first United States manned space flight program developed specifically to carry activities and equipment aimed at improving man's life on Earth.

Skylab will evaluate systems and techniques designed to gather information on Earth's resources and environmental programs.

Solar telescopes will substantially increase man's knowledge of our Sun and the multitude of solar influences on Earth's environment.

Medical experiments performed aboard Skylab will increase knowledge of man himself and his relationship to his Earthly environment and adaptability to space flight.

Additionally, Skylab will experiment with industrial processes which may be enhanced by the unique weightless, vacuum environment of space.

Skylab will operate in space for about eight months during which time there will be three manned missions separated by two periods of unmanned operation. The first mission will begin in the spring of 1973 with two launches from Kennedy Space Center, Florida.

The first launch will be unmanned. The first two stages of a Saturn V launch vehicle will place the Skylab into Earth orbit.

The next day a manned modified Command/Service Module (CSM), much like the one used in the Apollo lunar exploration program, will be sent into Earth orbit by the smaller Saturn 1B launch vehicle. On board the CSM will be Skylab's first three-man crew. The crew will dock the CSM with the Skylab. The crew will then activate Skylab.

In Skylab, the crew will be able to work and relax unencumbered by space suits.

Its facilities will enable the astronauts to eat, sleep, wash, exercise, and work for periods of up to 56 days in space. Skylab's living space is about that of a large two-bedroom house.

After four weeks in space, the crew will return to their CSM, pull away from the rest of Skylab, and go through the sequence of atmospheric entry, parachute descent, and splashdown in the Pacific Ocean. There, a recovery force will pick up the crew.

About sixty days later, another crew will be launched in a CSM into orbit. This crew will conduct Skylab experiments for eight weeks before returning to Earth.

Some thirty days after the return of the second crew, a third crew will be rocketed up to Skylab. This crew will also conduct experiments for 56 days before returning home.

The Skylab workshop is America's first manned space station. In its 390 cubic-meter (13,000 cubic-foot) interior, three-man crews will conduct nearly sixty experiments during space missions which will last as long as 56 days. NASA has invited world wide participation in analyses and interpretation of the resulting data.

Remote sensing of Earth from space is a potentially effective technique for conservation of natural resources on a global scale and for better understanding and management of the interaction between man and these natural resources. Systematic application of remote sensing techniques over large areas of the Earth will be undertaken from Skylab. Remote sensing will be used for mapping geographic and weather features, crop and forestry cover, health of vegetation, types of soil, water storage in snow pack, geologic features associated with surface or near-surface mineral deposits, sea surface temperature, wind and sea conditions, and the location of likely feeding areas for fish.

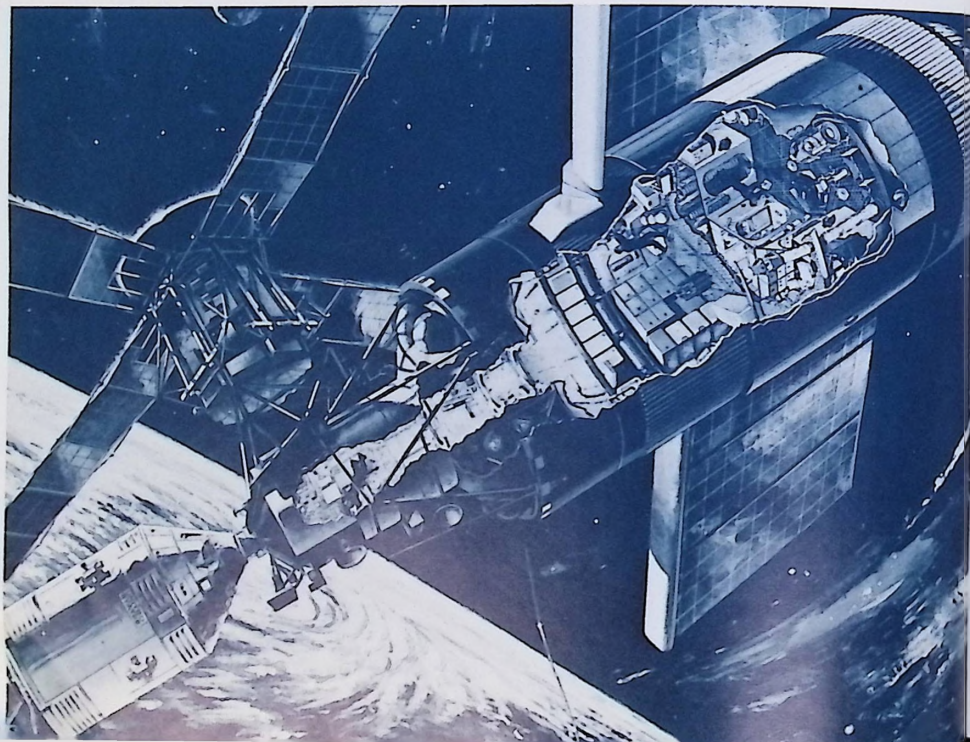
Skylab will fly over the entire United States except Alaska, and its flight path will cover about 75 percent of the Earth's surface. Skylab will repeat its track every five days during the 8-month lifetime of the Skylab Program.

The solar astronomy experiments are expected not only to increase knowledge about the Sun but also to open new doors to basic knowledge that will eventually contribute to mankind's benefit. Since so much of what happens on Earth depends on the Sun, Skylab's solar astronomy experiments can prove vital to mankind's future. Study of the Sun can contribute to unlocking the secret of controlled atomic fusion, which is the source of the Sun's energy and which could provide great quantities of clean power on Earth.

Manufacture of products not possible on Earth may be possible in zero gravity (weightless) conditions. Casting of perfect spheres, growth of pure crystal structures, and development of high strength materials are some of the space manufacturing techniques to be tested.

Skylab will also lay a groundwork for future, more permanent space stations and for the years-long manned missions to other planets of our solar system, when they are undertaken. Some of Skylab's experiments are aimed at improving structures and equipment for space operations, designing more habitable spacecraft and learning how to maneuver and work inside a space station.

Unlike previous manned space flight programs, Skylab provides a means for astronaut rescue, should trouble occur. A Command/Service Module (CSM) similar to the one in which astronauts will commute to and from Skylab can be modified into a rescue vehicle accommodating five rather than three crewmen. Two astronauts can pilot the modified CSM to Skylab and bring back Skylab's three crewmen.



Space Shuttle

The Space Shuttle will be a space transportation system designed to carry out various missions in Earth orbit at a fraction of the cost of present systems. It will consist of two stages, a booster for launch from Earth, and an airplane-like manned reusable orbiter for flight into orbit where it will conduct space missions. Then, the orbiter will be flown back to land at a conventionally sized airstrip.

The shuttle will be launched vertically. The orbiter will separate from its booster and go into orbit under its own power. When it accomplishes its mission, its pilots will fire its rockets to slow it down, fly it through the atmosphere, and land it like an airplane on a jet size airstrip.

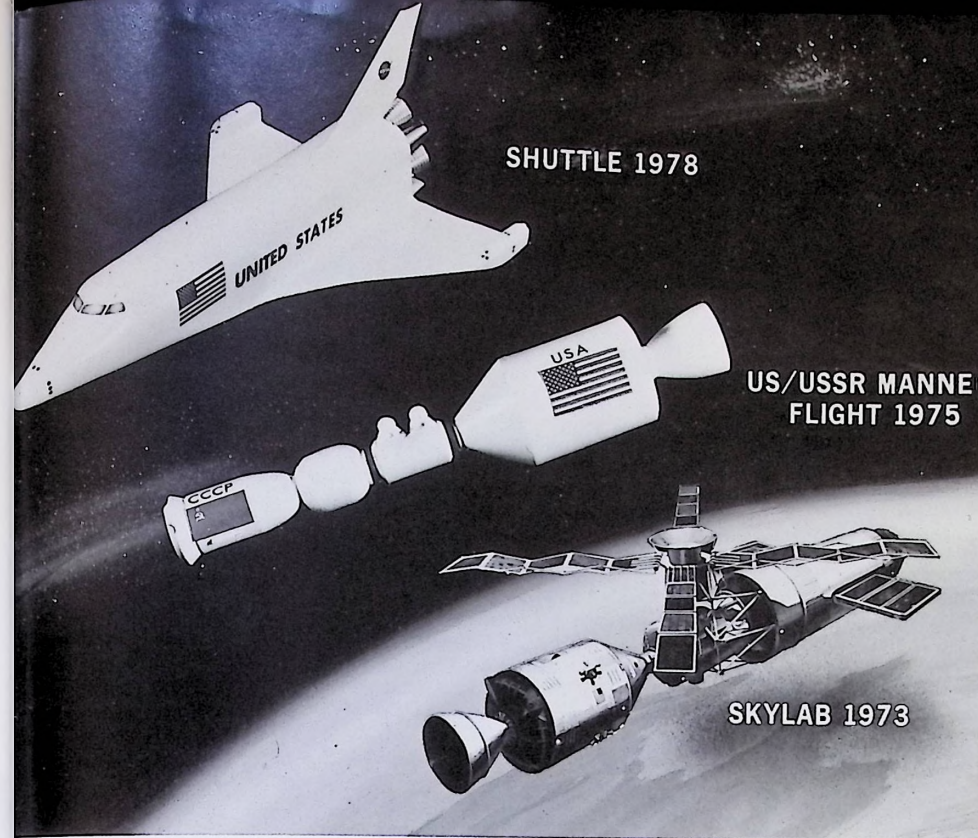
The delta-winged manned orbiter will be about the size of a DC-9 airplane. The cargo compartment, which can accommodate experiments and passengers, will be about 4½ meters (15 feet) in diameter and up to 18 meters (60 feet) long. The orbiter will be able to carry cargo and/or passengers weighing in total as much as 29,500 kilograms (65,000 pounds).

The shuttle orbiter crew will consist of two pilots and two flight engineers. Maximum G forces on launch and reentry will be no more than a mild 3G.

The shuttle after entry will not have to follow a ballistic trajectory to the ground. It will be able to maneuver right or left some 1760 kilometers (1100 nautical miles). Each orbiter will be designed for reuse up to a hundred times.

The Space Shuttle is expected to be ready to play its major role in space by the end of this decade. It will then be used to launch all but the very smallest and very largest payloads. It will send some spacecraft into orbit from which the spacecraft's own rockets would send them into higher orbits or toward the Moon and other planets.

The shuttle represents an investment in mankind's future. It can provide dividends that will continue for decades.



Epilogue

With the successful completion of the Apollo program, scientists are hopeful that data gathered on lunar soil composition and history may contain vital clues to the beginnings of the planet Earth. Eventually permanent bases may be built on the Moon for astronomical observation and experimentation in space biology, physics, and chemistry.

It is also likely that, using the Moon as a base of operations, Man will explore the rest of the universe—an undertaking that staggers the imagination.

To reach the Moon, Man has combined the scientific knowledge of 25 centuries with modern organizational techniques and the resources of American Industry. His flights to the moon have shrunk the solar system by an imperceptible amount, and even though it was his first step into space, it certainly will not be his last or his longest. In the decades ahead Man's imagination will be excited anew as he strives to reach neighboring planets and star systems through technology as unknown to today's society as nuclear power was to Galileo.

RCA in Space

Communications Satellites

SCORE I	Transmitter and Tape Recorder
ECHO I and II	Beacon Transmitters
RELAY I and II	Satellite designed and built by RCA

Weather Satellites

TIROS I to X	Satellites designed and built by RCA
ESSA I to IX	Satellites designed and built by RCA
ITOS-1, NOAA-1 and NOAA-2	Advanced Meteorological and Environmental Satellites designed and built by RCA
NIMBUS I to V	Automatic Picture Transmission System, Advanced Vidicon Camera System, High Data Rate Storage System, Power System, Command Receiver

Space Tracking Network

Radar tracking	RCA-built Radars around the world for tracking space missions, TV Camera Scan Converters
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Unmanned Spacecraft

RANGER VII-VIII-IX	Each carried 6 RCA Cameras—17,000 photos of Moon surface
LUNAR ORBITER I-V	Communications and Power Supply Systems
OAQ I-II	Space TV Cameras
OGO	Digital Tape Recorders
SERT I	Space Electric Rocket Engine Spacecraft designed and built by RCA
SNAP 10	Thermoelectric Modules for Power Conversion
NAVSAT	Navigation Satellite built by RCA
ALOUETTE I and II	Satellites designed and built by RCA Limited, Canada
ISIS I and II	Satellites designed and built by RCA Limited, Canada
MARINER	Science Operational Support Equipment
ERTS-1	Return Beam Vidicon Cameras, Satellite and Ground Station Video Tape Recorders, Power System, Command and Control Receivers

Manned Spacecraft

GEMINI	Telemetry Transmitter and Recorder
APOLLO Program	
110A Computers	Checkout and launch Saturn V rockets
Lunar Module	Electronics, Rendezvous Radar, Expandable Antenna, Stabilization/Control Systems, Landing Radar, Descent Engine Control Assembly, Attitude and Translation Control Assembly, Communications Subsystems, Extra-Vehicular Communications System
Command Module	Apollo 7 and 8 Television Camera, VHF Transceiver, Test Equipment, Laser Altimeter, Lunar Sounder Radar
Lunar Rover	Ground-Commanded Color Television Assembly, Lunar Communications Relay Unit
SKYLAB	Spacecraft Video Tape Recorders, VHF Ranging System, Telemetry Transmission System, 110A Checkout Computers, Ground Tracking Radars

Space Equipment and Systems Under Development

ATMOSPHERE EXPLORER	Satellite designed and built by RCA
VIKING	Communications Subsystems
SPACE SHUTTLE	Various Command and Control Subsystems proposed