LUNAR MODULE DERIVATIVES FOR FUTURE SPACE MISSIONS

The assets of the Apollo Program collectively represent a major resource for future United States space missions. These assets include test, production, tracking, and launch facilities; trained astronauts; spacecraft; launch vehicles; and the experienced government/industry/university team.

In particular, the Lunar Module's versatility, ability to fly manned or unmanned, propulsive capability, and payload volume envelope offer attractive options to achieve significant space objectives in the future. These include increases in scientific knowledge, benefits to Man, space technology, and mission time.

A variety of LM-derived vehicles for use in earth or lunar orbit, and on the lunar surface, are described in this section. Missions of 2-month duration in earth orbit (longer with revisits) and at least 2-week duration on the moon for a variety of important space objectives are possible utilizing the LM. These missions would apply the experience gained from the early LM mission, to reduce costs while greatly increasing mission and scientific objectives. Additionally, these missions could serve as the springboard for significant future space ventures.

APOLLO LUNAR MODULE

This—the basic Apollo Lunar Module, or LM—is the two-stage spacecraft from which all the concepts shown are derived. For Project Apollo, the LM mission is essentially this:

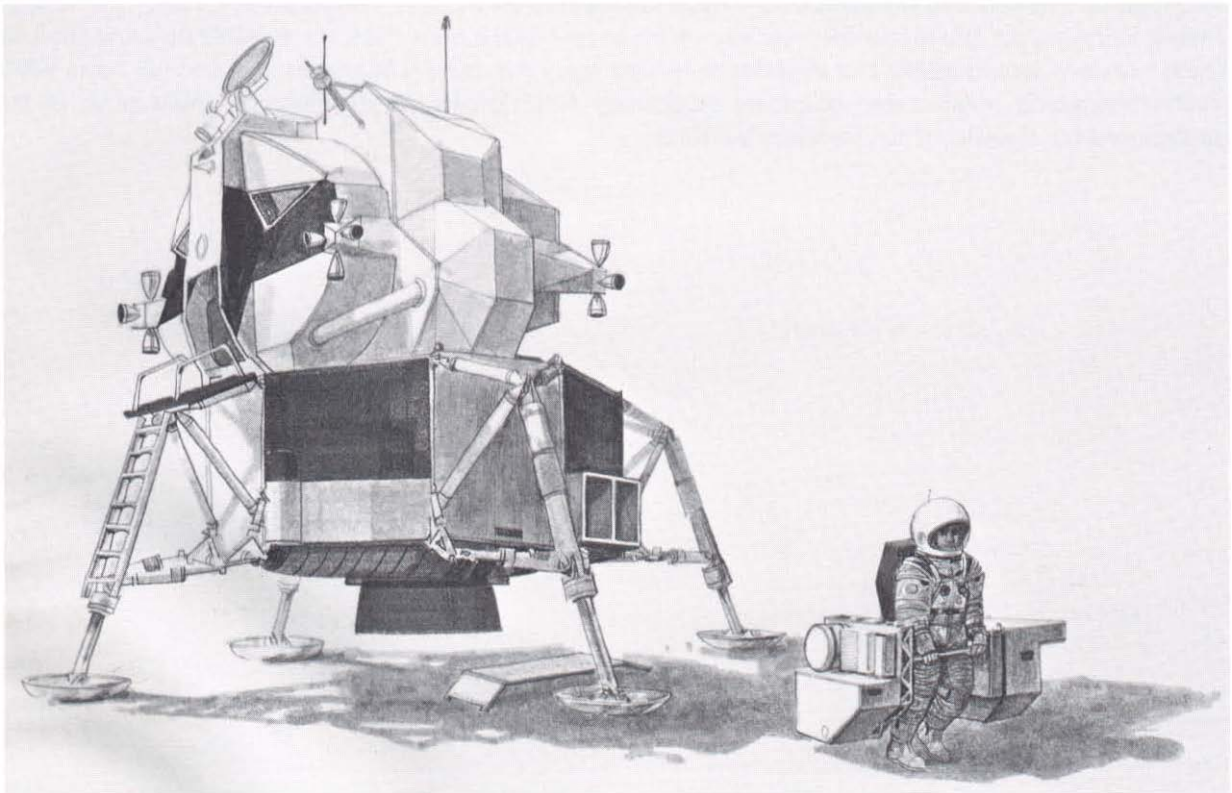
Ferry two astronauts to the surface of the moon from the Command and Service Module (CSM) parked in lunar orbit.

Sustain the lives of the men during their lunar stay

Exploration and gathering scientific data and samples

Return the astronauts safely to the CSM through an ascent and rendezvous maneuver.

The descent stage carries the equipment and expendables used during the descent to the moon and lunar exploration; the equipment includes the engine, propellant, the landing gear, and the Apollo Lunar Scientific Experiment Package. The ascent stage contains the crew's life support equipment, expendables, and storage provisions for return of scientific samples; this stage contains most of the spacecraft's other operating subsystems including the engine and propellants used to return the astronauts to the CSM. As designed for the initial Project Apollo missions, LM was capable of sustaining the astronauts for up to 48 hours away from the CSM, carrying a 300-pound scientific payload to the moon, and transporting a 100-pound payload on its return trip to the CSM.



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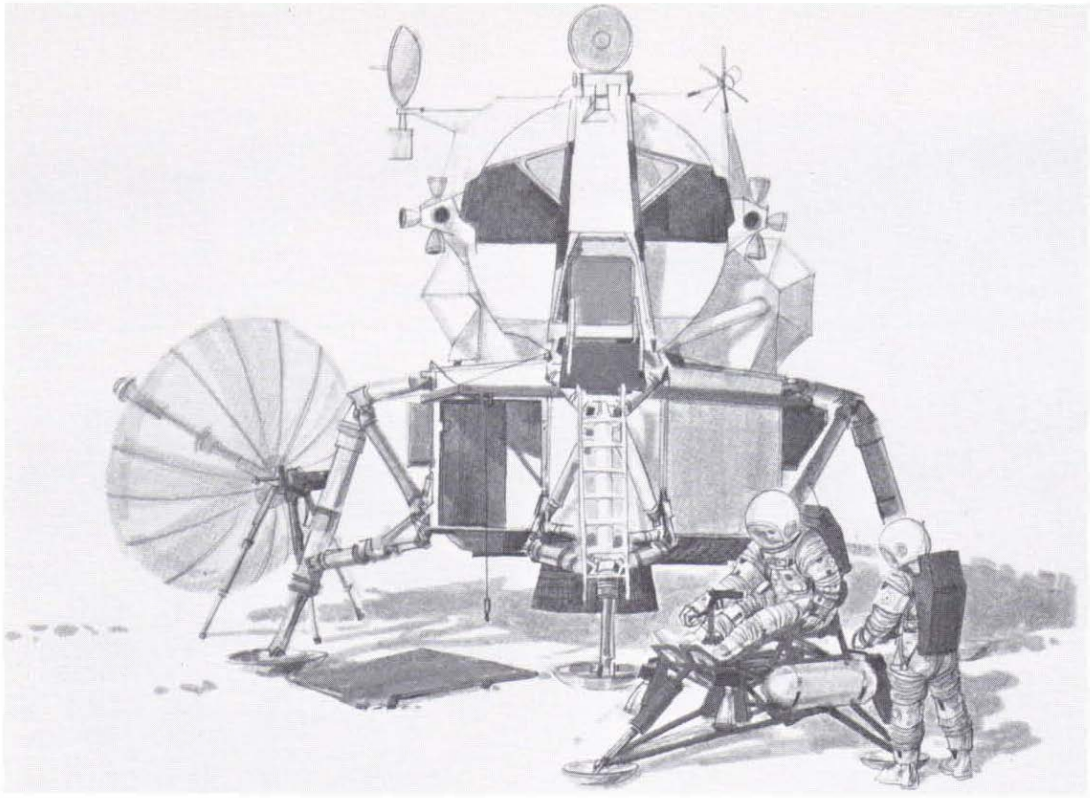

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EXTENDED LM

For single-launch missions, experience gained from the initial Apollo lunar landing, combined with some LM modifications, permits an increase in LM payload. These modifications extend astronaut time on the moon to 72 hours while providing the astronauts with as much as 1000 pounds of scientific equipment, including Lunar Roving Vehicles (LRV's) or possibly Lunar Flying Vehicles (LFV's).

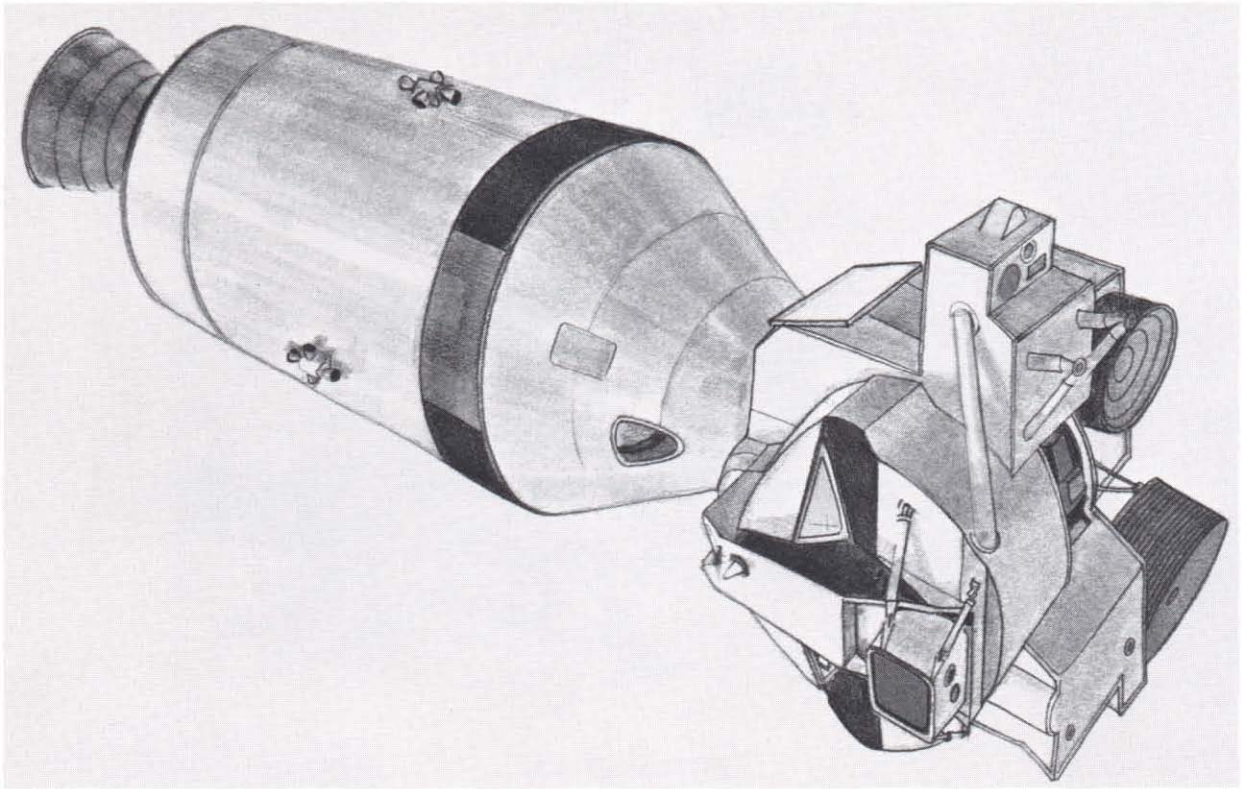
LUNAR RECONNAISSANCE MODULE

The Lunar Reconnaissance Module (LRM) is an orbiting version of the LM equipped with extensive photo-mapping, geochemical, and electromagnetic surveying equipment. Docked to the CSM, it is inserted into a lunar polar orbit from which, for the first time, the surface, subsurface, and near-lunar environment is surveyed.

The LM descent stage is used for initial Lunar Orbit Insertion (LOI), after which it is jettisoned. The ascent stage, stripped of its Propulsion and Reaction Control Subsystems, contains all the sensors for the reconnaissance mission.

The LRM carries its own equipment thermal control system and electrical power supply system, in addition to navigation and control equipment for the descent engine docked burn.

The LRM completely surveys the moon during 14 days in lunar orbit. Normal equipment servicing, such as film reloading, is accomplished in a shirtsleeve environment.

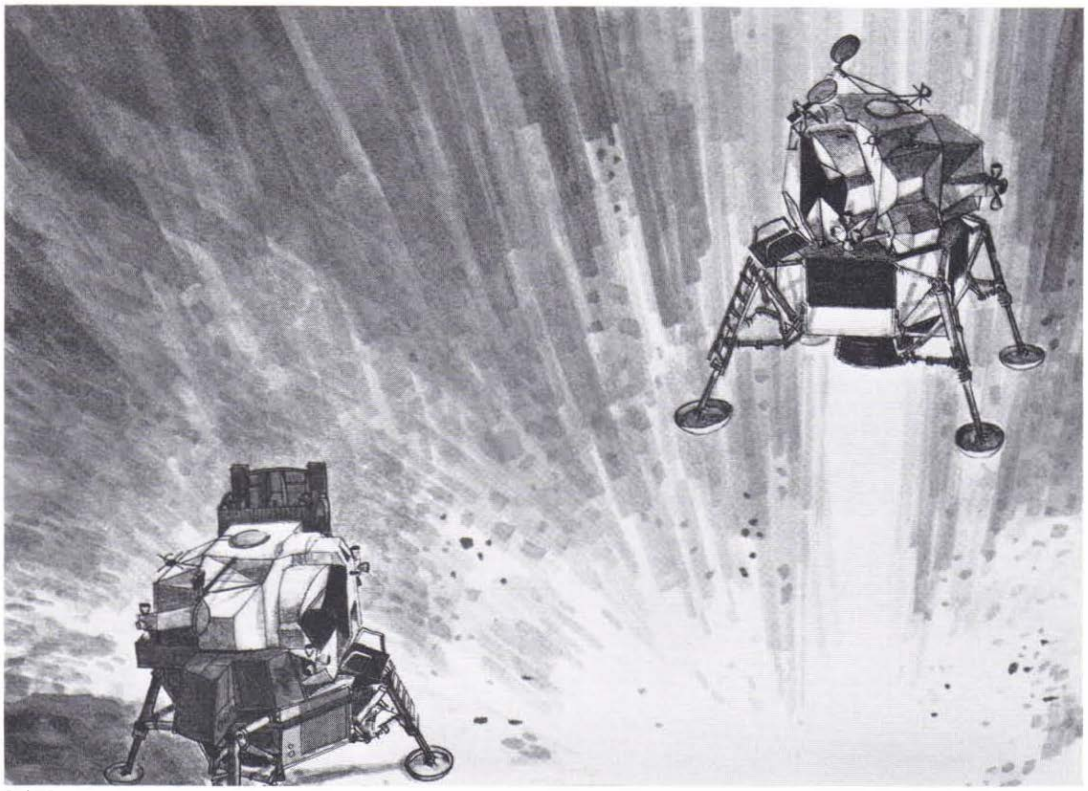


R-147

LM LABORATORY

Heavily equipped with experiment instrumentation, capable of operation in earth or lunar orbit, and provisioned to sustain two astronauts for 45 days in space, the LM Laboratory is an exciting science-oriented offshoot of the LM. Its experiment sensors include radiometers, spectrometers, a stellar camera, a terrain camera, multispectral cameras, X-ray sensors, a day-night camera, and an IR imager. Experiment categories in which these devices are used include meteorology, astronomy, earth resources, lunar survey and mapping, bioscience, and engineering technology.

The laboratory is compatible for docking with the CSM. It can be launched by the Uprated Saturn I or Saturn V vehicle.



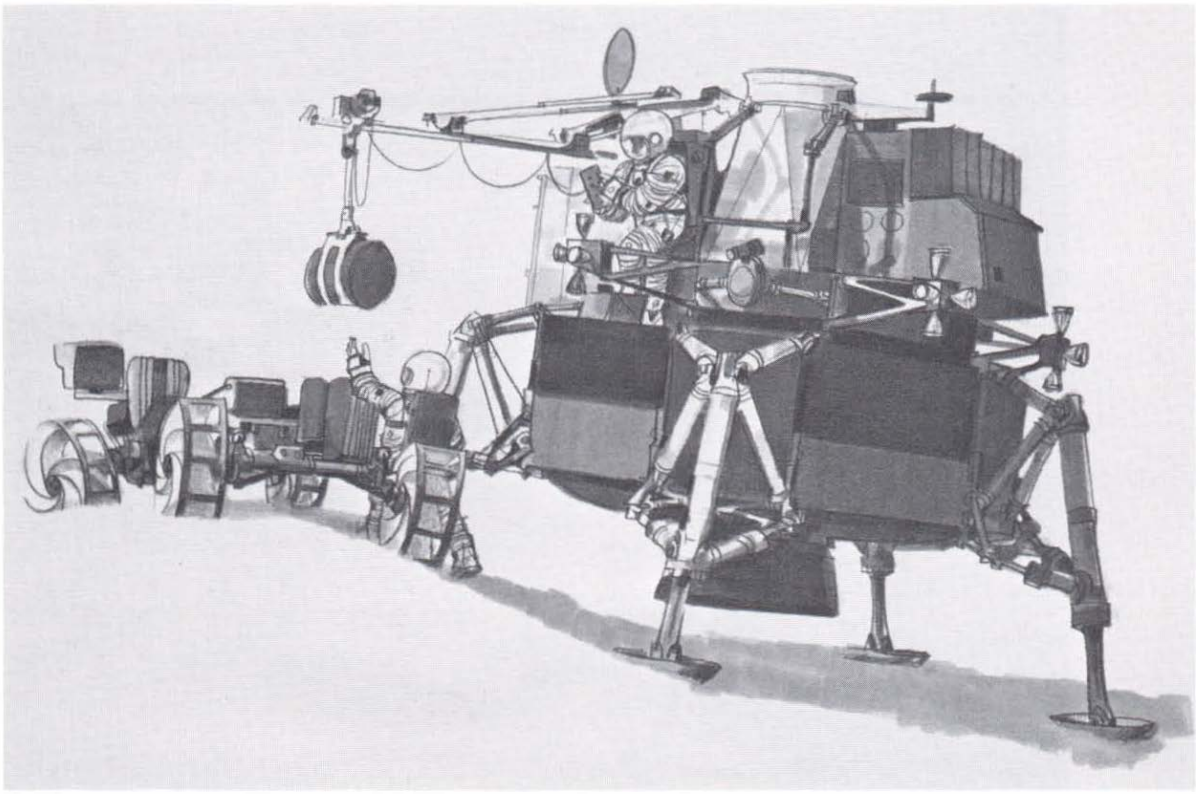
R-141

LM TAXI

Outwardly identical with the Apollo LM, the LM Taxi differs from its parent spacecraft by a few subtle modifications to accommodate the slightly different nature of its mission. The LM Taxi ferries two astronauts to the moon on the second leg of a dual launch, following the successful unmanned landing of a LM Truck/Shelter on the first leg.

The Taxi carries the same life support provisions as the Apollo LM. The astronauts will shut down and store the Taxi after landing, and transfer quarters to the Shelter vehicle for the 14-day stay. During this period, the status of mission-critical Taxi hardware is monitored on earth via MSFN.

During quiescent storage, the propellants, engines, and much of the Taxi equipment must be thermally controlled, to permit rapid abort. The Apollo LM thermal control system has been modified to include a hatch cover, window shades, and isotope heat sources. Additional instrumentation has been added to enable complete evaluation of Taxi status at all times. A Radioisotope Thermoelectric Generator (RTG) supplements the battery power supply capability. All subsystems are qualified for the extended life requirements of the Taxi.



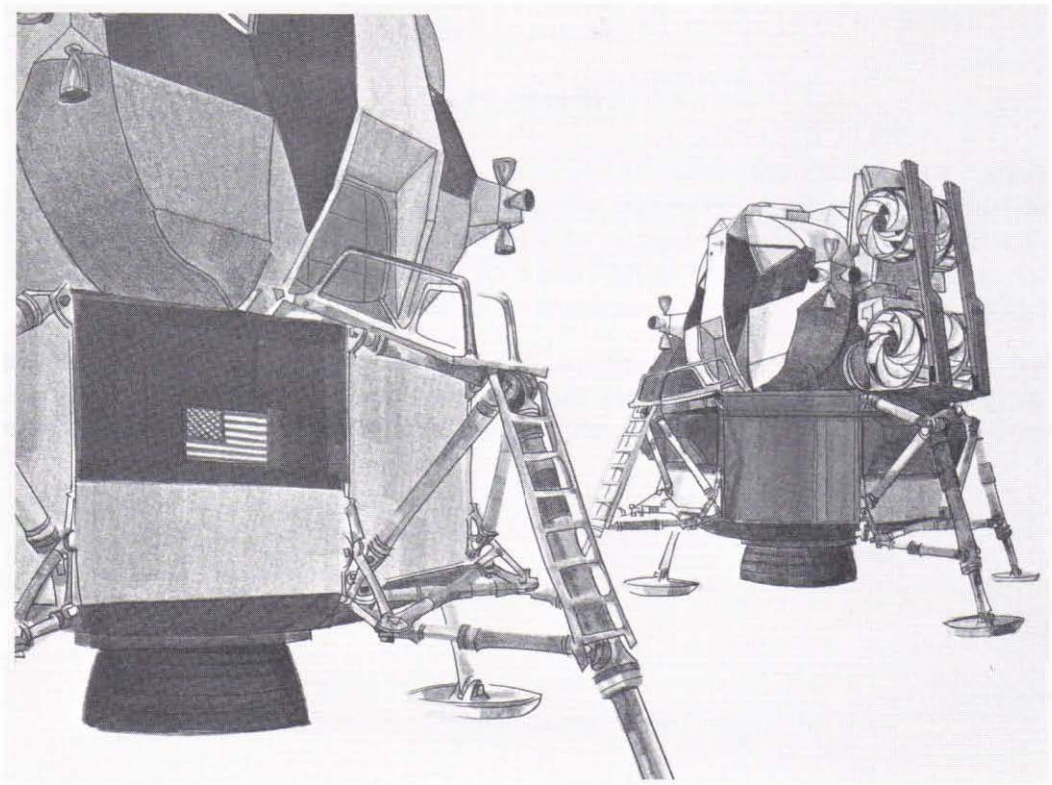
R-142

LM TRUCK

The LM Truck is an unmanned lunar lander that transports cargo in the volume otherwise occupied by the LM ascent stage. Components from the removed ascent stage that are vital to the Truck mission are relocated in a central docking structure attached to the existing interstage fittings on an unmodified descent stage.

The docking structure enables CSM transposition and docking with the Truck in lunar orbit and extraction of the Truck from the Spacecraft LM Adapter (SLA). Thereupon, an astronaut from the CSM can reach into the structure through the docking tunnel and, using a keyboard stored in the structure, update the Truck's Guidance, Navigation, and Control Subsystem so that the spacecraft's trajectory to landing is held within acceptable tolerances.

A typical mission payload, shown in the artist's rendering, might comprise a Lunar Roving Vehicle for surface transportation, resupply modules for supporting two men on the lunar surface for as long as 14 days, and a 5,300-pound, 900-cubic-foot scientific cargo.



R-145

LUNAR PAYLOAD MODULE

Unlike the LM Truck, the Lunar Payload Module retains the basic LM ascent stage, but is stripped of the ascent propulsion system and components unnecessary for lunar landing. In this configuration, the existing ascent and descent stage structures can accommodate a 7,300-pound payload within a useful volume of approximately 800 cubic feet.

Otherwise, its mission is similar to the other shelter vehicles launched at the start of a dual-spacecraft mission. The payload module, landed unmanned, replenishes shelter and astronaut supplies.

LM SHELTER

The Shelter is an Apollo LM minus its ascent propulsion system and modified to: (1) make an unmanned landing on the moon, (2) remain quiescent for as long as 60 days, and (3) support two men for 14 days. Successful launch and landing of a Shelter would be followed by a manned Taxi in a dual-launch mission. Shelter payload could consist of expendables, mobility aids, a 30-meter lunar drill, and an advanced Apollo Lunar Surface Equipment Package.

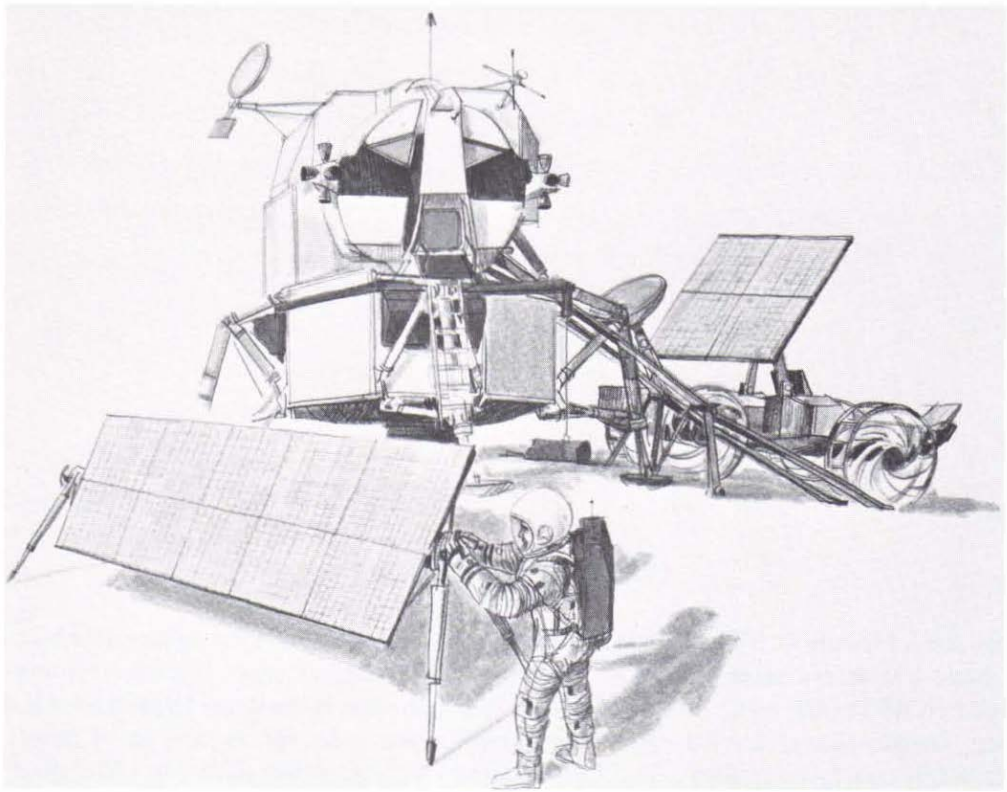
Removal of the ascent engine increases the habitable volume of the cabin. Special hammocks provide more comfortable sleeping quarters for the astronauts. An airlock, attached to the forward hatch, serves as an EMU station and eliminates the need to depressurize the cabin before lunar surface egress.

LM TRUCK

This alternate LM Truck is a modification wherein all ascent stage components needed for unmanned landing are integrated into the descent stage. The vacated ascent stage volume can be filled with a 9,000-pound payload.

The representative payload shown consists of 760-cubic-foot fixed crew living quarters, Lunar Roving Vehicle, crew provisions for as long as 14 days, and a 4,800-pound, 550-cubic-foot scientific cargo.

A Truck landing represents only half of a dual-launch mission. After the payload arrives successfully on the moon, a second earth launch of a LM Taxi dispatches astronauts who use the life-support and scientific equipment in the LM Shelter in performing their duties during long-duration lunar explorations.



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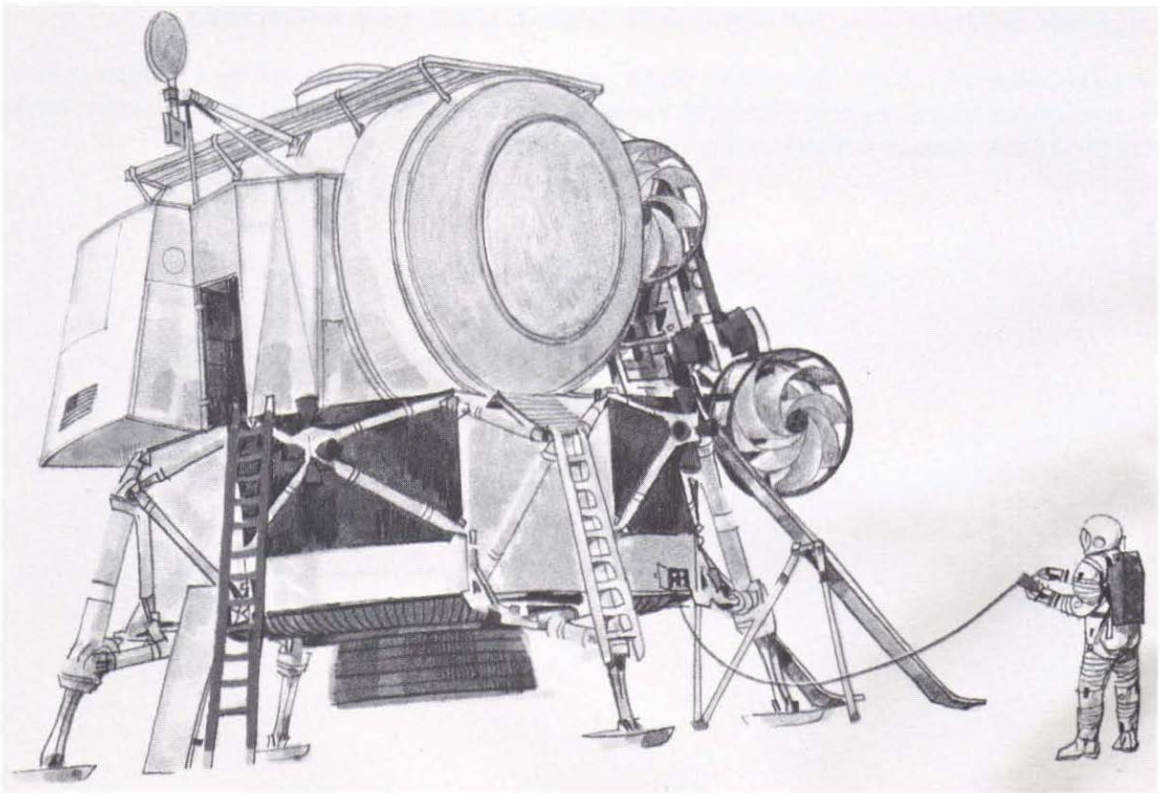


R-144

LUNAR BASE MODULE

The Lunar Base Module (LBM) provides the largest habitable volume for lunar surface operation; it retains the basic LM ascent stage structure. The ascent propulsion system has been removed, and the cabin enlarged to 450 cubic feet. The LBM, like the LM Shelter, is designed to land unmanned on the lunar surface, remain stored for 60 days, then support two men for as long as 14 days. Two beds provide maximum comfort for sleep. The LBM is used in conjunction with the LM Taxi in the dual mission mode.

Cabin volume is increased by enlarging the midsection diameter, moving the rear bulkhead back against the aft equipment rack, and removing the ascent propellant and helium tanks.

The Environmental Control Subsystem water sublimator has been replaced by a radiator, and solar panels have been added to the Electrical Power Subsystem. Both of these changes were made to support the 14-day mission with a minimum-weight vehicle.

MOBILITY AIDS

Flying and roving vehicles are being developed to support advanced lunar surface scientific exploration. Typical mobility aids that can be carried on the LM derivatives are:

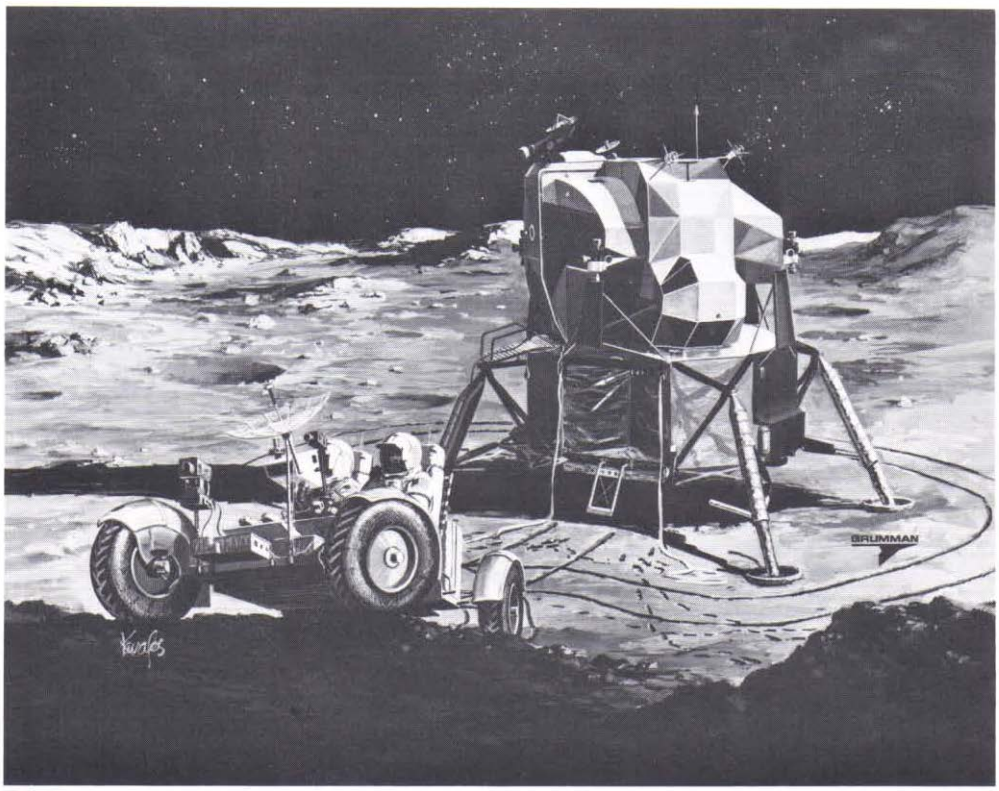
Lunar Roving Vehicle (LRV)

Capable of supporting 1000 pounds, including two astronauts, their life support equipment, 200 pounds of tools, scientific equipment and lunar soil and rock samples; the LRV is small enough to be carried on a single-launch mission. Although its radius of operation will be 3 nautical miles, allowing crewmen to safely walk back to their landing craft in an emergency, the LRV will travel more than 20 miles during its lunar traverses.

The basic vehicle weighing less than 500 pounds, is about 10 feet long, 6 feet wide, 45 inches high, is battery powered, and is propelled by electric motors contained in each wheel.

Lunar Flying Vehicle (LFV)

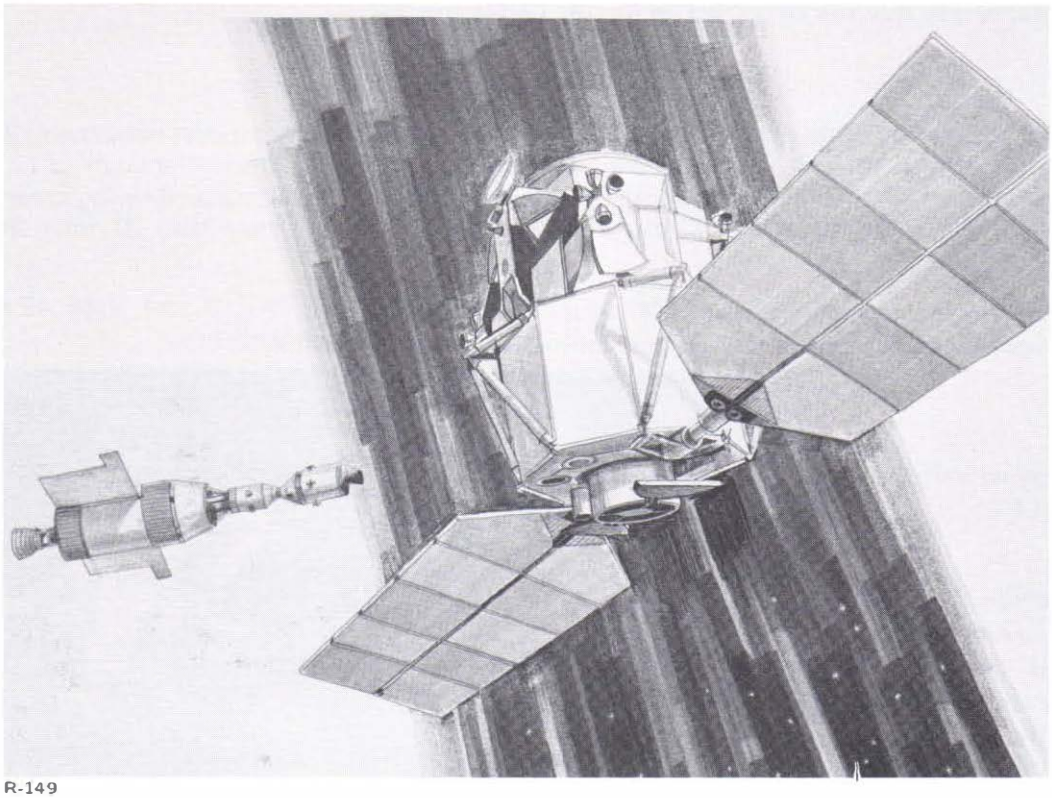
This vehicle can be carried on a single-launch mission. It weighs 180 pounds dry and carries 300 pounds of the same propellant used by the LM descent engine; therefore, LM residual propellant can be transferred to the LFV after landing. The LFV can carry one man with approximately 370 pounds of scientific equipment or, on a rescue mission, two men without the equipment.



R-146

Dual-Mode Lunar Roving Vehicle (DLRV)

The DLRV is a 1,000-pound vehicle, including 350 pounds of scientific equipment; it has a growth capability to 1,750 pounds of which 750 pounds is scientific equipment. In the manned mode, the DLRV has a 6-nautical-mile radius of operation; in the unmanned mode, controlled remotely from earth, it can traverse more than 600 nautical miles. The DLRV would be carried on an Extended LM or on an unmanned logistic spacecraft such as the LM Shelter or Truck.

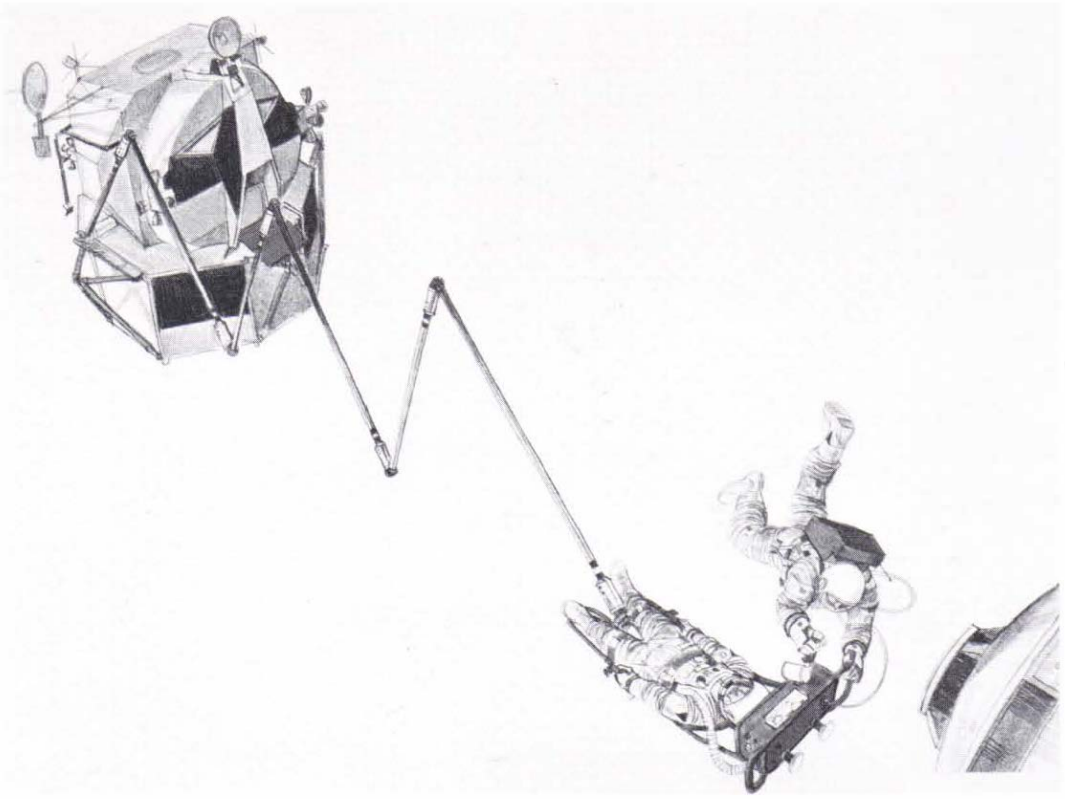


R-149

LM/STELLAR ATM

One of the purposes of the Apollo Telescope Mount (ATM) mission is to evaluate performance essential to the development of advanced manned orbiting solar and stellar observation systems. The experience gained on the ATM mission may be applied to other observatory missions by replacing the solar telescope with a large-aperture steller telescope. The Stellar ATM could then be used to collect scientific data on celestial objects in the ultraviolet spectrum. Such a configuration could be operated in a manned or man-attended mode of operation.

Periods of unmanned free flight away from the main orbital assembly would fall into the category of man-attended operation; such operation may be desirable because of the longer stabilization periods and higher pointing accuracy required with stellar targets. Such a configuration is shown in the artist's rendering. The solar array depicted is gimbaled to permit orientation with the sun, independent of the line of sight of the experiment package. The LM guidance, control, and propulsive capability, would be of particular use in this mode of operation.



R-150

RESCUE LM

The LM's highly efficient Main Propulsion Subsystem, combined with the fully redundant Reaction Control Subsystem and versatile guidance and navigation capability, offers an in-orbit maneuvering, manned vehicle of unique capability. A LM with very limited modifications will permit application of this capability to effect in-orbit interception of, and rendezvous with, other space vehicles for such purposes as personnel rescue (as shown) and spacecraft inspection or repair.