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NASA FACTS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

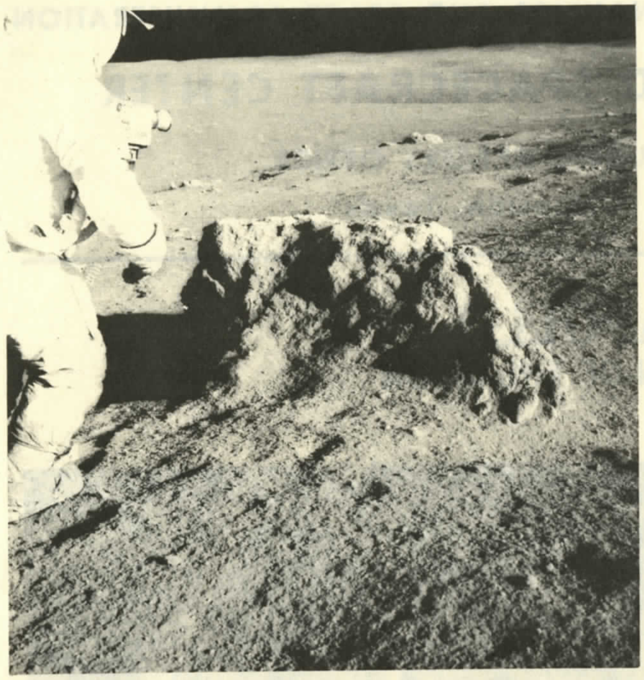
MANNED SPACECRAFT CENTER

PUBLIC AFFAIRS OFFICE

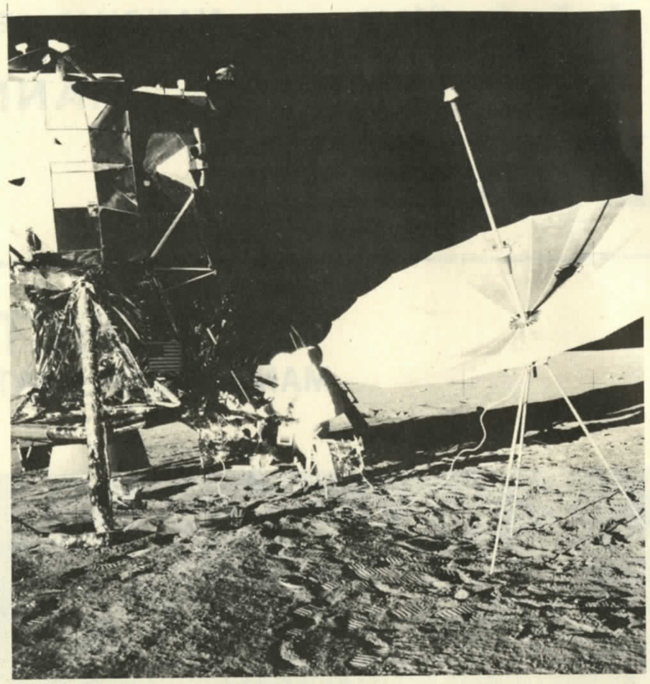
Houston, Texas

PROJECT APOLLO

MANNED EXPLORATION OF THE MOON



Obtaining samples of lunar soil and rock is one of the important goals of each Apollo lunar landing mission. Early Apollo landing sites were relatively smooth and free of large rocks. However, the missions were designed to progress ambitiously to landings in areas strewn with large boulders, like the one shown in this photograph, and even to mountain ranges and canyons.



The lunar surface experiments, which were designed to continue collecting data long after the Apollo astronauts have returned home, are packaged on earth for easy deployment on the moon. The experiments are unloaded from the lunar module storage bay and set up a short distance from the spacecraft. The umbrella-like antenna is aimed at the earth.

INITIAL GOALS OF THE APOLLO PROGRAM

The initial goals of the Apollo Program were achieved in July 1969 when the Apollo 11 astronauts landed in the Pacific Ocean. The goals were:

1. To land American explorers on the moon and return them safely to earth
2. To establish the technology required to meet other national interests in space
3. To achieve for the United States preeminence in space.

The Apollo Program is scheduled to continue through 1972 with the following objectives: (1) carry out a program of scientific exploration of the moon, (2) maintain the United States' preeminence in space, and (3) develop man's capability to work in the lunar environment.

To achieve these objectives, Apollo missions have been designed to increase progressively the scientific payload transported to lunar orbit and to the lunar surface, to achieve increasing flexibility in landing-site selection, to increase the lunar-orbit and lunar-surface stay time, and to increase lunar surface mobility.

HISTORY OF THE APOLLO PROGRAM

Initial planning for a launch vehicle with the heavy payload capability necessary for a manned lunar mission began in April 1957. In August 1958, studies concluded that a clustered booster generating a total of 1.5 million pounds thrust was feasible, and the research and development effort was started to build the booster. Rocketdyne, a division of North American Rockwell Corporation, developed the 200 000-pound-thrust version of the H-1 engine from the previously used Thor and Jupiter H-1 engine by updating the engine and by increasing its thrust. Concurrently, from more advanced studies, the 1.5-million-pound-thrust F-1 engine was conceived for even larger boosters. In October 1958, the Army started the development of a high-performance booster for advanced space missions. Tentatively called Juno V and finally designated Saturn, the booster was turned over to NASA in late 1959.

NASA proposed a manned flight program designated Project Apollo in July 1960. Its goals at that time were earth-orbital and circumlunar flights of a three-man spacecraft. During 1960, McDonnell Douglas Corporation was selected to build the Saturn I second stage (S-IV), and Rocketdyne was chosen to develop the hydrogen-fueled J-2 engine for future upper stages of the Saturn vehicles.

On May 25, 1961, President John F. Kennedy proposed to Congress that the United States accelerate its space program and establish as a national goal a manned lunar landing and return by the end of the decade. In his report to Congress, President Kennedy said:

"Now is the time . . . for this nation to take a clearly leading role in space achievement, which in many ways may hold the key to our future on earth.

" . . . this is not merely a race. Space is open to us now; and our eagerness to share its meaning is not governed by the efforts of others. We go into space because whatever mankind must undertake, free men must fully share.

"No single space project in this period will be more impressive to mankind or more important for the long-range exploration of space . . .

"Let it be clear . . . that I am asking the Congress and the Country to accept a firm commitment to a new course of action, a course which will last for many years and carry very heavy costs . . . If we are to go only halfway, or reduce our sights in the face of difficulty, in my judgment it would be better not to go at all."

On August 9, 1961, the Massachusetts Institute of Technology was selected to develop the Apollo spacecraft guidance and navigation system. Three and a half months later, NASA selected North American Rockwell Corporation as the principal contractor for the Apollo spacecraft command and service modules.

With an endorsement by Congress, the national objective of manned lunar exploration hastened the need for more powerful boosters, which were designated the Saturn family of boosters. For earth-orbital flights, the Apollo spacecraft would be launched by the two-stage Saturn IB booster, which was built by Chrysler Corporation. The Saturn IB was an uprated version of the original Saturn I and produced 1.6 million pounds of thrust (rather than the 1.5 million pounds of thrust produced by the Saturn I) from eight clustered H-1 engines. The second stage J-2 engine used liquid hydrogen as the fuel and liquid oxygen as the oxidizer to produce about a quarter of a million pounds of thrust. The second stage of the Saturn IB, also used as the third stage of the Saturn V booster, was built by McDonnell Douglas Corporation. The Saturn V launch vehicle generates a total of 7.5 million pounds of thrust in its five F-1 first-stage engines and can boost nearly 100 000 pounds of payload on its way to the moon. Five J-2 engines power the second stage of the Saturn V. The National Aeronautics and Space Administration awarded contracts to The Boeing Company for construction of the first stage and to the North American Rockwell Corporation for construction of the second stage.

In July 1962, NASA selected the lunar orbital rendezvous method for the lunar-landing mission. The method called for the development of a two-man

The Apollo flight controllers in the Mission Operations Control Room at the Manned Spacecraft Center in Houston watch the television picture (on the wall projection screen at the top-center of the photograph) from space. The picture on the screen shows the launch vehicle third stage and the lunar module as the command module moves in for docking shortly after leaving earth orbit for the moon.

lunar module to be used for landing on the moon and returning to lunar orbit. On November 7, 1962, Grumman Aerospace Corporation was selected to design and build the lunar module.

One year later, the first boilerplate Apollo command module was flown at White Sands Missile Range, New Mexico, in a launch-pad abort test. The first high altitude abort was successfully demonstrated on May 13, 1964, at White Sands. Fifteen days later, a Saturn I placed the first unmanned Apollo command module into orbit from Cape Kennedy, Florida. The first phase of the Saturn launch vehicle program was completed in 1965. All 10 flights of the Saturn I had been successful.

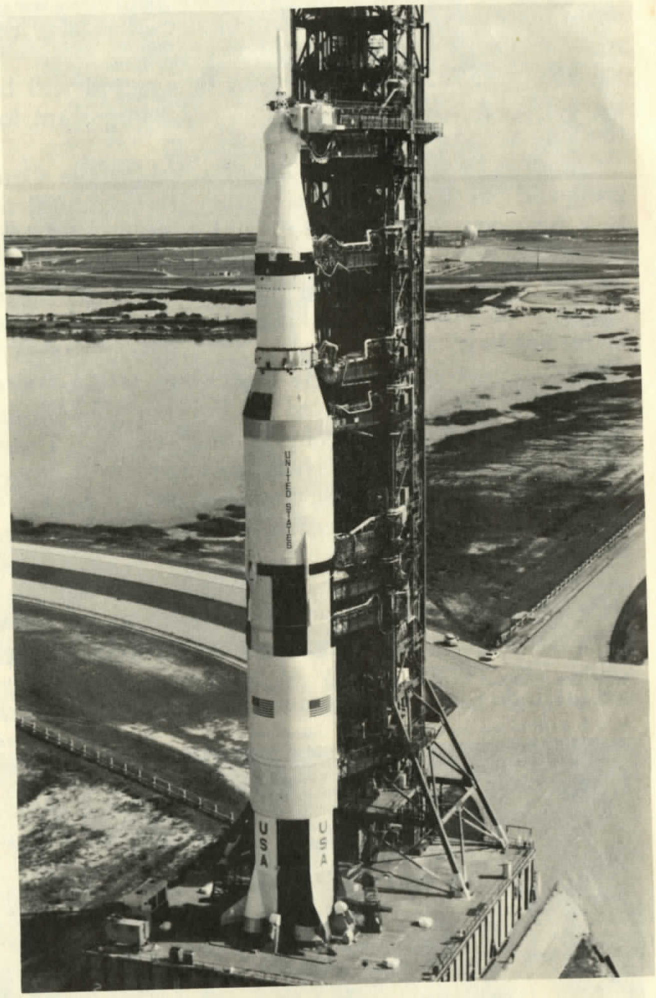
On February 26, 1966, the first full-systems Apollo command module was launched aboard a Saturn IB. The flight successfully tested the command module's reentry heat shield. The test was also the first flight of a Saturn IB. Saturn IB launch vehicles were successfully flown three times in three attempts in 1966. Two of the launches carried unmanned command and service modules, and the third flight was a test of the launch vehicle without a spacecraft. The two launches of the Apollo spacecraft met all test requirements and qualified the command and service modules for manned earth-orbit operations.

On January 27, 1967, a fire erupted inside a command module during ground testing at Cape Kennedy. Astronauts Virgil I. Grissom, Edward H. White II, and Roger B. Chaffee, who were to fly the first manned Apollo mission, died in the fire. After 2-1/2 months of investigation, which involved 1500 persons, the inquiry board determined that the most likely cause of the fire was electrical arcing from spacecraft wiring. The board recommended numerous corrective measures, which were adopted prior to the first manned Apollo flight.

On November 9, 1967, the first flight test of the Apollo/Saturn V space vehicle was successfully accomplished. Designated Apollo 4, the unmanned flight demonstrated the performance of the previously unflown first and second stages of the launch vehicle, the restart-in-orbit capability of the third stage, the spacecraft capability of reentering earth atmosphere at lunar-mission reentry speeds, the performance of the integrated space vehicle, and the operational readiness of Kennedy Space Center Launch Complex 39.

The unmanned Apollo 5 mission was flown January 22 and 23, 1968. This was the first flight of the lunar module, and its systems and structural performances met all objectives. The launch vehicle was a Saturn IB.

The Apollo 6 mission, on April 4, 1968, was the second unmanned Saturn V mission to demonstrate launch vehicle and spacecraft systems performance specifications. On the basis of the unmanned flight history, the spacecraft and launch vehicle were declared ready for manned earth-orbit missions.



The Saturn V launch vehicle with the Apollo spacecraft in place moves slowly from the assembly building to the launch pad. Note the comparative size of the men standing at the base of the crawler that carries the big rocket.

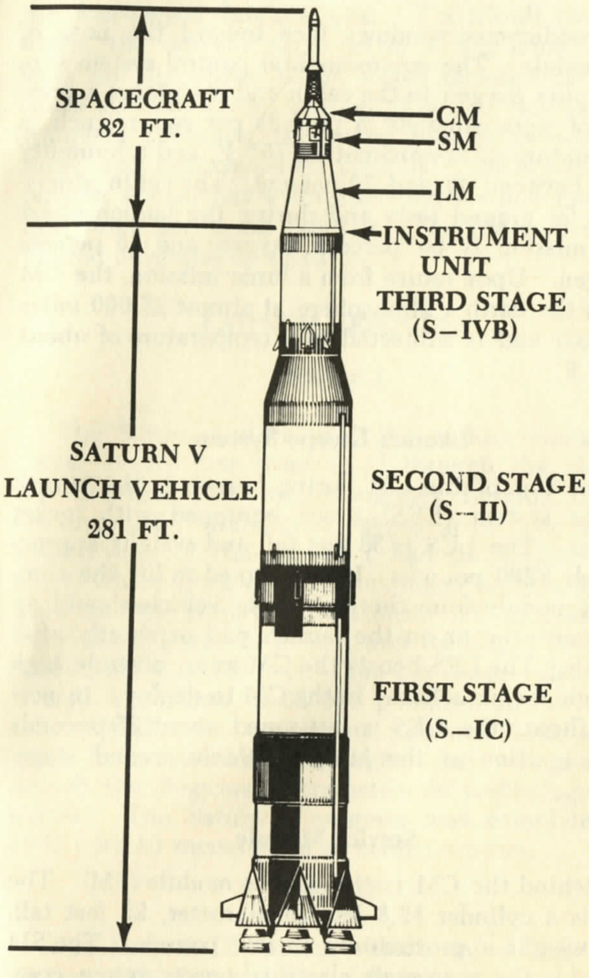
APOLLO MANNED MISSIONS

Apollo 7

The Apollo 7 mission was the first manned flight in the Apollo series and the first United States three-man space flight. The Apollo 7 earth-orbit mission, which qualified the command and service modules for lunar missions, was flown October 11 to 22, 1968. Live television was beamed to earth from a United States manned spacecraft for the first time. The crewmen were Walter M. Schirra, Jr., Donn F. Eisele, and Walter Cunningham.

Apollo 8

The Apollo 8 mission was the first manned flight to the vicinity of the moon. The command and service modules orbited the moon 10 times. The mission, which marked the first time man had visited the neighborhood of another celestial body, was flown December 21 to 27, 1968. Live television was broadcast from lunar orbit. The crewmen were Frank Borman, James A. Lovell, Jr., and William A. Anders.



Apollo 9

The Apollo 9 mission was the first of the complete Apollo spacecraft (command, service, and lunar modules) and was conducted in earth orbit March 3 to 13, 1969. The successful manned checkout of the lunar module and the portable life support system to be used by astronauts on the lunar surface indicated the readiness of the vehicle and equipment for lunar-landing missions. The Apollo 9 mission accomplished the first docking of two manned spacecraft and the first Apollo extravehicular activity (EVA). The crewmen were James A. McDivitt, David R. Scott, and Russell L. Schweickart. The command module was called Gumdrop, and the lunar module was named Spider.

Apollo 10

The Apollo 10 flight, flown May 18 to 26, 1969, was a lunar mission in which everything required for a lunar landing mission was demonstrated, except the actual landing. The crewmen were Thomas P. Stafford, John W. Young, and Eugene A. Cernan. In lunar orbit, Stafford and Cernan detached the lunar module from the command module and descended in the lunar module to within 9.7 miles of the lunar surface to inspect the site for Apollo 11 lunar-landing attempt in the Sea of Tranquility. Young remained in the orbiting command module. Apollo 10 remained in lunar orbit for 31 revolutions and transmitted live color television to earth. The command module was named Charlie Brown and the lunar module was called Snoopy.

Apollo 11

The Apollo 11 mission was the first lunar-landing mission and fulfilled the national goal to land men on the moon and return them safely to earth before 1970. It was flown July 16 to 24, 1969, by Neil A. Armstrong, Michael Collins, and Edwin E. Aldrin, Jr. The lunar module touched down on the moon at 3:18 p.m., c.d.t., July 20. Armstrong and Aldrin explored the lunar surface while Collins remained in orbit around the moon. Armstrong, the first man on the moon, stepped onto the lunar surface at 9:56 p.m., c.d.t., July 20. The lunar surface activity of the astronauts was televised throughout the world and was seen by the largest television audience in history. Scientific instruments were left on the lunar surface to continue broadcasting information long after the astronauts had returned to earth, and samples of the lunar surface material were returned to earth for scientific study. The command module was named Columbia, and the lunar module was called Eagle.

Apollo 12

The Apollo 12 flight was the second lunar landing mission. It was flown November 14 to 24, 1969, by Charles Conrad, Jr., Richard F. Gordon, Jr., and Alan L. Bean. Conrad and Bean, during their 31-1/2 hour stay on the lunar surface, conducted two periods of exploration and set up a more sophisticated scientific package than had been deployed during the Apollo 11 mission. The mission also demonstrated the capability for precise point landings. The lunar module touched down on the Ocean of Storms near the unmanned Surveyor III spacecraft, which had been on the moon 2-1/2 years. The crew returned several pieces of the Surveyor III spacecraft to earth. Apollo 12's command module was called Yankee Clipper, and the lunar module was named Intrepid.

Apollo 13

The Apollo 13 mission was launched April 11, 1970, with the objective of landing on the Fra Mauro lunar upland area, where the crew was to collect surface samples and set up geophysical instruments during two EVA periods. The crewmen were James A. Lovell, Jr., John L. Swigert, and Fred W. Haise, Jr. Swigert, a member of the backup crew, had replaced prime crewman Thomas K. Mattingly 2 days before the launch. Mattingly was replaced by Swigert because he had been exposed to the 3-day measles and was found to have no immunity to the disease. Two and a half days after the launch, an explosion caused the loss of all oxygen stored in the service module. The oxygen is used in fuel cells to produce electric power as well as in the environmental control system of the command module for life support. The crew was forced to abort the mission and use the attached lunar module as a "life boat." By using the lunar module descent engine for propulsion, the crew looped their crippled spacecraft around the moon and returned safely to earth on April 17. The command module was named Odyssey, and the lunar module was called Aquarius.

The Apollo 13 Review Board determined that a short circuit had ignited electrical insulation in the spacecraft oxygen tank No. 2. The resulting fire caused the tank to rupture. The oxygen system was modified to eliminate potential combustion hazards.

Apollo 14

America's first man in space, Alan B. Shepard, Jr., commanded the Apollo 14 mission, with Stuart A. Roosa and Edgar D. Mitchell as his crew. The January 31 to February 9, 1971, flight was to the Fra Mauro highlands, which had been the objective of the Apollo 13 mission. The 33-hour stay on the lunar surface included two EVA periods, which lasted almost 5 hours each. The second EVA was a long-distance traverse to Cone Crater. A color television camera enabled viewers on earth to watch much of the activity. While Shepard and Mitchell set up the scientific experiments and gathered geologic samples on the lunar surface, Roosa continued to orbit the moon. From the command module Kitty Hawk, Roosa conducted several electronic experiments and photographic programs. The lunar module was named Antares after the brightest star in the constellation Scorpius, which appeared in the LM window when the craft pitched over into its landing trajectory.

APOLLO SPACECRAFT

The Apollo spacecraft assembly is 82 feet tall and weighs about 45 tons. It is composed of three modules (separable units) plus an adapter and a launch escape system.

Command Module

The command module (CM) is the only module which returns to earth from a mission. The CM contains the crew's living compartment and all the controls for the inflight maneuvers. The coneshaped spacecraft is 12.8 feet in diameter at the bottom and stands about 12 feet high. It consists of two shells, which are a pressurized inner crew compartment and an outer heat shield. Launch weight of the CM is about 12 000 pounds. The CM has two side windows, a hatch window, and two rendezvous windows. The rendezvous windows face toward the nose of the module. The environmental control system supplies pure oxygen in the cabin and maintains a pressure of approximately 5 pounds per square inch, a temperature of approximately 75° F, and a humidity index between 40 and 70 percent. The cabin atmosphere for ground tests and during the launch phase of a mission is 60 percent oxygen and 40 percent nitrogen. Upon return from a lunar mission, the CM enters the earth's atmosphere at almost 25 000 miles per hour and is subjected to a temperature of about 5000° F.

Launch Escape System

On top of the CM during launch is the launch escape system (LES) tower equipped with rocket motors. The LES is 33 feet tall and weighs approximately 8200 pounds. It is designed to lift the command module from the rest of the vehicle should an emergency occur on the launch pad or shortly after launch. The LES boosts the CM to an altitude high enough for parachutes in the CM to deploy. In normal flight, the LES is jettisoned about 35 seconds after ignition of the launch vehicle second stage.

Service Module

Behind the CM is the service module (SM). The SM is a cylinder 12.8 feet in diameter, 22 feet tall, and weighs approximately 55 000 pounds. The SM contains the spacecraft electrical power source, cryogenic oxygen and hydrogen tanks, and the primary propulsion system, which produces 20 500 pounds of thrust. This multiple-start engine is used for maneuvers during the translunar and transearth periods of a mission, to slow the spacecraft for insertion into a lunar orbit, and to add velocity to boost the spacecraft out of lunar orbit. The SM is jettisoned just before the CM enters the earth atmosphere.

Spacecraft Lunar Module Adapter

The spacecraft lunar module adapter (SLA) connects the command and service module to the third stage of the Saturn V launch vehicle and serves as a protective covering for the lunar module during launch and in earth orbit. The SLA is a fairing 28 feet tall, 12.8 feet in diameter at the top to match the width of the Apollo spacecraft, and 22 feet in diameter at the bottom to match the width of the launch vehicle third stage. The weight of the adapter section is approximately 4000 pounds.

Lunar Module

The lunar module (LM) is the flight unit that descends to the lunar surface with two of the three astronauts aboard. The LM is a two-stage vehicle.

The bottom stage contains the descent engine and the four-legged landing gear. For lift-off from the moon, the descent stage serves as the launch platform for the upper stage, which includes the crew cabin and the ascent engine. The LM has its own complete guidance, computer, control, communications, and environmental systems. The descent propulsion system has a throttle control which can vary the thrust for a soft landing. The LM is designed to land on slopes up to 12°.

LAUNCH VEHICLES

Saturn I

The Saturn I developed 1.5 million pounds of thrust in its first stage (S-1) through the clustering of eight H-1 rocket engines burning refined kerosene (RP-1) and liquid oxygen (lox). The second stage (S-IV) of the Saturn I had six RL-10-A3 engines, which burned liquid hydrogen and lox to produce 90 000 pounds total thrust. The diameter of the Saturn I was 21.5 feet, and its height (without spacecraft) was 125 feet. The two-stage vehicle delivered a payload of 22 000 pounds into low earth orbit. It placed a boilerplate Apollo CM into earth orbit in unmanned test flights and was used to launch the Pegasus micrometeoroid technology satellites. The Saturn I program was completed in 1965 with 10 successes in as many launches.

Saturn IB

The Saturn IB launch vehicle is an improved version of the Saturn I first stage with a more powerful second stage, the S-IVB. A Saturn IB launched the first manned Apollo spacecraft (Apollo 7) into earth orbit. It also will be used in the Skylab Program. The second stage of the Saturn IB consists of one J-2 engine, which burns liquid hydrogen and lox and produces about 230 000 pounds thrust. The low-earth-orbit payload for the Saturn IB is 40 000 pounds.

Saturn V

The first stage (S-IC) of the Saturn V launch vehicle is 33 feet in diameter and is powered by a cluster of five F-1 engines, each of which develops 1.5 million pounds of thrust. The second stage (S-II) is a cluster of five J-2 engines that generates a total of approximately 1.15 million pounds of thrust. The third stage (S-IVB) is identical with the Saturn IB second stage. The three-stage booster is 281 feet tall. The entire Apollo/Saturn V assembly is 363 feet high at the launch pad and weighs 6 million pounds when fueled for a lunar mission. The Saturn V booster can launch 140 tons into low earth orbit and accelerate a 47.5-ton payload to earth escape velocity. On a lunar mission, both the Apollo spacecraft and the Saturn V third stage go into an earth parking orbit, after which the third stage is reignited to send the spacecraft on its way to the moon.

APOLLO TRACKING NETWORK

A network of tracking stations around the world maintains voice and telemetry communications with the spacecraft. One group of stations follows the spacecraft at launch, during earth orbit, and again at the end of the mission. As the spacecraft leaves earth orbit and starts toward the moon, it passes from the range of these stations. Tracking then switches to a second group of stations whose powerful transmitters and sensitive receivers are designed for communications at great distances. These stations are located at Goldstone, California; Madrid, Spain; and Canberra, Australia. The three stations are approximately one-third of the earth circumference (120°) apart. As the rotating earth cuts off one station's direct line of contact with the spacecraft, the next station rises over the horizon and takes over.

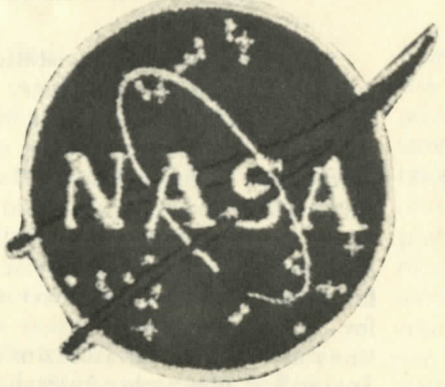
APOLLO SCIENCE PROGRAM

Lunar Surface Science

In addition to returning lunar rocks and soil to earth for detailed study by scientists throughout the world, Apollo astronauts deploy an Apollo Lunar Surface Experiment Package (ALSEP) at each landing site. The ALSEP system is designed to return scientific data to earth for at least a year after each landing. The data obtained by the instruments provide the scientific community with knowledge of the lunar environment, particularly in the areas of geology, geophysics, geochemistry, and particles and fields. Areas of particular scientific interest include (1) measurement of natural lunar seismology, (2) properties of the lunar interior, (3) properties of the lunar material at shallow depths, (4) chemical sorting of lunar mantle material, (5) thermal insulating properties of the lunar surface, (6) measurement of lunar dust, (7) interaction of the solar wind and the moon, (8) measurement of the lunar magnetic field and of temporal variations in the field at the lunar surface, (9) composition of the lunar atmosphere, (10) lunar ionosphere positive-ion detection, (11) lunar atmospheric pressure, and (12) laser ranging using a retroreflector.

Lunar-Orbit Science

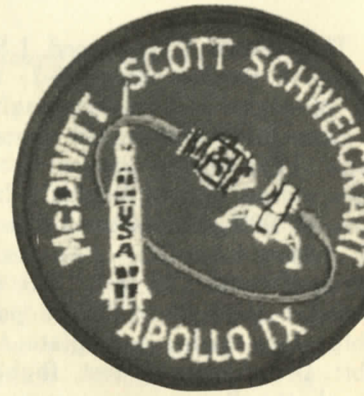
Lunar-orbit science experiments have been added to study deep space and the surface of the moon by photography and sensor techniques. The experiments include a subsatellite which will be placed in lunar orbit during two of the Apollo missions to investigate the formation and the dynamics of the earth magnetosphere and the boundary layer of the solar wind as it flows over the moon. The scientific equipment will be carried in a bay of the SM and will require extravehicular activity to retrieve film.



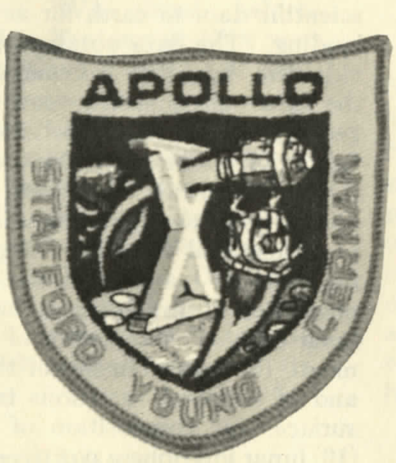
APOLLO MANNED MISSION EMBLEMS

APOLLO 7

APOLLO 8



APOLLO 9



APOLLO 10

APOLLO 11

APOLLO 12

APOLLO 13

APOLLO 14

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