THE MOON

The landing of Apollo astronauts, and their return to earth with lunar soil samples, will help solve some of the mysteries of the moon. What is known about the moon, from centuries of astronomical observation and from the recent space mission, is this:

Terrain—Mountainous and crater-pitted, the former rising thousands of feet and the latter ranging from a few inches to 180 miles in diameter. The craters are thought to be formed by the impact of meteorites. The surface is covered with a layer of fine-grained material resembling silt or sand, as well as small rocks.

Environment—No air, no wind, and no moisture. The temperature ranges from 250 degrees in the two-week lunar day to 280 degrees below zero in the two-week lunar night. Gravity is one-sixth that of earth. Micrometeoroids pelt the moon (there is no atmosphere to burn them up). Radiation might present a problem during periods of unusual solar activity.

Dark Side—The dark or hidden side of the moon no longer is a mystery. It was first photographed by a Russian craft and since then has been photographed many times, particularly by NASA's Lunar Orbiter spacecraft.

Origin—There is still no agreement among scientists on the origin of the moon. The three theories: (1) the moon once was part of earth and split off into its own orbit, (2) it evolved as a separate body at the same time as earth, and (3) it formed elsewhere in space and wandered until it was captured by earth's gravitational field.

Physical Facts

Diameter	2,160 miles (about 1/4 that of earth)
Circumference	6,790 miles (about 1/4 that of earth)
Distance from earth	238,857 miles (mean; 221,463 minimum to 252,710 maximum)
Surface temperature	250 (sun at zenith) -280 (night)
Surface gravity	1/6 that of earth
Mass	1/100th that of earth
Volume	1/50th that of earth
Lunar day and night	14 earth days each
Mean velocity in orbit	2,287 miles per hour
Escape velocity	1.48 miles per second
Month (period of rotation around earth)	27 days, 7 hours, 43 minutes

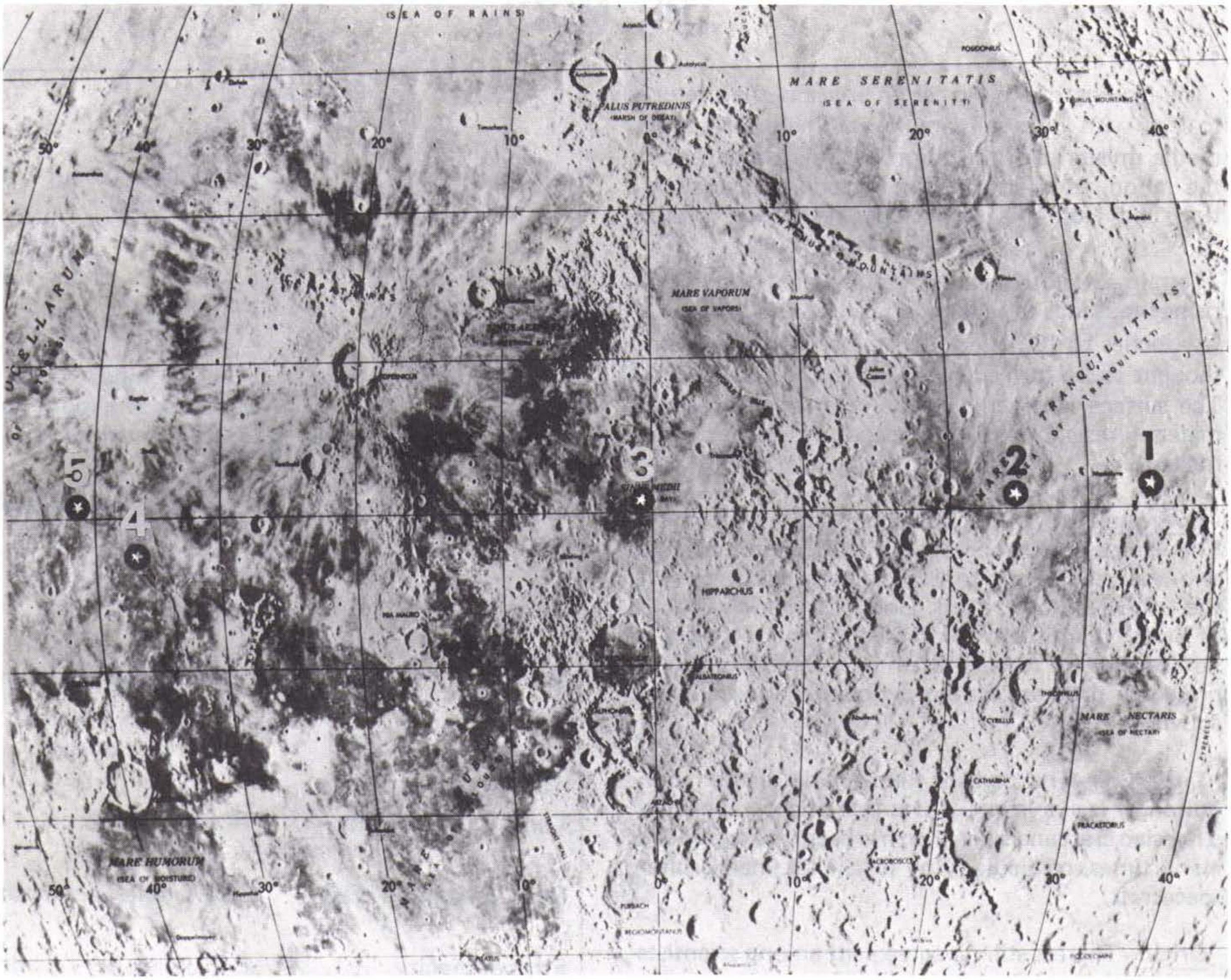
Possible landing sites for Apollo's lunar module have been under study by NASA's Apollo Site Selection Board for about two years. Thirty sites originally were considered, and these were later narrowed down to eight.

Selection of the final five sites was based on high-resolution photographs returned by Lunar Orbiter, plus close-up photos and surface data provided by Surveyor.

All of the original sites were on the visible side of the moon within 45 degrees east and west of the center of the moon and 5 degrees north and south of its equator.

The final five choices were based on these factors:

- Smoothness (relatively few craters and boulders)
- Approach (no large hills, high cliffs, or deep craters that could cause incorrect altitude signals to the landing radar)
- Propellant (selected sites allow the least expenditure of propellant)



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The five Apollo moon landing sites

- Recycling (selected sites allow for necessary recycling time if the Apollo/Saturn countdown is delayed)

- Free return (sites are within reach of the spacecraft in a free-return trajectory)

- Slope (there is little slope—less than 2 degrees—in the landing area and approach path)

Three of the five sites will be chosen for a specific lunar landing mission so that a three-day period each month will be available for the launch.

The Apollo lunar landing sites:

No.	Coordinates	Location
1	34° E, 2 40'N	Sea of Tranquility
2	23° 37' E, 0° 45'N	Sea of Tranquility
3	1° 20'W, 0° 25'N	Central Bay
4	36° 25'W, 3° 30'S	Ocean of Storms
5	41° 40'W, 1° 40'N	Ocean of Storms

MANNED SPACE PROGRAM

The United States manned space program has been conducted in three major phases–Mercury, Gemini, and Apollo. Each manned flight has led to increased knowledge of the systems and techniques needed to operate successfully in space, and each phase represents a significant advancement over the previous one.

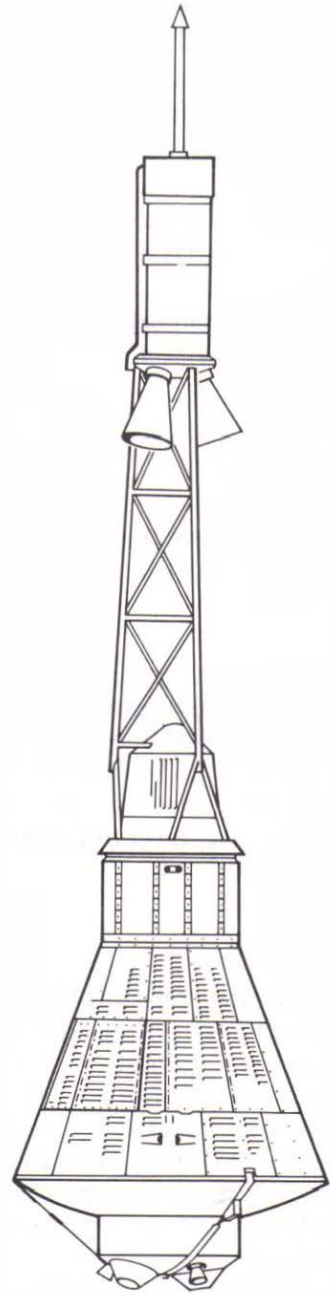
The first man in space was the Russian Yuri Gagarin, who made one orbit of the earth in his Vostok 1 spacecraft on April 12, 1961. The first American spaceman was Alan B. Shepard, Jr., who rode his Mercury spacecraft into space atop a Redstone booster on May 5, 1961. The first American to orbit the earth was John H. Glenn, Jr., who made three orbits in a Mercury spacecraft on Feb.20,1962.

To date (August 1, 1968), 19 Americans have been in space, and seven of these have made two space flights. There were six manned flights during the Mercury program and 10 manned flights in the Gemini program.

Eleven Russians have been in space in their nine-launch program. The Russian manned program also has involved three spacecraft, with six flights aboard the one-man Vostok, two flights with the Voskhod (one a three-man and the other a two-man craft), and a single flight with the Soyuz spacecraft.

There have been no fatalities in space, but accidents have marred the advanced programs of both the United States and Russia. Three American astronauts–Virgil I. Grissom, Edward H. White, II, and Roger B. Chaffee–died in a fire aboard an Apollo spacecraft on the pad at Kennedy Space Center. Grissom, a veteran of two space flights, was pilot of the second Mercury spacecraft and commander of the first Gemini to go into space. White was aboard the second manned Gemini spacecraft in orbit, and made the historic 21-minute "walk in space." The accident occurred on Jan. 27, 1967, as the three men were rehearsing countdown procedures for what was to have been the first Apollo manned launch.

The Russian tragedy occurred during a space mission, but not in space. Cosmonaut Vladimir Komarov died in the Soyuz 1 spacecraft on April 24, 1967, when it crashed during landing. The Soyuz flight, which lasted about 25 hours, had been characterized as successful by the USSR. It had entered the atmosphere and was at an altitude of about 4.3 miles when its parachutes became fouled and it plunged to earth. Komarov was the first Russian to go into space twice: he was one of the three cosmonauts aboard the Voskhod 1.



P-42 *Mercury spacecraft*

MERCURY

Project Mercury was America's first step into space. The one-man Mercury capsules were designed to

MERCURY FLIGHTS

Date	Vehicle	Astronaut	Revolutions	Hours	
May 5, 1961	Mercury-Redstone 3	Alan B. Shepard, Jr.	*	00:15:22	First American in space; Freedom 7
July 21, 1961	Mercury-Redstone 4	Virgil I. Grissom	*	00:15:37	Capsule sank; Liberty Bell 7
Feb. 20, 1962	Mercury-Atlas 6	John H. Glenn, Jr.	3	04:55:23	First American in orbit; Friendship 7
May 24, 1962	Mercury-Atlas 7	M. Scott Carpenter	3	04:56:05	Landed 250 miles from target; Aurora 7
Oct. 3, 1962	Mercury-Atlas 8	Walter M. Schirra, Jr.	6	09:13:11	Landed 5 miles from target; Sigma 7
May 15-16, 1963	Mercury-Atlas 9	L. Gordon Cooper, Jr.	22	34:19:49	First long flight; Faith 7

*Sub-orbital

answer the basic questions about man in space; how he was affected by weightlessness, how he withstood the gravitational forces of boost and entry, how well he could perform. A milestone in applied science and engineering, the Mercury flights proved that man not only could survive, he could greatly increase the knowledge of space.

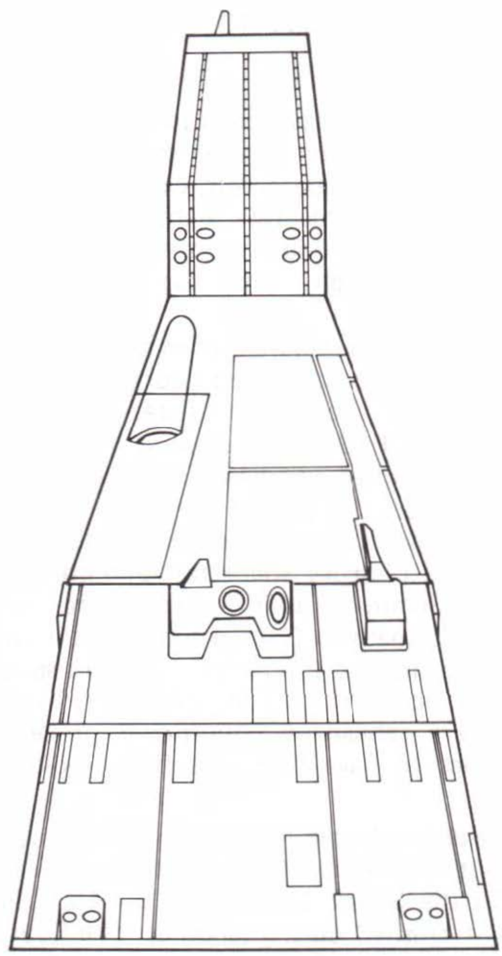
GEMINI

Gemini was the next step in NASA's program. The goal of these two-man flights was to find out how man could maneuver himself and his craft, and to increase our knowledge about such things as celestial mechanics and space navigation. Gemini has a record of 10 successful manned flights and set many records, including the longest duration (almost 14 days), the first rendezvous by two maneuverable spacecraft, and the first docking.

RUSSIAN MANNED PROGRAM

The Soviet Union opened the space age when it put the first man, Yuri Gagarin, into space in April of 1961. They followed four months later with the 25-hour flight of Gherman Titov.

The Russians waited a year after the Gagarin flight before their next, but that was the first group flight;



P-43 *Gemini spacecraft*

GEMINI FLIGHTS

Date	Vehicle	Astronauts	Revolutions	Hours	
Mar. 23, 1965	Gemini III	Virgil Grissom John Young	3	4.9	First manned orbital maneuvers
June 3-7, 1965	Gemini IV	James McDivitt Edward White	62	97.9	21-minute "space walk" by White
Aug. 21-29, 1965	Gemini V	Gordon Cooper Charles Conrad	120	190.9	First extended manned flight
Dec. 4-18, 1965	Gemini VII	Frank Borman James Lovell	206	330.6	Longest space flight; served as Gemini VI-A target vehicle
Dec. 15-16, 1965	Gemini VI-A	Walter Schirra Tom Stafford	16	25.9	Rendezvous within 1 foot of Gemini VII
Mar. 16-17, 1966	Gemini VIII	Neil Armstrong David Scott	6.5	10.7	First docking, to Agena target; short circuit cut flight short
June 3-6, 1966	Gemini IX-A	Tom Stafford Eugene Cernan	45	72.3	Rendezvous, extra-vehicular activity, precision landing
July 18-21, 1966	Gemini X	John Young Michael Collins	43	70.8	Rendezvous with 2 targets; retrieved package from Agena in space walk
Sept. 12-15, 1966	Gemini XI	Charles Conrad Richard Gordon	44	71.3	Rendezvous and docking, 161-minute extravehicular activity
Nov. 11-15, 1966	Gemini XII	James Lovell Edwin E. Aldrin	59	94.6	3 successful extra-vehicular trips, rendezvous and docking, rendezvous with solar eclipse

two spacecraft on successive days. A 10-month lull followed before the second group flight, this time including a woman, Valentina Tereshkova, as one of the cosmonauts.

These six flights were with the Soviet Union's first manned spacecraft, the Vostok. Their second-generation spacecraft, the Voskhod, made only two flights about six months apart. The first Voskhod mission, 16 months after the last Vostok flight, carried a crew of three and was the first spacecraft with more than one passenger. The second Voskhod flight carried only two men but featured the first man to leave his spacecraft and "walk" in space.

The Soviet Union's third-generation spacecraft, Soyuz, made its only flight in April of 1967, when Komarov was killed.

RUSSIAN MANNED FLIGHTS

Date	Spacecraft	Cosmonaut	Revolu-tions	Hours	
Apr. 12, 1961	Vostok 1	Yuri Gagarin	1	1.8	First manned flight
Aug. 6, 1961	Vostok 2	Gherman Titov	17	25.3	More than 24 hours in space
Aug. 11, 1962	Vostok 3	Andrian Nikolayev	64	94.4	First group flight
Aug. 12, 1962	Vostok 4	Pavel Popovich	48	71.0	Came within 3.1 miles of Vostok 3 on first orbit
June 14, 1963	Vostok 5	Valery Bykovsky	81	119.1	Second group flight
June 16, 1963	Vostok 6	Valentina Tereshkova	48	70.8	Passed within 3 miles of Vostok 5; only woman in space
Oct. 12, 1964	Voskhod 1	Vladimir Komarov K. Feoktistov B. Yegorov	16	24.3	First 3-man craft
Mar. 18, 1965	Voskhod 2	A. Leonov P. Belyayev	17	26.0	Leonov was first man outside spacecraft in 10-minute "walk"
Apr. 23, 1967	Soyuz 1	Vladimir Komarov	17	25.2	Heaviest manned craft; crashed killing Komarov

SPACECRAFT DIFFERENCES

Many differences in the three manned U.S. spacecraft are readily apparent, such as size and weight. The major differences are in the complexity and refinement of subsystems. Apollo's requirement for hardware "maturity" is significantly higher than for earlier spacecraft programs. Each subsystem has become progressively more complex, with many more demands made upon it and a correspondingly greater capability. Only Apollo has its own guidance and navigation system.

Electrical power is a good example of increased system complexity. Electrical power for Mercury was supplied by six batteries; for Gemini, it was supplied by seven batteries and two fuel cell powerplants; for Apollo, it is supplied by five batteries and three fuel cell powerplants. The three systems do not sound too different physically. In operation, however, the differences are considerable.

The greatest demand on the Mercury system was to supply power to sustain the 4,265-pound spacecraft and its single astronaut for a day and a half (the 34-hour flight of Gordon Cooper). In Gemini, the electrical power system had to provide sufficient power to operate a typical 7,000-pound craft containing two astronauts for as long as two weeks (the 14-day flight of Frank Borman and James Lovell). In Apollo, the system is designed to support a 100,000-pound spacecraft carrying three men for up to two weeks.

BASIC SPACECRAFT DIFFERENCES

	Mercury	Gemini	Apollo
Height	26 ft	19 ft	82 ft
Diameter	6.2 ft	10 ft	12 ft 10 in.
Launch weight	4265 lb at launch 2987 lb in orbit 2422 lb at recovery	8360 lb	109, 500 lb at launch 100,600 lb injected
Crew	1	2	3
Major components	Manned capsule (6 ft 10 in.) Adapter (4 ft 3 in.) Launch escape tower (16 ft 11 in.)	Entry (manned) module (11 ft 4 in.) Adapter module (7 ft 6 in.)	Command module (10 ft 7 in.) (top of apex cover) Service module (24 ft 2 in.) (top of fairing) Lunar module (22 ft 11 in.) (legs folded) Launch escape system (33 ft) Adapter (28 ft)
Subsystems			
Abort	Launch escape rocket and tower to carry manned capsule to safety	Ejection seat for each astronaut up to about 70,000 ft; malfunction detection system	Launch escape rocket and tower (similar to Mercury but about twice the size); emergency detection system
Communications	UHF and HF for voice; UHF for telemetry; C-band and S-band tracking radar	UHF primary for voice with HF backup; C-band tracking beacon; rendezvous radar; 300 flight measurements telemetered to ground	VHF-AM primary for near earth; S-band primary for deep space; rendezvous radar; 700 flight measurements telemetered to ground
Docking	None	Index bar (to fit in notch on target vehicle) and latches	Probe and docking ring on CM, drogue on LM
Earth Landing	4 chutes: main, drogue, reserve, pilot	3 chutes: main, drogue, pilot, and ejection seats	8 chutes: 3 main, 2 drogue, 3 pilot

	Mercury	Gemini	Apollo
Electrical Power	6 batteries: 3 main auxiliary, 2 stand-by, and 1 isolated	2 small fuel cells; 2 cryogenic tanks, 4 entry batteries, 3 pyro batteries	3 large fuel cells; 4 cryogenic tanks; 3 entry batteries; 2 pyro batteries
Environmental Control	Suit cooling and oxygen loop, cabin cooling loop (water coolant); cabin pressurized to 5 psi; no space radiators	Suit cooling and oxygen loops; redundant cabin cooling loops (silicon ester coolant); cabin pressurized to 5 psi; space radiators, cold-plates for operating equipment; shirt-sleeve environment	Four major loops: oxygen, suit circuit, water, and coolant (water-glycol); space radiators and cold-plates; cabin pressurized to 5 psi; shirtsleeve operations
Guidance and Control	Attitude control equipment (2 attitude gyros, 3 rate gyros, logic and programming circuits); automatic system using 12 small H_2O_2 thrusters and manual system using 6 small H_2O_2 thrusters; horizon sensors, periscope	Small computer (4,000-word memory), horizon sensor, no redundancy; 16 orbital attitude maneuvering system thrusters of 25 to 100 lb (No redundancy); 16 entry control thrusters (redundant systems of 8 25-lb engines); inertial platform, rendezvous radar	Large computer (39,000-word memory), telescope and sextant; semi-automatic operation; optical, inertial, and computer systems; attitude control through stabilization and control systems; 16 SM reaction control engines (100-lb) redundant systems, 12 CM reaction control engines in redundant systems; separate guidance and control systems in LM
Propulsion	3 posigrade rockets for separation from booster, 3 retrograde rockets for entry from orbit	4 retrograde rockets for entry (2,500 lb each)	Restartable service propulsion engine (20,000 lb); liquid propellant rodset propulsion with unlimited restart and thrust vector control (automatic and manual)