APOLLO SPACECRAFT
NEWS REFERENCE

It took 400 years of trial and failure, from da Vinci to the Wrights, to bring about the first flying machine, and each increment of progress thereafter became progressively more difficult.

But nature allowed one advantage: air. The air provides lift for the airplane, oxygen for engine combustion, heating, and cooling, and the pressurized atmosphere needed to sustain life at high altitude. Take away the air and the problems of building the man-carrying flying machine mount several orders of magnitude. The craft that ventures beyond the atmosphere demands new methods of controlling flight, new types of propulsion and guidance, a new way of descending to a landing, and large supplies of air substitutes.

Now add another requirement: distance. All of the design and construction problems are re-compounded. The myriad tasks of long-distance flight call for a larger crew, hence a greater supply of expendables. The functions of navigation, guidance, and control become far more complex. Advanced systems of communications are needed. A superior structure is required. The environment of deep space imposes new considerations of protection for the crew and the all-important array of electronic systems. The much higher speed of entry dictates an entirely new approach to descent and landing. Everything adds up to weight and mass, increasing the need for propulsive energy. There is one constantly recurring, insistent theme: everything must be more reliable than any previous aerospace equipment, because the vehicle becomes in effect a world in miniature, operating with minimal assistance from earth.

Such is the scope of Apollo.

Appropriately, the spacecraft was named for one of the busiest and the most versatile of the Greek gods. Apollo was the god of light and the twin brother of Artemis, the goddess of the Moon. He was the god of music and the father of Orpheus. At his temple in Delphi, he was the god of prophecy. Finally, he was also known as the god of poetry, of healing, and of pastoral pursuits.

The Apollo Spacecraft News Reference was prepared by the Space Division of North American Rockwell Corp., Downey, Calif., in cooperation with NASA's Manned Spacecraft Center.

The book is arranged in five distinct parts. The first (identified by white tabs) includes general information about the program, the elements of the spacecraft and launch vehicles, and the missions. The second part (blue tabs) is a detailed description of the Apollo modules. The third (tan tabs) contains descriptions of the equipment and operation of major subsystems. The fourth (green tabs) concerns vital operations and support, and the fifth (gray tabs) contains a series of references.

Information on most of the subsystems follows this format: first, a general description of the system, its equipment, and its function; second, an equipment list containing all major data about key equipment; and third, a detailed description of subsystem operation. The general description should provide all the information normally needed about each subsystem; the detailed description is necessarily quite technical and is included in response to requests for this level of detail.

Descriptions and data are taken from the latest available information. As modifications are made to equipment in response to continuing tests, the book will be amended to reflect these changes.

Photographs or illustrations in this volume are available for publication. Prints may be ordered according to the code designation (P-1, P-2, etc.) appearing at the lower left corner of each illustration. Send requests to:

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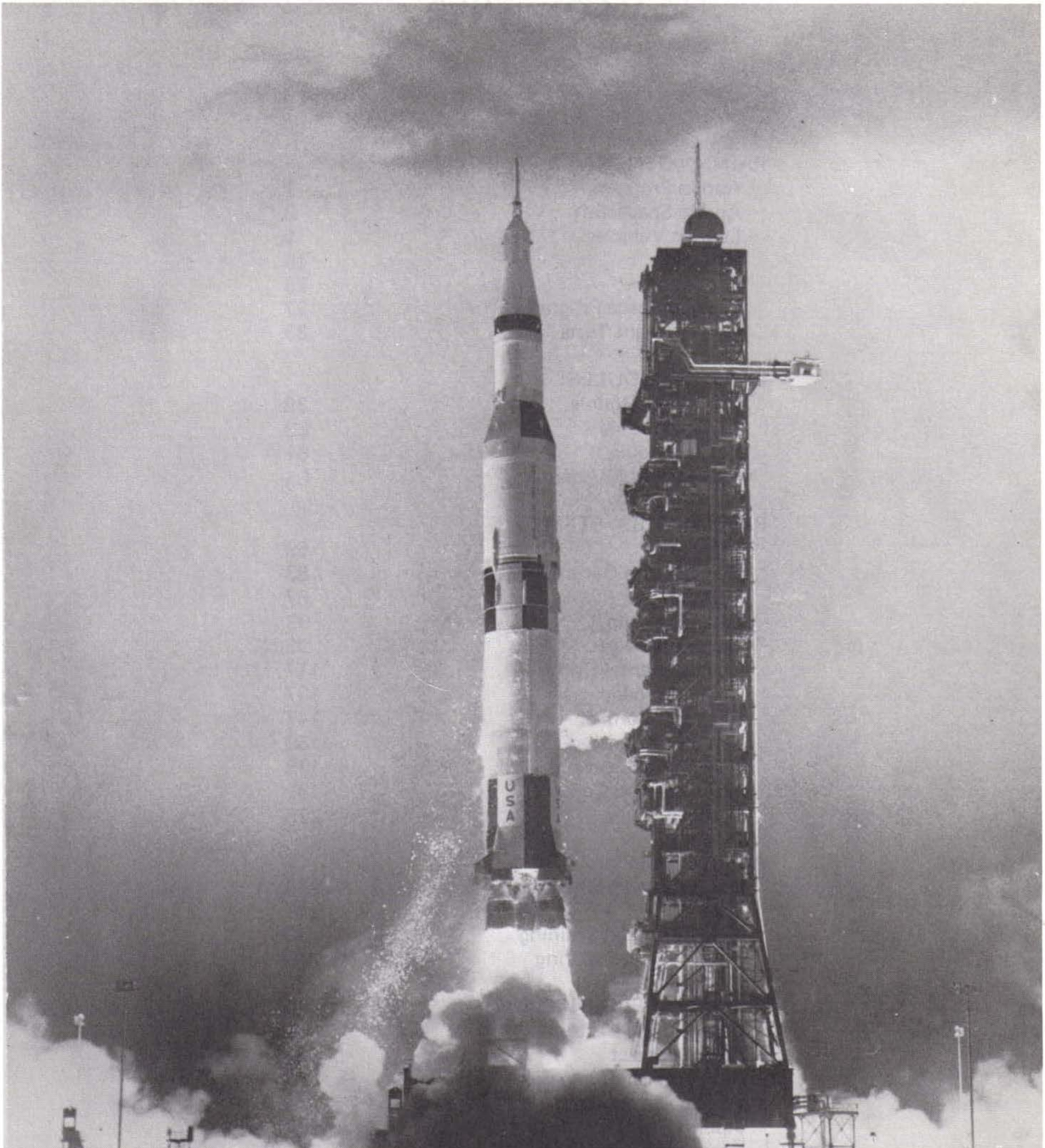


P-1 *Saturn V lifts Apollo spacecraft off pad in unmanned flight test*

APOLLO PROGRAM

Apollo is the United States program to land men on the moon for scientific exploration and return them safely to earth. It has been described as the greatest scientific, engineering, and exploratory challenge in the history of mankind.

The challenge essentially was to create an artificial world: a world large and complex enough to supply all the needs of three men for two weeks. The world had to contain all of the life-sustaining elements of earth—food, air, shelter—as well as many special complex extras (navigation, propulsion, communications). Perhaps the greatest challenge was that of reliability; everything had to work and keep working no matter what the circumstances. Unlike the previous manned space programs in which crewmen could return to earth almost within minutes if an emergency arose, it could be as much as three days before the Apollo crew can get back to earth from the moon.

A parallel problem was to develop a launch vehicle large enough to put this world into space and to send it on its way to the moon 239,000 miles away. Many different plans were examined before the technique of lunar orbit rendezvous was selected.

NASA announced the Apollo program and its objectives in July of 1960. As President Kennedy pointed out to Congress on May 25, 1961, the overall objective is 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." Of the lunar landing mission in particular, he said: "No single space project in this period will be more exciting, or more impressive to mankind, or more important for the long-range exploration of space; and none will be so difficult or so expensive to accomplish."

On Nov. 28, 1961, after a series of studies on the feasibility of the project, NASA awarded the basic Apollo spacecraft contract to the Space Division of North American Rockwell Corporation (at that time North American Aviation, Inc.). Development of a large carrier rocket—the Saturn program—had begun in late 1958 and in early 1962 was changed and expanded to meet the new goal of a landing on the moon.

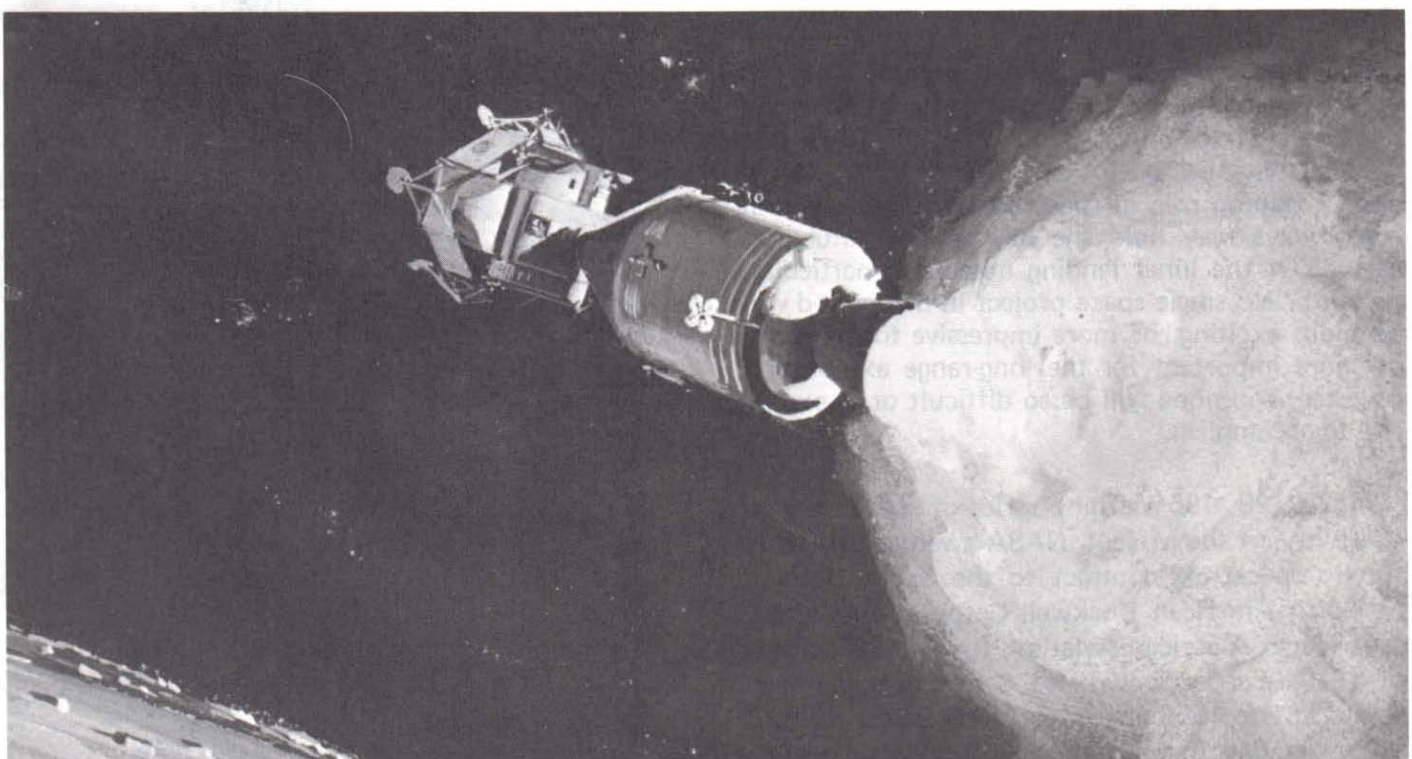
P-2 *Saturn V/Apollo shortly before launch*

Briefly, the objective of the program is to send a three-man spacecraft to the moon and into orbit around it, land two of the three men on the moon while the third remains in orbit, provide up to 35 hours on the moon, return the two moon explorers to the orbiting spacecraft, and return all three safely to earth. The entire trip, from launch to earth landing, is expected to last between 8 and 10 days; the Apollo spacecraft has been designed for 14-day operation to give a wide margin of safety.

The program is the most extensive ever undertaken by any nation. During the peak in 1966, more than 20,000 companies and 350,000 persons throughout the country participated directly in it. North American Rockwell Corp.'s Space Division is principal contractor for the spacecraft's command and service modules, the launch escape system, and spacecraft-lunar module adapter, and the Saturn V second stage (the S-II). The rocket engines for all stages are produced by North American Rockwell's Rocketdyne Division. The lunar module (LM) contractor is Grumman Aircraft Engineering Corp. Spacecraft associate contractors include the Massachusetts Institute of Technology and AC Electronics Division of General Motors Corp. for the guidance and navigation subsystem, International Latex Co. for space suits, and United Aircraft Corp. for lunar surface life support equipment. Major North American Rockwell Space Division subcontractors for Apollo (contracts of more than $500,000) are listed in Part 5..

The Saturn program involves three separate launch vehicles. Two of them are used with Apollo spacecraft: the Saturn IB, a two-stage vehicle with a first stage thrust of 1,600,000 pounds, which is used for earth-orbital missions of the Apollo program; and the Saturn V, a three-stage vehicle with a maximum off-the-pad thrust of 7,500,000 pounds, which will be used for some earth-orbital missions and for the lunar mission. The Saturn I launch vehicle was used to develop large rocket engine technology.

The Apollo program is under the management of the Office of Manned Space Flight, Headquarters NASA. The Apollo spacecraft program is directed by NASA's Manned Spacecraft Center in Houston, Tex. The Saturn program is under the management of NASA's Marshall Space Flight Center in Huntsville, Ala. Pre-flight checkout and testing and launch activities are directed by NASA's Kennedy Space Center at Cape Kennedy, Fla.



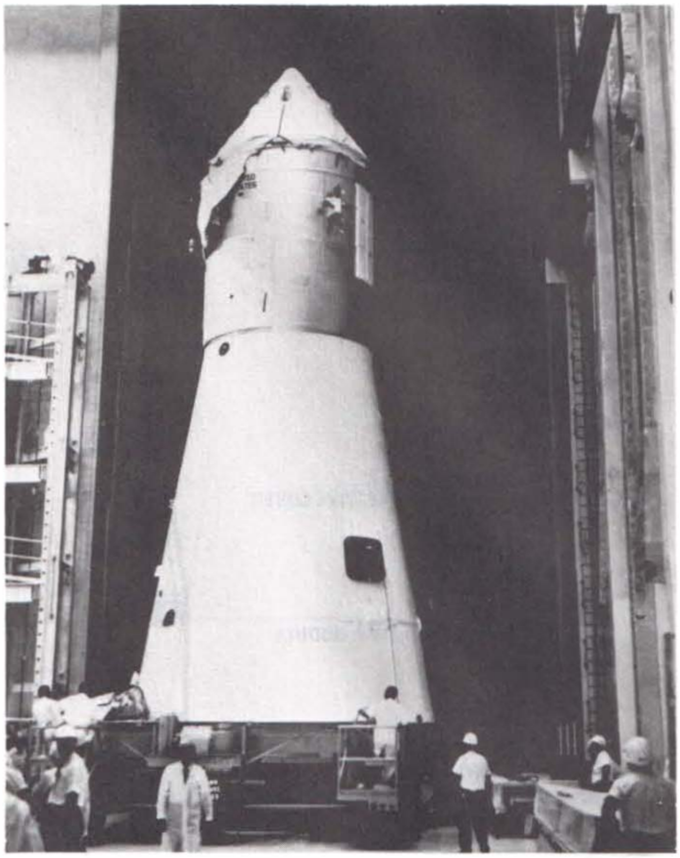
P-2a *Artist's conception of Apollo spacecraft in orbit around the moon before lunar landing*

APOLLO SPACECRAFT

The Apollo spacecraft is the entire structure atop the launch vehicle. It is 82-feet tall and has five distinct parts: the command module, the service module, the lunar module, the launch escape system, and the spacecraft-lunar module adapter.

The three modules make up the basic spacecraft; the launch escape system and adapter are special-purpose units which are jettisoned early in the mission after they have fulfilled their function. The launch escape system is essentially a small rocket which will thrust the command module—with the astronauts inside—to safety in case of a malfunction in the launch vehicle on the pad or during the early part of boost. The spacecraft-lunar module adapter serves as a smooth aerodynamic enclosure for the lunar module during boost and as the connecting link between the spacecraft and the launch vehicle.

The spacecraft program has been divided into two parts, referred to as Block I (early earth-orbital test) and Block II (lunar mission version). The Block I program has been completed, and all future Apollo spacecraft flights will be with the Block II lunar mission type.



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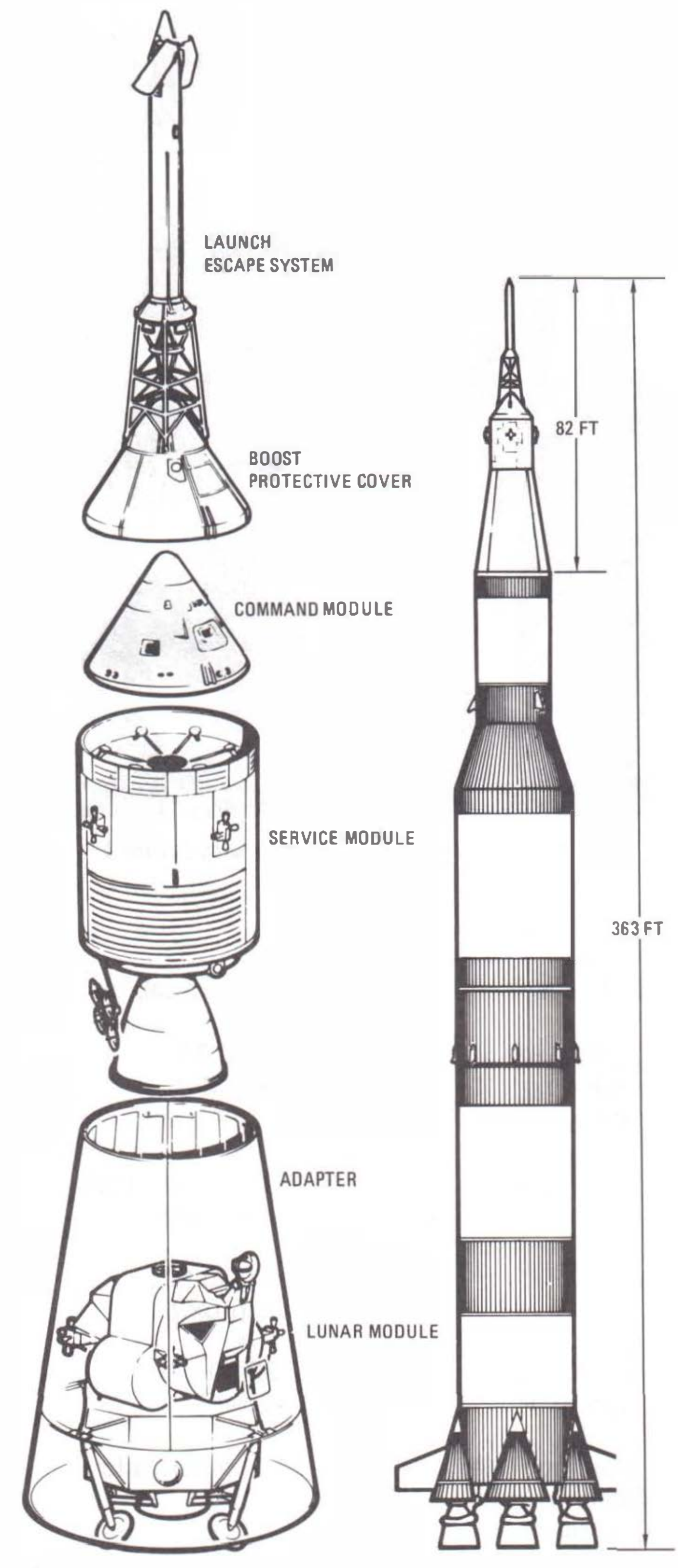
Spacecraft just before mating with Saturn V

	CM	SM	LM
Shape	Cone	Cylinder	Bug-like cab on legs
Height	10 ft, 7 in.	22 ft, 7 in. excluding fairing	22 ft, 11 in. (legs extended)
Diameter	12 ft, 10 in.	12 ft, 10 in.	29 ft, 9 in. (legs extended)
Habitable volume	210 cu ft		160 cu ft (approx.)
Launch weight	13,000 lb (approx.)	53,000 lb (approx.)	32,500 lb (approx.)
Primary material	Aluminum alloy Stainless steel Titanium	Aluminum alloy Stainless steel Titanium	Aluminum alloy



Apollo spacecraft

The basic difference in the two versions was in the addition, in Block II, of some equipment and systems designed specifically for the lunar mission. NASA's purpose in dividing the program was to get basic structure and systems tested in space as quickly as possible, while providing the time and the flexibility to incorporate changes. Thus, in addition to lunar equipment, Block II contains a great number of refinements and improvements of equipment and systems, many the result of continuing research and many evolving from the Block I unmanned flight and ground tests.

The spacecraft and systems described in this book are Block II.

For brevity, abbreviations for a few basic items of the Apollo program will be used throughout the book. For the spacecraft, these are CM for command module, SM for the service module, LM for the lunar module, CSM for the command and service modules together, and SLA for the spacecraft-lunar module adapter.

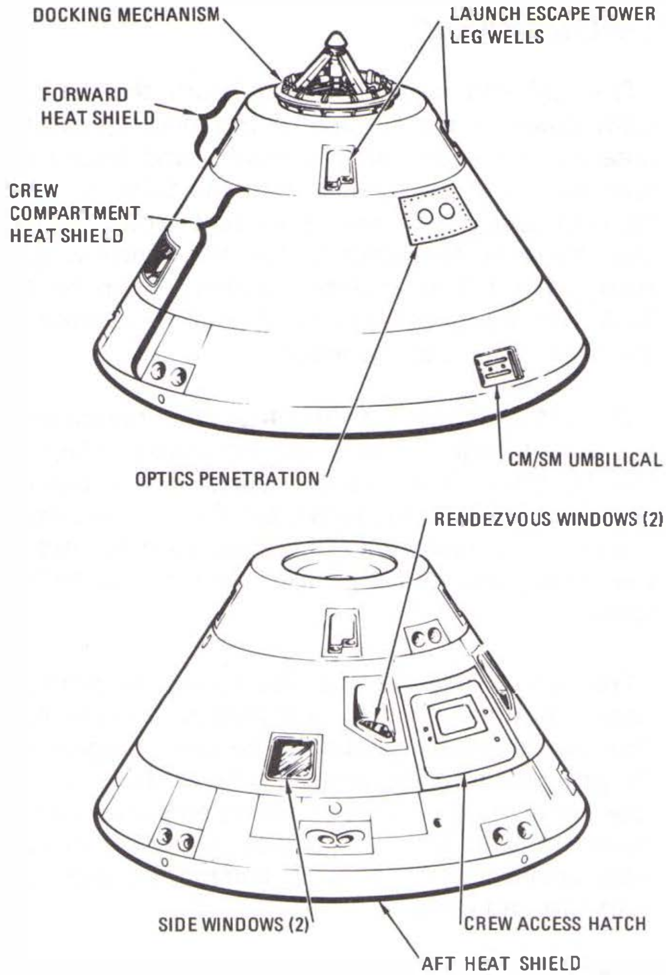
Abbreviations and acronyms are a key part of the engineering jargon; thousands are used commonly in the Apollo program. Many of the major ones are listed at the end of the glossary. Otherwise, they appear in this book only on a few diagrams or schematics where it was impossible because of limited space to spell them out. If the text does not make it clear what item of equipment is being referred to, a check with the glossary should provide the answer.

COMMAND MODULE

This is the control center for the spacecraft; it provides living and working quarters for the three-man crew for the entire flight, except for the period when two men will be in the LM for the descent to the moon and return. The command module is the only part of the spacecraft that returns to earth from space.

The CM consists of two shells: an inner crew compartment (pressure vessel) and an outer heat shield. The outer shell is stainless steel honeycomb between stainless steel sheets, covered on the outside with ablative material (heat-dissipating material which chars and falls away during earth entry).

The inner shell is aluminum honeycomb between aluminum alloy sheets. A layer of insulation separates the two shells. This construction makes the



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Command module

CM light as possible yet rugged enough to stand the strain of acceleration during launch, the shock and heat of earth entry, the force of splashdown, and the possible impact of meteorites.

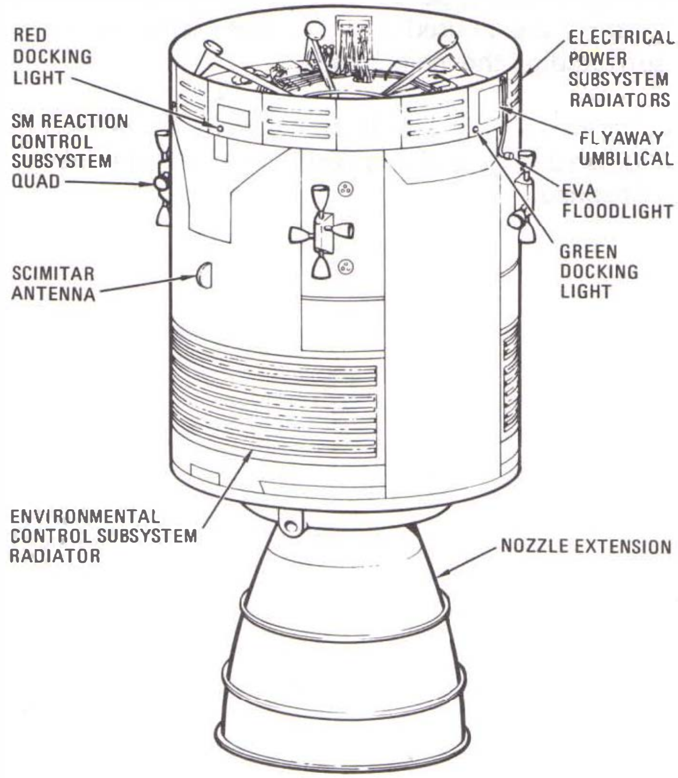
Inside, it is a compact but efficiently arranged combination cockpit, office, laboratory, radio station, kitchen, bedroom, bathroom, and den. Its walls are lined with instrument panels and consoles, and its cupboards (bays) contain a wide variety of equipment. In flight, the cabin is air conditioned to a comfortable 70 to 75 degrees. The atmosphere is 100-percent oxygen, and the pressure is about 5 pounds per square inch (a little better than one-third of sea-level pressure of 14.7 pounds per square inch).

The command module's controls enable the crew to guide it during flight. Test equipment permits checkout of malfunctions in spacecraft subsystems. Television, telemetry and tracking equipment, and two-way radio provide communication with earth and among the astronauts during moon exploration and the moon orbit rendezvous. These and other subsystems, such as the reaction control, guidance and navigation, earth landing, and parts of the environmental control and electrical power, occupy almost every inch of available space in the module.

Although crewmen can move about from one station to another, much of their time will be spent on their couches. The couches can be adjusted so the crew can stand or move around. Space by the center couch permits two men to stand at one time. The couches are made of steel framing and tubing and covered with a heavy, fireproof fiberglass cloth. They rest on eight crushable honeycomb shock struts which absorb the impact of landing. Control devices are attached to the armrests.

SERVICE MODULE

The service module's function, as its name implies, is to support the command module and its crew. It houses the electrical power subsystem, reaction control engines, part of the environmental control subsystem, and the service propulsion subsystem including the main propulsion engine for insertion into orbit around the moon, for return from the moon, and for course corrections.



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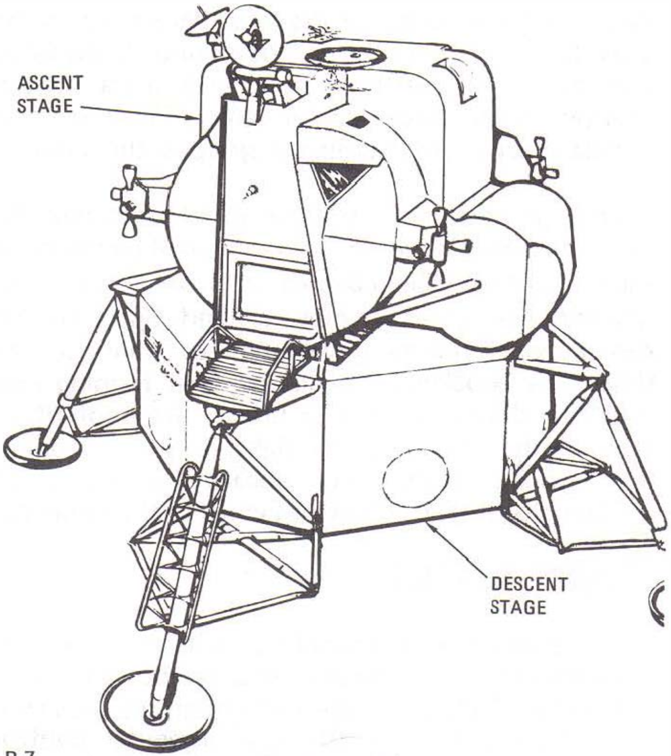
Service module



Lunar module

The SM is constructed of aluminum alloy. Its outer skin is aluminum honeycomb between aluminum sheets. Propellants (a combination of hydrazine and unsymmetrical dimethylhydrazine as fuel and nitrogen tetroxide as oxidizer) and various subsystems are housed in six wedge-shaped segments surrounding the main engine.

The service module is attached to the command module until just before earth entry, when the SM is jettisoned.

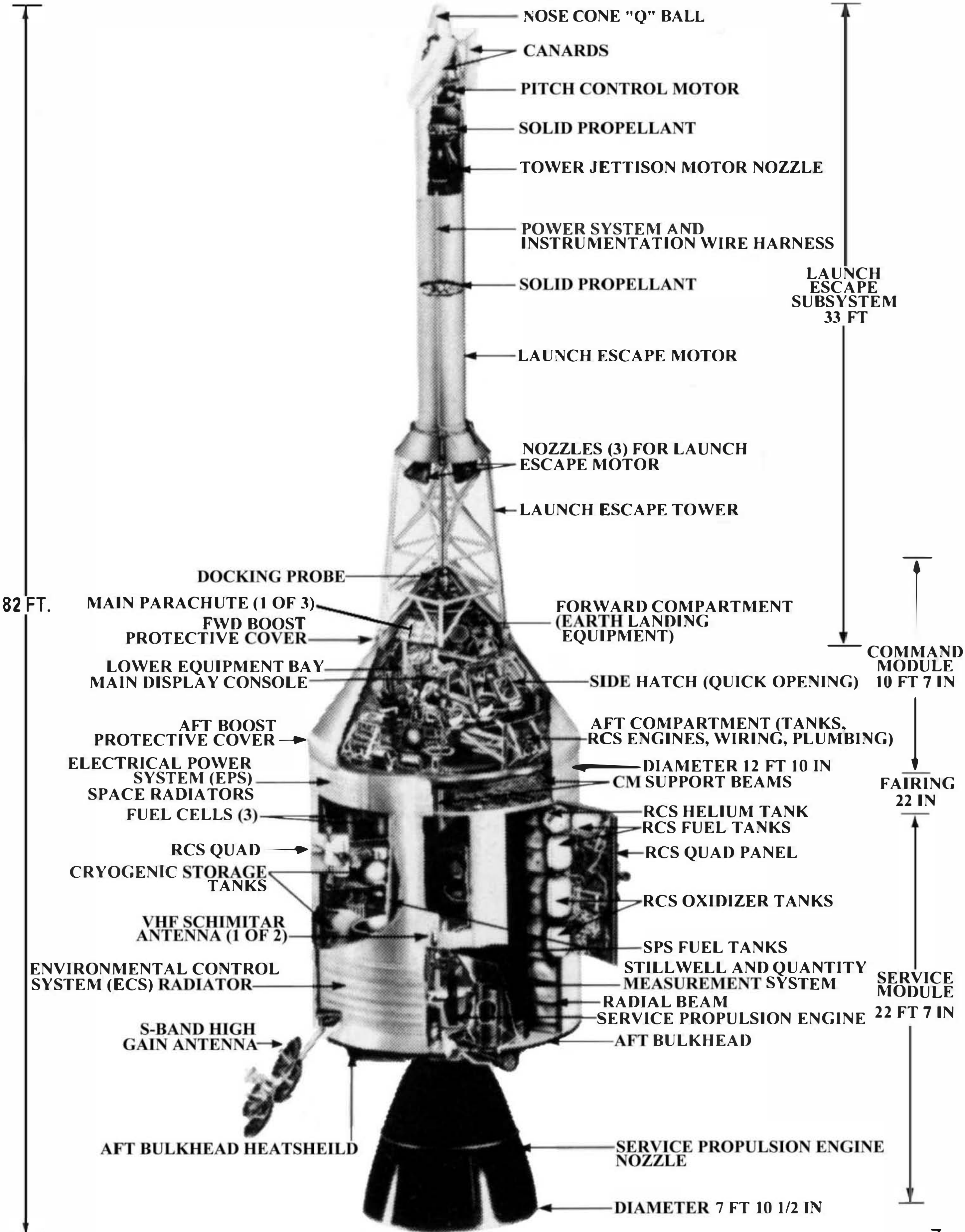
LUNAR MODULE

The LM will carry two men from the orbiting CSM down to the surface of the moon, provide a base of operations on the moon, and return the two men to a rendezvous with the CSM in orbit. Its odd appearance results in part from the fact that there is no necessity for aerodynamic symmetry; the LM is enclosed during launch by the SLA and operates only in the space vacuum or the hard vacuum of the moon.

The LM structure is divided into two components: the ascent stage (on top) and the descent stage (at the bottom). The descent stage has a descent engine and propellant tanks, landing gear assembly, a section to house scientific equipment for use on the moon, and extra oxygen, water, and helium tanks.

The ascent stage houses the crew compartment (which is pressurized for a shirtsleeve environment like the command module), the ascent engine and its propellant tanks, and all LM controls. It has essentially the same kind of subsystems found in the command and service modules, including propulsion, environmental control, communications, and guidance and control.

Portable scientific equipment carried in the LM includes an atmosphere analyzer, instruments to measure the moon's gravity, magnetic field, and radiation, rock and soil analysis equipment, a seismograph, a soil temperature sensor, and cameras (including television).


NOSE CONE "Q" BALL
CANARDS
PITCH CONTROL MOTOR
SOLID PROPELLANT
TOWER JETTISON MOTOR NOZZLE
POWER SYSTEM AND INSTRUMENTATION WIRE HARNESS
SOLID PROPELLANT
LAUNCH ESCAPE SUBSYSTEM 33 FT
LAUNCH ESCAPE MOTOR
NOZZLES (3) FOR LAUNCH ESCAPE MOTOR
LAUNCH ESCAPE TOWER
DOCKING PROBE
82 FT.
MAIN PARACHUTE (1 OF 3)
FWD BOOST PROTECTIVE COVER
FORWARD COMPARTMENT (EARTH LANDING EQUIPMENT)
COMMAND MODULE 10 FT 7 IN
LOWER EQUIPMENT BAY
MAIN DISPLAY CONSOLE
SIDE HATCH (QUICK OPENING)
AFT BOOST PROTECTIVE COVER
AFT COMPARTMENT (TANKS, RCS ENGINES, WIRING, PLUMBING)
ELECTRICAL POWER SYSTEM (EPS) SPACE RADIATORS
DIAMETER 12 FT 10 IN
CM SUPPORT BEAMS
FAIRING 22 IN
FUEL CELLS (3)
RCS HELIUM TANK
RCS FUEL TANKS
RCS QUAD
RCS QUAD PANEL
CRYOGENIC STORAGE TANKS
RCS OXIDIZER TANKS
VHF SCHIMITAR ANTENNA (1 OF 2)
SPS FUEL TANKS
ENVIRONMENTAL CONTROL SYSTEM (ECS) RADIATOR
STILLWELL AND QUANTITY MEASUREMENT SYSTEM
SERVICE MODULE 22 FT 7 IN
RADIAL BEAM
SERVICE PROPULSION ENGINE
S-BAND HIGH GAIN ANTENNA
AFT BULKHEAD
AFT BULKHEAD HEATSHEILD
SERVICE PROPULSION ENGINE NOZZLE
DIAMETER 7 FT 10 1/2 IN