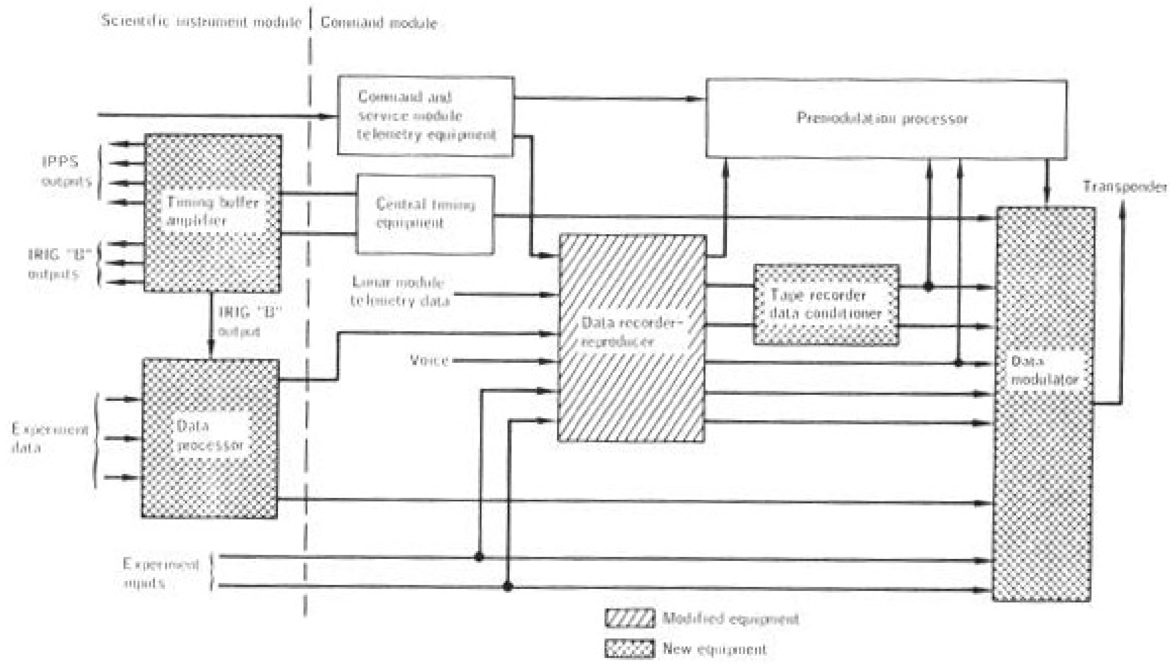


Figure A-4.- Scientific data system block diagram.

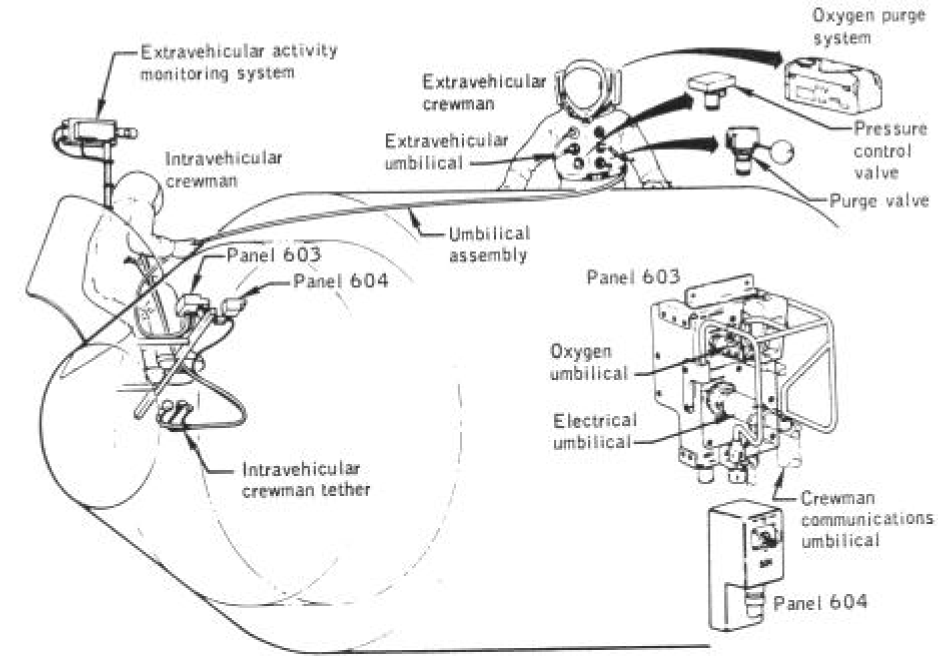


Figure A-5.- Extravehicular activity system and equipment

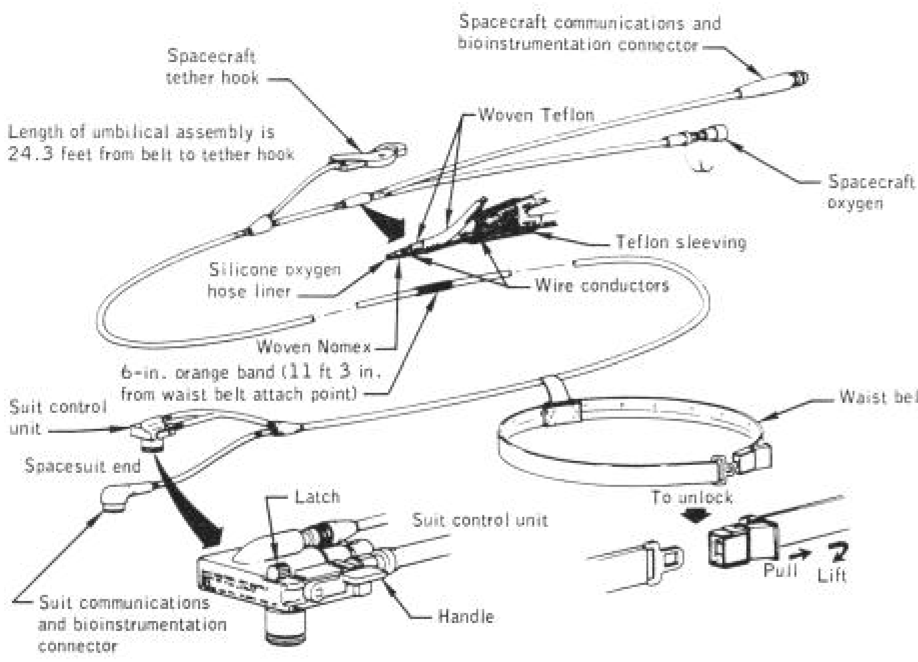


Figure A-6.- Extravehicular umbilical assembly.

A.2 LUNAR MODULE

A.2.1 Structure and Thermal Systems

A number of structural changes were made to the lunar module in order to provide greater consumables storage capacity, permit stowage of a lunar roving vehicle, and allow a heavier load of scientific equipment to be carried. The most significant structural changes were as follows:

The descent stage propellant tanks and the openings for the tanks were enlarged.

Two tanks and supporting structure were added in descent stage quadrant IV for storage of water and gaseous oxygen.

The structure in descent stage quadrants I and III was modified to accommodate the lunar roving vehicle and its equipment pallet, respectively.

The descent stage beam panels, tank supports, lower diagonals, beam, capstrips, and the ladder were strengthened structurally.

Descent batteries 1 and 2 (previously located in quadrant IV) and descent batteries 3 and 4 (previously located in quadrant I) were moved to the minus Z outrigger.

The size of the modular equipment stowage assembly was increased.

Heaters, additional insulation and shielding were incorporated in quadrants I, III, and IV of the descent stage to protect equipment stowed in those areas. Insulation in the docking tunnel was increased, and shielding was added to reduce the heat leak to the cabin through the docking tunnel. The fire-in-the-hole shield as well as the base heat shield were modified to accommodate changes in the descent propulsion system (par. A.2.4).

The ascent stage reaction control system tanks were insulated, and the coating on the tank bay thermal shields was changed to a material with a lower absorptivity-to-emissivity ratio to compensate for the extended lunar stay time and higher sun angles.

A.2.2 Electrical Power

In addition to the four descent batteries (par. A.2.1), a fifth battery (called the lunar battery) was provided to increase lunar stay time capability. The capacity of each battery was 415 ampere-hours compared with 400 ampere-hours for previous missions. Other differences in the descent batteries were as follows:

The battery relief valve, cell manifold relief valve and pressurizing port adapters were changed from nylon plastic to ABS plastic.

The method for attaching the cell manifold to the manifold relief valve adapter was changed to prevent leakage.

A battery relay control assembly was added to route battery status information to the proper channels because of the electrical control assembly sections shared by batteries 2, 3, and the lunar battery, and an interlock was added so that the lunar battery could not be switched to both buses at the same time.

A-2.3 Instrumentation and Displays

Water sensors were changed from quantity measuring devices to pressure transducers for greater reliability. Descent fuel and oxidizer temperature sensors were changed from immersion to container-surface measurements because the measurements would provide more useful data. Temperature sensors were added in the modular equipment stowage assembly to provide flight statistical data. Instrumentation was added, and controls and displays were changed on panel 14 because of the addition of the lunar battery.

A-2.4 Propulsion

The descent propellant system was modified to increase the tank capacity 1200 pounds, and the engine performance and operating life were increased. These changes involved: (1) increasing the length of the tanks, (2) changing material in the thrust chamber from an ablative silicon to an ablative quartz, (3) replacing the exit cone with a lightweight cone, and (4) increasing the nozzle extension 10 inches. Routing of pressurization lines was modified to accommodate the larger propellant tanks. Modifications to decrease the amount of unusable propellant consisted of deleting propellant balance lines between like tanks and adding trim orifices to the tank discharge lines (one orifice is fixed and the other is adjustable).

The oxidizer lunar dump valve installation was modified to be identical to the Apollo 14 fuel lunar dump valve configuration. Thus, both valves were installed to reverse flow direction through them and an orifice was added upstream of each valve. This change was made to insure that the valve would remain open with either liquid or gas flow.

In the reaction control system, a weight reduction of approximately 25 pounds resulted from the removal of the isolation valves from all engines.

A.2.5 Environmental Control System

Extended stay time on the lunar surface required an increase in the supply of lithium hydroxide cartridges. The oxygen and water supply was increased for the same reason by adding a storage tank in the descent stage for each system. Check valves were added at the outlets of the original and new tanks, and servicing quick disconnects and pressure transducers were added in association with the new tanks.

A new high pressure (approximately 1400 psia) portable life Support system recharge capability was incorporated in conjunction with the added oxygen tank. The recharge assembly includes regulators, overboard relief valves, an interstage disconnect, a shutoff valve, and a quick disconnect to mate with the portable life support system recharge hose. In addition, the recharge hose was lengthened by 10 inches to permit recharging of the portable life support system before it was doffed.

Instead of providing stowed urine bags and a portable life support system condensate container as on Apollo 14, a 5-gallon tank was installed in quadrant IV of the descent stage for both urine and portable life support system condensate.

A.2.6 Crew Provisions and Cabin Stowage

Neck ring dust covers were provided to keep lunar dust out of the pressure garment assemblies when not being worn. Tool carriers, attachable to the portable life support system, were provided to facilitate carrying of geological tools, sample bags and rock bags. An adapter was stowed to permit the crewmen to connect their liquid cooling garments to the lunar module water supply after removal of their pressure garment assemblies.

The ascent stage lower midsection and the lower left- and right-side consoles were modified to carry additional lunar samples (each area could carry a 40-pound bag). In order to carry the 70-mm, camera with 500-mm lens and 70-mm film magazines, a special multipurpose container was installed in the area behind the engine cover.

A-3 LUNAR SURFACE MOBILITY SYSTEMS

A-3.1 Extravehicular Mobility Unit

The pressure garment assembly was changed to improve mobility and visibility, to permit easier donning and doffing, and to improve it otherwise. The changes were as follows:

Neck and waist joints were added.

The wrist rings were enlarged.

The shoulder area was modified.

The torso zipper was moved.

Gas connectors were repositioned.

A manual override relief valve was added.

The insuit drinking device was redesigned to hold 32 ounces of water instead of 8 ounces.

The portable life support system was modified to extend the lunar surface stay time capability. There were four major changes:

An auxiliary water bottle was added.

A larger battery was incorporated.

A higher pressure oxygen bottle was used.

Higher capacity lithium hydroxide cartridges were used.

A.3.2 Lunar Roving Vehicle

The lunar roving vehicle (**Fig. A-7**), used for the first time on Apollo 15, is a four-wheeled manually-controlled, electrically-powered vehicle that carried the crew and their equipment over the lunar surface. The increased mobility and ease of travel made possible by this vehicle permitted the crew to travel much greater distances than on previous lunar landing missions. The vehicle was designed to carry the two crewmen and a science payload at a maximum velocity of about 16 kilometers per hour (8.6 mi/hr) on a smooth, level surface, and at reduced velocities on slopes up to 25 degrees. It can be operated from either crewman's position, as the control and display console is located on the vehicle centerline. The deployed vehicle is approximately 10 feet long, 7 feet wide and 45 inches high. Its chassis is hinged such that the forward and aft sections fold back over the center portion, and each of the wheel suspension systems rotates so that the folded vehicle will fit in quadrant I of the lunar module. The gross operational weight is approximately 1535 pounds of which 455 pounds is the weight of the vehicle itself. The remainder is the weight of the crew, their equipment, communications equipment, and the science payload.

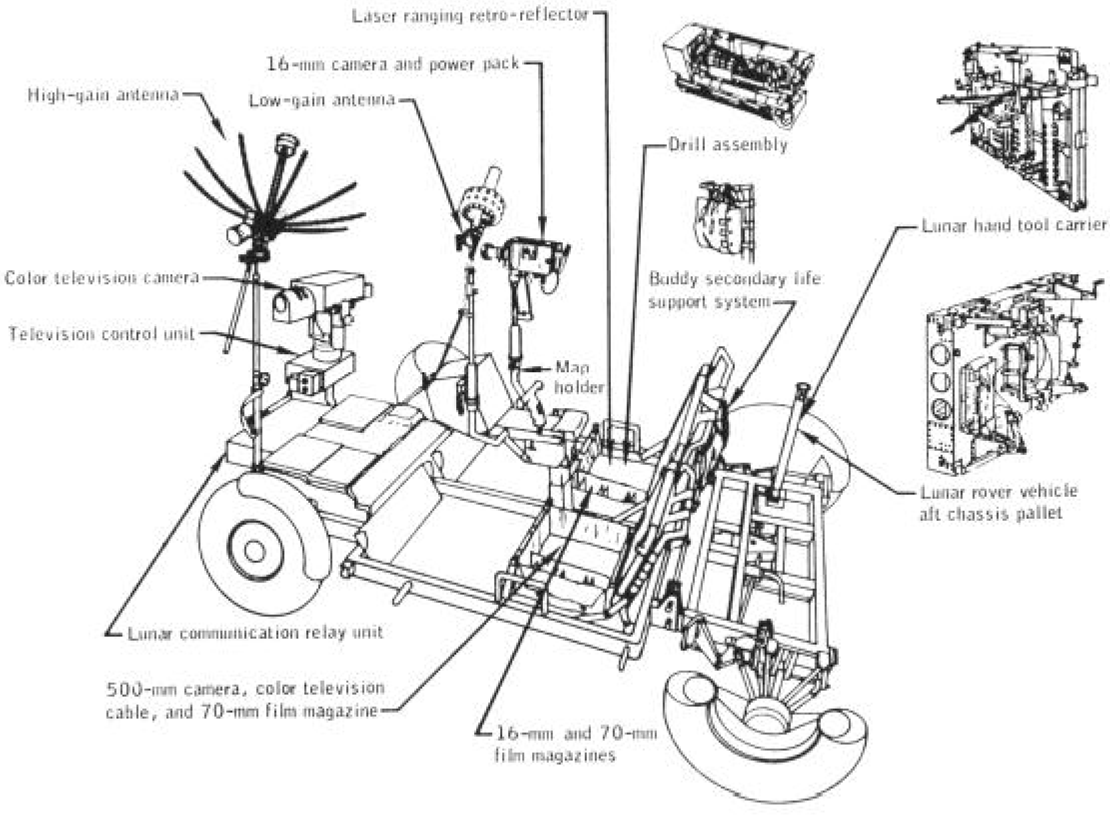


Figure A-7.- Lunar roving vehicle and lunar surface equipment.

The wheels have open-mesh tires with chevron tread covering 50 percent of the surface contact area. The tire inner frame prevents excessive deflection of the outer wire mesh frame under high impact load conditions. Each wheel is provided with a separate traction drive consisting of a harmonic-drive reduction unit, drive motor, and brake assembly. A decoupling mechanism permits each wheel to be decoupled from the traction drive, allowing any wheel to "free-wheel." The traction drives are hermetically sealed to maintain a 7.5-psia internal pressure. An odometer on each traction drive transmits pulses to the navigation signal processing unit at the rate of nine pulses per wheel revolution. The harmonic drive reduces the motor speed at the rate of 80:1 and allows continuous application of torque to the wheels at all speeds without requiring gear shifting. The drive motors are 1/4-horsepower direct-current, series, brushtype motors which operate from a nominal input voltage of 36 Vdc. Speed control for the motors is furnished by pulse-width modulation from the drive controller electronic package. The motors are instrumented for thermal monitoring and the temperatures are displayed on the control and display panel.

The chassis (**Fig. A-8**) is suspended from each wheel by a pair of parallel triangular arms connected between the vehicle chassis and each traction drive. Loads are transmitted to the chassis through each suspension arm to a separate tension bar for each arm. Wheel vertical travel and rate of travel are limited by a linear damper connected between the chassis and each traction drive. The deflection of the suspension system and tires combines to allow 14 inches of chassis ground clearance when the lunar roving vehicle is fully loaded and 17 inches when unloaded.

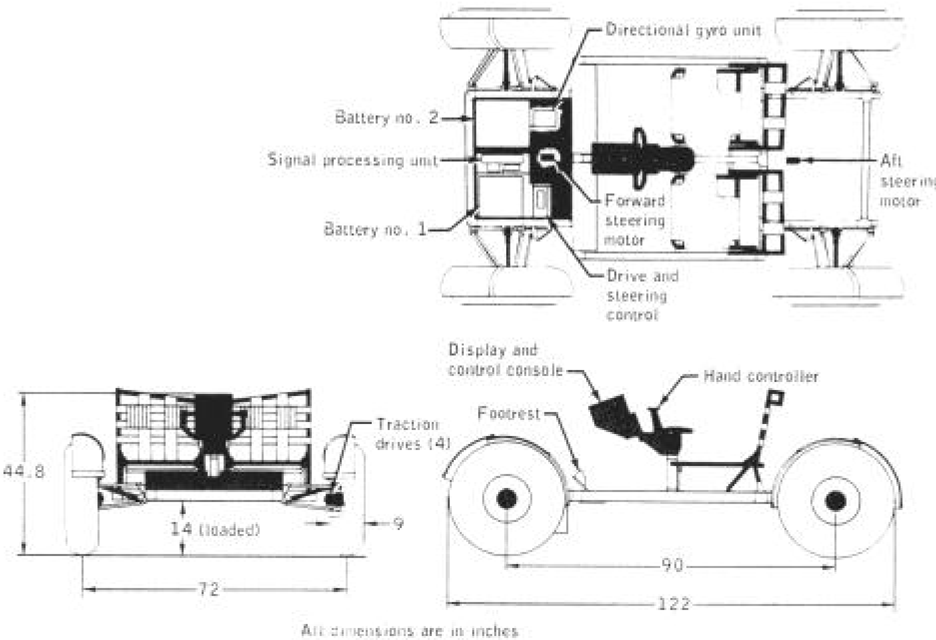


Figure A-8.- Lunar roving vehicle

Steering is accomplished by two electrically-driven rack and pinion assemblies with each assembly steering a pair of wheels. Simultaneous use of both front and rear wheel steering results in a minimum turning radius of 122 inches. Steering is controlled by moving the hand controller left or right from the nominal position. This operation energizes the separate electric motors, and through a servo system, provides a steering angle proportional to the position of the hand controller. The front and rear steering assemblies are electrically and mechanically independent of each other. In the event of a malfunction, steering linkage can be disengaged, and the wheels centered and locked so that operations can continue using the remaining active steering assembly.

Speed control is maintained by the hand controller. Forward movement proportionately increases the forward speed. A neutral deadband exists for about the first 1.5 degrees of forward motion. A constant torque of about 6 inch-pounds is required to move the hand controller beyond the limit of the deadband. To operate the vehicle in reverse, the hand controller is pivoted rearward. However, before changing forward or reverse directions, the vehicle must be brought to a full stop before a commanded direction change can be made. Braking is initiated in either forward or reverse by pivoting the hand controller rearward about the brake pivot point. Each wheel is braked by conventional brake shoes driven by the mechanical rotation of a cam in response to the hand controller.

The vehicle is powered by two silver-zinc batteries, each having a nominal voltage of 36 Vdc and a capacity of 120 ampere hours. During lunar surface operations, both batteries are normally used simultaneously on an approximate equal load basis. These batteries are located on the forward chassis and are enclosed by a thermal blanket and dust covers. The batteries are monitored for temperature, voltage, output current, and remaining ampere hours on the control and display panel. Each battery is protected from excessive internal pressures by a relief valve set to open at 3.1 to 7 psi differential pressure. The circuitry was designed so that if one battery fails, the entire electrical load can be switched to the remaining battery.

The control and display console is separated into two main functional parts - navigation on the upper part and monitoring controls on the lower part. Navigation displays include pitch, roll, speed, heading, total distance traveled, as well as the range and bearing back to the lunar module. Heading is obtained from a sun-aligned directional gyro, speed and distance from wheel rotation counters, and range and bearing are computed from these inputs. Alignment of the directional gyro is accomplished by relaying pitch, roll and sun angle readings to earth where an initial heading angle is calculated. The gyro is then adjusted by slewing with the torquing switch until the heading indicator reads the same as the calculated value. The displays utilize a radioluminescent material (promethium) that provides visibility under lunar shadow conditions.

Thermal control devices are incorporated into the vehicle to maintain temperature sensitive components within the necessary temperature limits. They consist of special surface finishes, multilayer insulation, space radiators, surface mirrors, thermal straps, and fusible mass heat sinks. The basic concept of thermal control for forward chassis components is to store energy during operation, and transfer energy to deep space while the vehicle is parked between sorties. The space radiators are mounted on the top of the signal processing unit, the drive control electronics, and on batteries 1 and 2.

A-3.3 Extravehicular Communications

Because the lunar roving vehicle takes the crew beyond the range of reliable radio communications with the lunar module using the portable life support system communications equipment, radio communications equipment are provided on the lunar roving vehicle that operate independently of the lunar module. This communications equipment is capable of relaying voice and telemetry data from the moon to the earth as well as transmitting color television pictures. The equipment also provides the capability for reception of voice communications from the earth, relay of voice to the crew, and ground-command control of the television camera. The lunar roving vehicle radio equipment, technically called the lunar communications relay unit, employs a VHF radio link between the lunar roving vehicle and earth. The color television camera with its positioning assembly, technically called the ground commanded television assembly, is connected to the lunar communications relay unit by a cable which carries ground commands to the television control unit and returns the television pictures to the lunar communications relay unit for transmission to earth. The crewmen communicate directly with each other using their extravehicular communications systems. Three batteries per crewman are provided for the three traverses. However, a connection is made to the lunar roving vehicle power system when the communications equipment is placed on the vehicle to provide a backup power system for communications. A functional diagram of the lunar communications relay unit is shown in **Fig. A-9**.

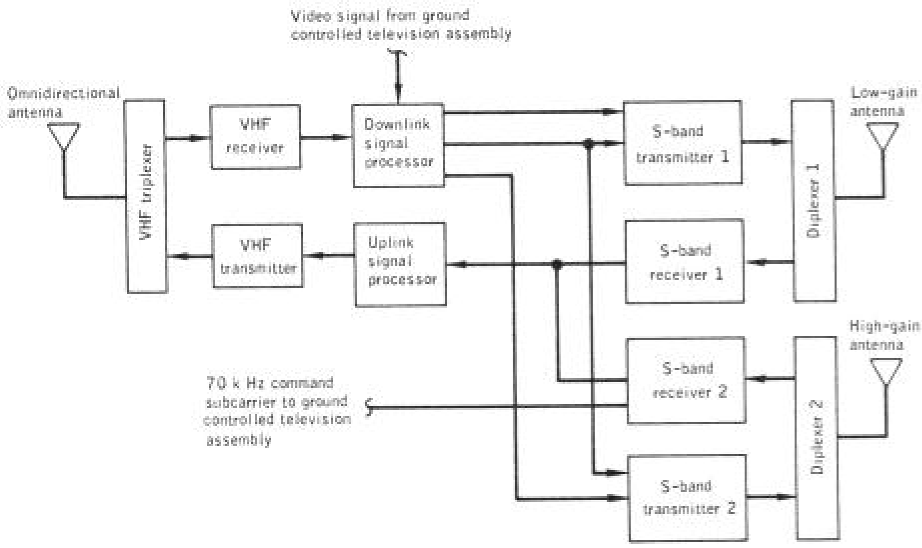


Figure A-9.- Lunar communications relay unit functional diagram.

The lunar communications relay unit, and its S-band high-gain antenna are installed on the forward chassis of the lunar roving vehicle by the crew after vehicle deployment on the lunar surface. The S-band low-gain antenna is installed into the lunar roving vehicle left inboard handhold.

The lunar communications relay unit is thermally controlled by three means: thermal blankets regulate the exposed radiating surface and insulate the unit from external environment; secondary-surface radiating mirrors reflect undesired solar heat and emit undesired heat generated within the lunar communications relay unit; and change-of-phase wax packages absorb excess heat and stabilize the unit temperature through an absorption-discharge cycle.

A.4 EXPERIMENT EQUIPMENT

A.4.1 Lunar Surface Science Equipment

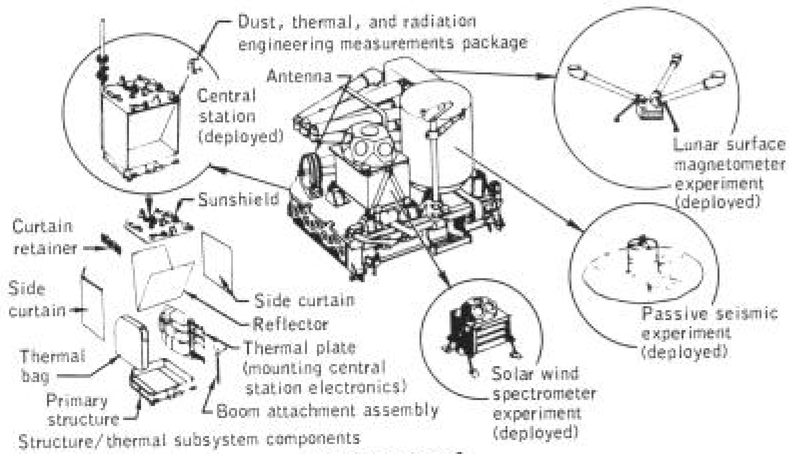
Descriptions of all of the Apollo 15 lunar surface science equipment may be found in previous Apollo mission reports (references 8 through 11); therefore, descriptions are not repeated here. **Figure A-10** illustrates the Apollo lunar surface experiment package, and **Figure A-11** shows the geological tools used on Apollo 15. **Table A-I** lists the lunar surface experiments and identifies the previous missions on which similar experiments were deployed or conducted.

TABLE A-I.- LUNAR SURFACE SCIENCE EXPERIMENTS

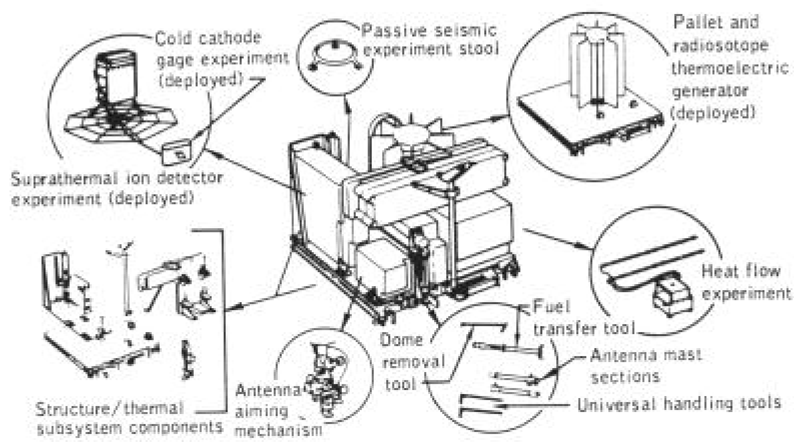
Experiment	Experiment number	Previous Apollo missions on which deployed or conducted
Apollo lunar surface experiment package:		
(1) Fuel capsule for radioisotope thermoelectric generator		12 and 14
(2) Subpackage 1:		
(a) Passive seismic experiment	S-031	12 and 14
(b) Solar wind spectrometer experiment	S-035	12
(c) Lunar surface magnetometer experiment	S-034	12
(d) Central station for command control: Lunar dust detector	M-515	12 and 14
(3) Subpackage 2:		
(a) Suprathermal ion detector experiment	S-036	12 and 14
(b) Cold cathode gage experiment	S-058	12 and 14
(c) Heat flow experiment	S-037	(a)
Laser ranging retro-reflector experiment	S-078	11 and 14
Solar wind composition experiment	S-080	11, 12, and 14
Lunar field geology	S-059	11, 12, and 14
Lunar soil mechanics	S-200	11, 12, and 14
Contingency sample collection		11, 12, and 14

[a]Described in Apollo 13 Mission Report.

[1]Although some changes have been made to science hardware since it was initially configured, the changes are not described in this report.



(a) Subpackage 1



(b) Subpackage 2

Figure A-10.- Apollo lunar surface experiment package (array A-2)

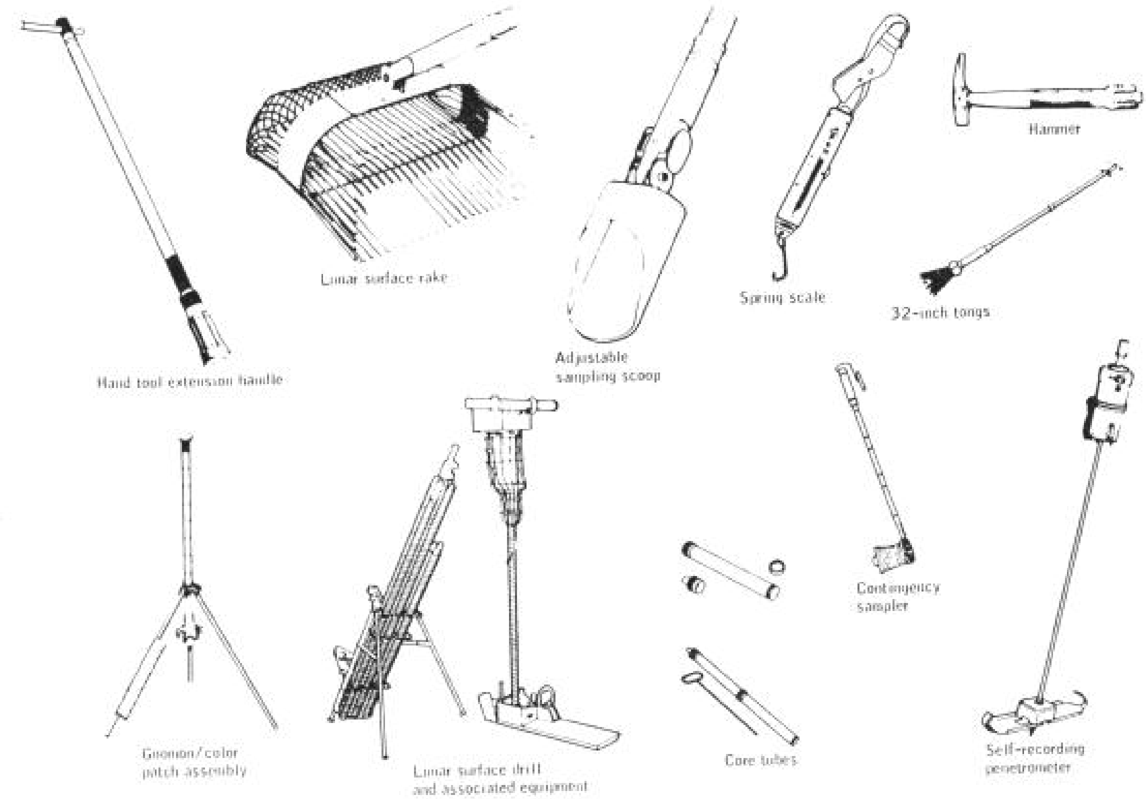


Figure A-11.- Lunar geology and soil mechanics tools.

A-19

A.4.2 Inflight Science Equipment

Twelve experiments and several photographic activities utilized equipment aboard the command and service modules during flight. Standard spacecraft equipment was used to perform some scientific tasks. However, most inflight science equipment was located in the scientific instrument module in sector I of the service module. A view of the equipment in the scientific instrument module, including some camera equipment, is shown in **Figure A-1**. All other cameras that were used for inflight experiments or photography were located in the command module. The equipment used and the kinds of information desired from each experiment and photographic activity are described in the following paragraphs.

Gamma-ray spectrometer.- The gamma ray spectrometer experiment (S-160) was conducted while in lunar orbit to obtain data on the degree of chemical differentiation that the moon has undergone and the composition of the lunar surface. The equipment was also operated during transearth coast to provide calibration data on spacecraft and space background fluxes, and provide data on galactic gamma-ray flux. A gamma-ray detector, capable of measuring gamma radiation in the energy range from 200 000 to 10 million electron volts, was mounted on a 25-foot boom located in the scientific instrument module (fig. A- 1). The boom could be fully extended or extended to two intermediate positions, retracted, or jettisoned by the crew using controls in the command module crew station. Controls were also provided to activate or deactivate the spectrometer, incrementally alter the sensitivity (gain) of the detector, and select either of two detector counting modes.

X-Rav fluorescence.- The X-ray fluorescence experiment (S-161) equipment consisted of an X-ray detector assembly capable of detecting X-rays the energy range from 1000 to 6000 electron volts, a solar monitor, and an X- ray processor assembly. The X-ray detector assembly, located in the scientific instrument module (fig. A-1), detected X-rays reflected from the moon's surface or emitted by galactic X-ray sources. The solar monitor, mounted in sector IV of the service module (displaced 1800 from the X-ray detector assembly), measured solar X-ray flux. The measurement of fluorescent X- ray flux from the lunar surface and the direct solar X-ray flux which produces the fluorescence was expected to yield information on the nature of the lunar surface material and the homogeneity of the upper few millimeters of the lunar surface. Deep space measurements were expected to provide information on galactic X-ray sources. Controls were provided in the command module crew station to activate and deactivate the experiment, open the solar monitor door, and open and close the X-ray detector protective cover.

Alpha particle spectrometer.- The alpha particle spectrometer experiment (S-162) was designed to gather data to be considered along with the gamma-ray and X-ray data in mapping the lunar chemical composition. The types of information desired from this experiment were the gross rate of lunar surface radon evolution and localized sources of enhanced radon emission. In addition, transearth coast data were desired for background and engineering evaluation of the alpha-particle and X-ray spectrometers. The experiment equipment., consisted of an alpha particle sensing assembly which could detect alpha particles in the energy range from 3.5 million to 7.5 million electron volts, supporting electronics, and temperature monitors housed in the same enclosure as the X-ray fluorescence experiment assembly (fig. A-1). Controls were provided in the command module crew station to deploy a shield protecting the experiment detectors from spacecraft contamination sources, and to activate and deactivate the experiment.

Mass spectrometer.- The mass spectrometer experiment (S-165) was conducted to obtain data on the composition of the lunar ambient atmosphere as an aid in understanding the mechanisms of release of gases from the surface, as a tool to locate areas of volcanism, and as a means of determining the distribution of gases in the lunar atmosphere. The experiment assembly consisted of the mass spectrometer and its electronic components mounted on a 24-foot boom which was extended from the scientific instrument module (fig. A-1). The instrument was capable of measuring the abundance of particles in the 12- to 66-atomic-mass-unit range. A shelf-mounted shield to protect the spectrometer from spacecraft contamination sources when in its stowed position opened and closed automatically when the boom was extended and retracted. In addition to acquiring data while in lunar orbit, the spectrometer was to be operated at various intermediate boom positions for specified periods during transearth coast to determine the concentration of constituents forming the command and service module contamination "cloud." Command module crew station controls were provided to extend, retract, and jettison the boom; activate/deactivate the spectrometer; select high and low spectrometer discrimination modes, and multiplier gains; and activate/deactivate the spectrometer ion source heaters and filaments.

S-band transponder (command and service module/lunar module).- The command and service module and/or lunar module were tracked in lunar orbit using the S-band transponders and high-gain antenna that were normal vehicle equipment. The S-band Doppler resolver tracking data obtained will be used to help determine the distribution of mass along the lunar ground track. Tracking data were to be obtained from the docked command and service module/lunar module while in the 170- by 60-mile elliptical orbit, the 60-mile circular orbit, and the low-altitude portion of the 60- by 8-mile elliptical orbit. Data were also to be obtained from the undocked command and service module during the unpowered portions of the 60-mile circular orbit, and from the undocked lunar module during unpowered portions of flight.

Subsatellite experiments.- The subsatellite, launched from the command and service module during lunar orbit, is the host carrier for three experiments for which data will be acquired over a planned one-year period. The experiments are:

S-band transponder (S-164)

Particle shadows/boundary layer (S-173)

Subsatellite magnetometer (S-174)

The basic elements of the system, in addition to the subsatellite itself, consisted of a mechanism to deploy and launch the subsatellite from the scientific instrument module, and a housing which encased the subsatellite and its deployment/launcher device (fig. A-1).

The subsatellite contains charged particle telescope detectors capable of detecting electrons in the energy range from 20 000 to 320 000 electron volts and protons in the energy range from 50 000 to 2.3 million electron volts. Spherical electrostatic analyzer detectors are used to detect electrons in selected energy bands from 580 to 15 000 electron volts. In addition, the subsatellite contains a biaxial fluxgate magnetometer which acquires data over a dynamic range of ±200 gammas, an optical solar aspect system for attitude determination, a data storage unit, an S-band communications system, and a power system. The primary power source consists of solar cells on the subsatellite external surfaces. A rechargeable silver cadmium battery is the secondary source of power that sustains operation during passage of the subsatellite through shadow. The subsatellite is hexagonal in shape, 30 inches in length, and weighs approximately 85 pounds. It has three equally-spaced booms mounted around its base that deployed automatically at launch to a length of 5 feet. The magnetometer is mounted at the end of one boom, whereas, the only purpose of the other two booms is to achieve the desired spin-stabilization characteristics. The subsatellite is shown in **Fig. A-12**.

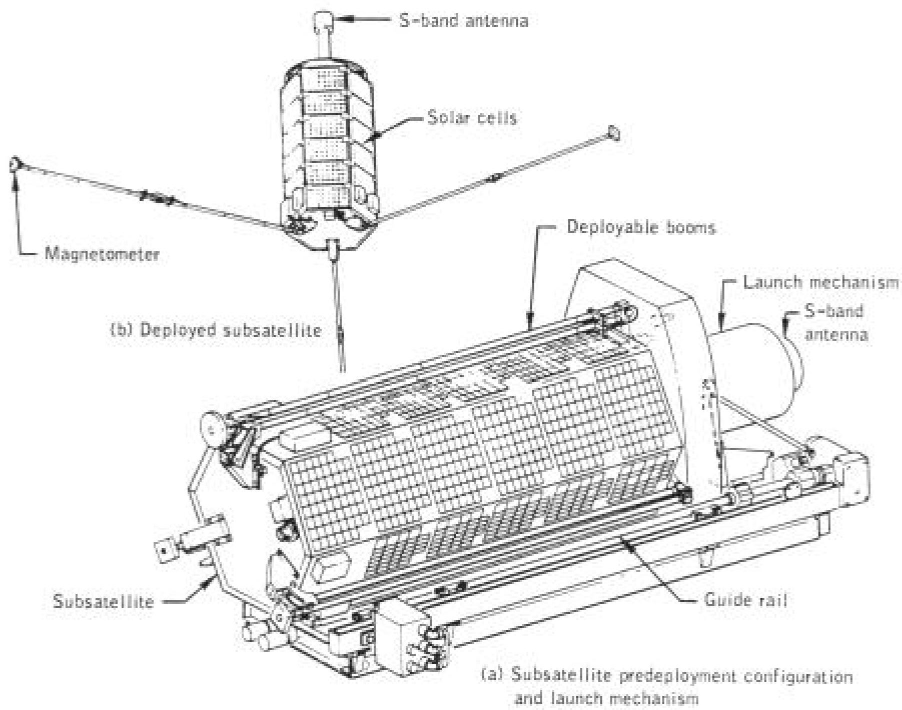


Figure A-12.- Subsatellite

Controls in the command module crew station were used for launching the subsatellite and retracting the deployment/launcher mechanism. The relative parting velocity was approximately 4 ft/sec and the subsatellite was spin-stabilized at approximately 12 revolutions per minute about a spin axis nearly perpendicular to the ecliptic plane.

S-band transponder experiment: Two-way S-band Doppler tracking measurements of the subsatellite are made to obtain lunar gravitational field data in addition to the data obtained from tracking the command and service module and the lunar module.

Particle shadows/boundary layer experiment: The charged particle detectors, the electrostatic analyzer detectors, and the subsatellite support systems are used to obtain data to study the formation and dynamics of the earth's magnetosphere, the interaction of plasmas with the moon, and the physics of solar flares.

Subsatellite magnetometer: The magnetometer and the subsatellite support systems are used to make magnetic field measurements in lunar orbit. These data will be used in studies of the physical and electrical properties of the moon and the interaction of plasmas with the moon.

Bistatic radar.- This experiment, technically designated "Downlink Bistatic Radar Observations of the Moon" (S-170), was conducted to provide fundamental new information on the upper few meters of the lunar crust, and to provide engineering and calibration data needed for similar experiments planned for the future. While the command and service module was in lunar orbit, S-band and VHF signals were transmitted from the spacecraft, reflected from the lunar surface, and recorded on the earth for subsequent analysis. The high-gain antenna was preferred for S-band, although an omnidirectional antenna was acceptable. The scimitar antenna was used for VHF. The crew was required to maintain an attitude in which the antenna was pointed toward the lunar surface during the time that bistatic radar measurements were being made.

Ultraviolet Photography - Earth and Moon.- Ultraviolet photography (S-177) of the earth was obtained from earth orbit, from different points during translunar and transearth coast, and from lunar orbit to determine ultraviolet emission characteristics of the earth's atmosphere. A portion of the photographs taken from lunar orbit were of the lunar surface. These will be used to extend the wavelength range of ground-based colormetric work and search for short-wavelength fluorescence.

The photographs were taken with a 70-mm Hasselblad electric camera and 105-mm ultraviolet transmitting lens. The camera was mounted on a bracket in the right-hand side window. Two ultraviolet band-pass filters (centered at 3750 and 2600 angstrom) and a visual-range filter (4000 to 6000 angstrom) were used. For each sequence of photographs requested, a minimum of four were to be taken using black-and-white film and the aforementioned filters, while one was to be taken using color film and a visual range filter. The crew was required to install the mounting bracket, mount and operate the camera, attach the filter slide and lens, change filters, and record the exposure time. The crew was also required to maintain the proper spacecraft attitude and attitude rates for each sequence.

Gegenschein from lunar orbit..- The Gegenschein from lunar orbit experiment (S-178) - required three sequences of photographs to be taken from the command module while in the shadow of the moon - one in the direction of the antisolar vector, one in the direction of the Moulton point, and one midway between these two. A Nikon 35-mm camera and 55-mm lens were used to obtain the photographs. The camera was mounted in the right-hand rendezvous window on a fixed mounting bracket. Window shades and a darkened spacecraft were required to minimize the effects of stray light from the spacecraft. The crew was required to maneuver the spacecraft to the proper attitude the mission control center provided the proper spacecraft orientation for camera pointing), inhibit the reaction control system engines after spacecraft attitude rates had been damped, operate the camera, and record the exposure time.

Apollo window meteroid.- The Apollo window meteroid experiment (S-176) utilizes the command module windows as meteroid detectors and collectors. Data are obtained by high-magnification scanning of the windows before and after the flight.

Service module orbital photographic tasks.- These photographic tasks comprised a detailed objective which required the use of the 24-inch panoramic camera assembly, the 3-inch mapping camera assembly, and the laser altimeter, all mounted in the scientific instrument module (fig. A-1).

Twenty-four-inch panoramic camera: This camera was included to obtain high-resolution (1- to 2-meters from an altitude of 60 miles) panoramic photographs with stereoscopic and monoscopic coverage of the lunar surface. The photographs will aid in the correlation of other orbital science data. The camera assembly consisted of a roll frame assembly, a gimbal assembly to provide stereo coverage and forward motion compensation, a main frame, a gaseous nitrogen pressure vessel to provide gas for certain bearings, an optics system, a film drive and control system, and a film cassette (that was required to be retrieved by an extravehicular crewman during transearth coast). The camera did not require deployment for operation. Controls were provided in the crew station to activate/deactivate camera heaters, supply/remove primary camera power, select operate/standby operation modes, supply film roller torque to prevent slack in film during launch and maneuvers, activate a five-frame film advance cycle if the camera was not operated in a 24-hour period, increase/decrease the width of the exposure slit, and select the stereo or monoscopic mode of operation.

Three-inch mapping camera: This camera was provided to obtain high quality metric photographs of the lunar surface and stellar photographs exposed simultaneously with the metric photographs. The lunar surface photographs will aid in the correlation of experiment data with lunar surface features. The stellar photographs provide a reference to determine the laser altimeter pointing vector and the cartographic lens pointing vector. The resolution capability of the metric camera was approximately 20 meters from a distance of 60 miles. The metric and stellar camera subsystems were integrated into a single unit which was deployed on a rail-type mechanism in order to provide an unobstructed field of view for the stellar camera. The system used the same gaseous nitrogen source as the panoramic camera to provide an inert pressurized atmosphere within the cameras to minimize potential static electrical corona discharge which could expose film areas. In addition to the optics, the camera system included a film drive/exposure/takeup system and a removable cassette (that was required to be retrieved by an extravehicular crewman during transearth coast). Controls were provided in the crew station to activate/deactivate camera heaters and functions, compensate for image motion and extend/retract the camera on its deployment rails.

Laser altimeter: The laser altimeter was furnished to obtain data on the altitude of the command and service module above the lunar surface. These data, acquired with a 1-meter resolution, were to support mapping and panoramic camera photography as well as other lunar orbital experiments. The laser altimeter could operate in either of two modes:

When the mapping camera was operating, the altimeter automatically emitted a laser pulse to correspond to mid-frame ranging for each film frame exposed.

The altimeter could be decoupled from the mapping camera to allow independent ranging measurements (one every 20 seconds).

Command module controls were provided to activate/deactivate the altimeter.

Command module photographic tasks.- Photographs were to be obtained of:

Lunar surface areas of high scientific interest and of specific portions of the lunar surface near the terminator.

Diffused galactic light of celestial objects, solar corona, the lunar libration region, and the zodiacal light.

The lunar surface to extend selenodetic control and mapping.

The moon during lunar eclipse by the earth, and of a comet if appropriate trajectory and celestial conditions existed.

These tasks involved the use of the following operational cameras:

A 16-mm data acquisition camera with an 18-mm lens.

A 70-mm Hasselblad electric camera with 80-mm and 250-mm 'Lenses.

A 35-mm camera with a 55-mm lens.

Crew participation was required to operate the cameras, change lenses and camera settings, record identification data, control the spacecraft attitude and attitude rates, and control cabin illumination.

A.5 SUMMARY OF PHOTOGRAPHIC EQUIPMENT

Nearly all experiments and detailed objectives require photography either as a primary data source or for validation purposes. Photographic equipment required for acquisition of data for experiments has been discussed in conjunction with the applicable experiments in the preceding section. For convenience, this equipment is also summarized in **Table A-II** along with photographic equipment required for other activities.

TABLE A-II.- PHOTOGRAPHIC EQUIPMENT

Subject	Camera type (a)	Lens	Film type (b)
EXPERIMENTS			
Inflight:			
Gamma-ray spectrometer			
X-ray fluorescence	PC	24-in.	LBW (3414)
Alpha-particle spectrometer	MC	3-in.	BW (3400)
Bistatic radar	SC	3-in.	BW (3401)
Ultraviolet photography	HEC	105-mm (UV transmitting)	IIa-O, CEX (SO-368)
Gegenschein from lunar orbit	35	55-mm	VHBW (2485)
Mass spectrometer	DAC	18-mm	BW (SO-164)
Subsatellite (launch)	DAC	75-mm	CEX (SO-368)
Lunar Surface:			
Apollo Lunar Surface Experiments Package	HEDC	60-mm	HCEX (SO-168)
Laser ranging retro-reflector	HEDC	60-mm	HCEX (SO-168)
Solar wind composition	HEDC	60-mm	BW (3401)
Lunar geology	HEDC LFLC	60-mm 500-mm	BW (3401) BW (3401)
Soil Mechanics	HEDC LDAC	60-mm 10-mm	HCEX (SO-168), BW (3401) CEX (SO-368)
DETAILED OBJECTIVES			
Inflight:			
Service module orbital photographic tasks	PC MC SC	24-in. 3-in. 3-in.	LBW (3414) BW (3400) BW (3401)
Command module photographic tasks	HEC HEC DAC 35	250-mm 80-mm 18-mm 55-mm	LBW (3414), CEX (SO-368) VHBW (2485), CEX (SO-368) VHBW (2485) VHBW (2485)
Scientific instrument module inspection during extra-vehicular activity	DAC	18-mm	CEX (SO-368)
Lunar Surface:			
Contingency sample collection	DAC	10-mm	CEX (SO-368)
Evaluation of lunar module landing gear performance	HEDC	60-mm	HCEX (SO-168)
Assessment of extravehicular maneuvering unit	LDAC	10-mm	CEX (SO-368)
Evaluation of lunar roving vehicle	LDAC HEDC	10-mm 60-mm	CEX (SO-368) HCEX (SO-168)

[a] Camera nomenclature:

DAC 16-mm data acquisition camera
HEC 70-mm Hasselblad electric camera
HEDC 70-mm Hasselblad electric data camera (with reseau)
LDAC Lunar surface 16-mm data acquisition camera (battery operated)
LFLC Long focal length camera (HEDC adapted for use with 500-mm lens)
35 35-mm camera
PC 24-in panoramic camera
MC 3-in mapping camera
SC 3-in stellar camera

[b] Film nomenclature:

CEX Color exterior (SO-368)
HCEX High-speed color exterior (SO-168)
BW Black and white (3400, 3401 & SO-164)
LBW Low-speed black and white (3414)
VHBW Very high-speed black & white (2485)
IIa-O Ultraviolet (UV) spectroscopic

A.6 MASS PROPERTIES

Mass properties for the Apollo 15 mission are summarized in **Table A-III**. These data represent the conditions as determined from postflight analyses of expendable loadings and usage during the flight. Variations in command and service modules and lunar module mass properties are determined for each significant mission phase from lift-off through landing. Expendables usage are based on reported real-time and postflight data as presented in other sections of this report. The weights and center-of-gravity of the individual modules (command, service, ascent stage, and descent stage) were measured prior to flight and inertia values calculated. All changes incorporated after the actual weighing were monitored, and the mass properties were updated.

TABLE A-III.- MASS PROPERTIES

Event	Weight, lb	Center of gravity, in.			Moment of inertia, slug-ft²			Product of inertia, slug-ft²		
		X	Y	Z	I_{XX}	I_{YY}	I_{ZZ}	I_{XY}	I_{XZ}	I_{YZ}
Command and service module/lunar module										
Lift-off	110 250	847.1	3.0	2.5	73 372	1 237 791	1 238 171	[illegible]	[illegible]	[illegible]
Earth orbit insertion	101 142	806.5	3.3	2.6	72 516	707 133	707 [illegible]	[illegible]	[illegible]	2580
Transposition and docking:										
Command & service modules	66 895	933.9	5.0	4.7	36 330	80 117	81 714	-2211	268	1781
Lunar module	36 100	1238.2	-0.6	0.8	25 830	26 126	27 068	+497	176	-438
Total docked	103 104	1040.8	3.0	3.3	62 401	575 976	578 639	-11 115	-5562	1936
Lunar orbit insertion	102 589	1041.3	3.0	3.4	61 948	574 273	577 062	-11 155	-5585	2058
Descent orbit insertion	76 078	1083.8	1.9	1.9	48 289	447 767	446 796	-8711	-1759	+1013
Separation	74 461	1088.4	1.9	1.8	48 684	432 715	435 604	-7948	-1543	-1124
Command and service module circularization	37 716	944.0	3.8	3.3	21 281	60 107	64 712	-2402	1316	+661
Command and service module plane change	37 219	944.4	3.9	3.2	20 973	59 911	64 094	-2406	1305	+635
Docking:										
Command & service modules	35 928	945.4	3.6	3.3	20 272	59 537	63 151	-2155	1317	+669
Ascent stage	5806	1165.3	4.7	42.4	3290	2302	2669	+114	+1	-377
Total after docking:										
Ascent stage manned	41 734	976.3	3.8	2.5	23 600	114 062	118 017	-2197	1	+1073
Ascent stage unmanned	41 732	974.5	3.7	2.5	23 490	110 396	114 334	-2476	727	-1040
After ascent stage jettison	36 407	946.3	3.8	3.0	20 375	59 485	63 054	-2100	1185	+544
Orbit shaping	36 292	946.4	3.9	3.1	20 267	59 399	63 014	-2163	1211	+587
Subsatellite jettison	36 219	946.7	3.8	3.0	20 171	59 314	62 820	-2190	1311	+676
Transearth injection	35 899	946.8	3.8	3.1	20 057	59 175	62 778	-2274	1151	+612
Transearth extravehicular activity	26 606	972.1	3.2	3.7	15 370	44 784	43 897	+740	[illegible]	+1039
Command and service modules prior to separation	26 323	972.7	3.3	4.0	15 047	44 287	47 477	+671	745	+1108
After separation:										
Service module	13 358	908.3	2.0	2.2	8092	14 650	14 375	+671	+48	-1076
Command module	12 965	1039.1	0.1	5.8	5929	5166	4734	-8	-395	-22
Entry	12 953	1039.1	0.1	5.8	5920	5092	4734	-8	+394	+21
Main parachute deployment	12 381	1037.6	0.1	6.0	5717	4892	4714	-9	-347	-15
Landing	11 731	1035.9	0.2	5.1	5533	4496	4254	51	+321	+1
Lunar module										
Lunar module at earth launch	36 100	184.1	0.4	-1.0	21 837	27 117	26 063	98	515	187
Separation	36 715	186.1	0.3	-0.2	27 282	28 512	27 430	91	823	177
Powered descent initiation	36 446	186.0	0.4	-0.4	27 171	27 411	27 [illegible]	87	806	167
Lunar landing	15 175	208.9	0.5	+0.6	15 552	20 603	17 675	78	84	193
Lunar lift-off	12 915	243.9	0.1	2.8	6753	4641	5640	64	187	-62
Orbit insertion	5981	257.1	0.3	5.1	3349	2864	2230	58	101	433
ᵃTerminal phase initiation	5965	257.0	0.3	5.2	3349	2888	2169	58	101	433
Docking	5806	256.6	0.3	5.3	3290	2960	2277	58	101	434
Jettison	5307	255.4	0.4	5.5	3117	2767	1949	[illegible]	[illegible]	440

[a]Post ullage

APPENDIX B - SPACECRAFT HISTORIES

The history of command and service module (CSM 112) operations at the manufacturer's facility, Downey, California, is shown in **Fig. B-1**, and the operations at Kennedy Space Center, Florida, in **Fig. B-2**.

The history of the lunar module (LM-10) at the manufacturer's facility, Bethpage, New York, is shown in **Fig. B-3**, and the operations at Kennedy Space Center, Florida, in **Fig. B-4**.

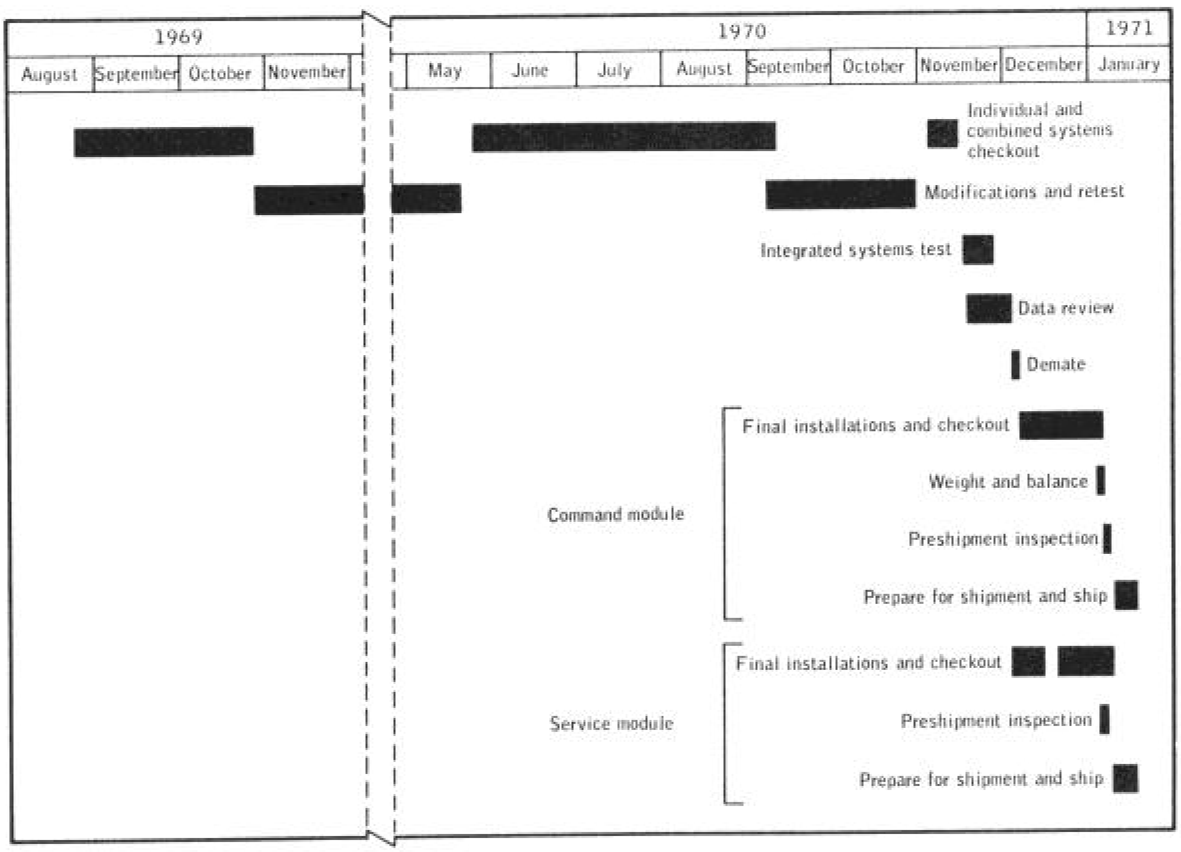


Figure B-1.- Checkout flow for command and service modules at contractor's facility.

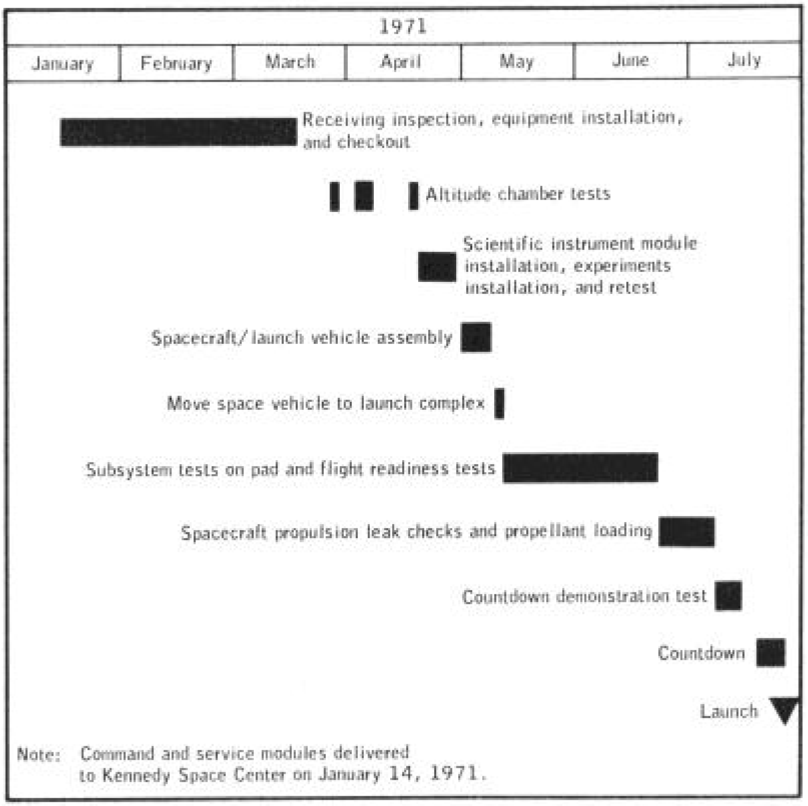


Figure B-2.- Command and service module checkout history at Kennedy Space Center.

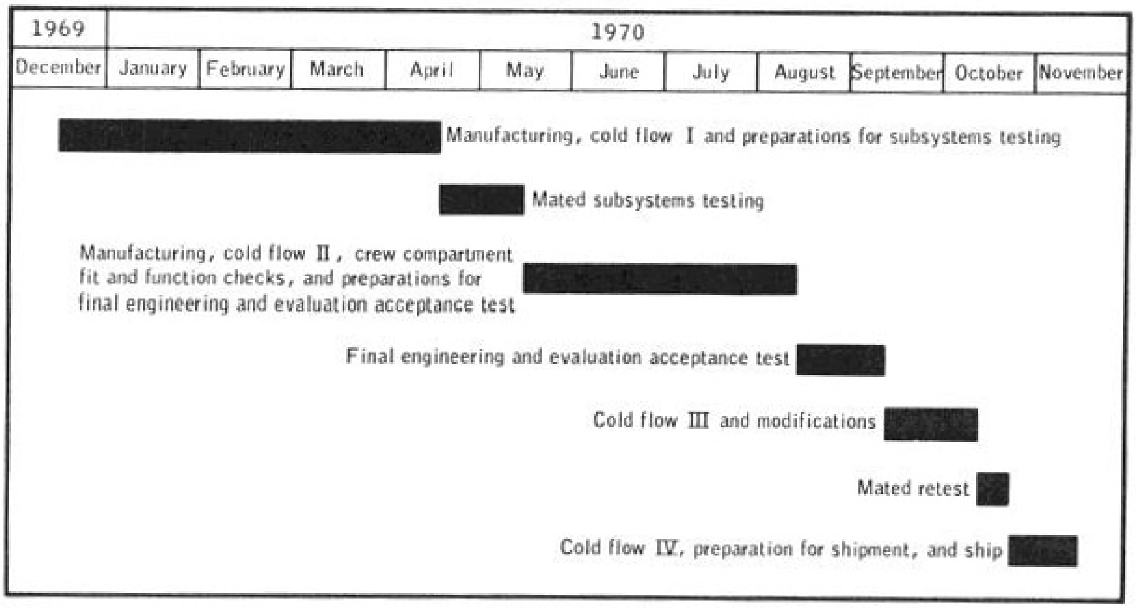


Figure B-3.- Checkout flow for lunar module at contractor's facility.

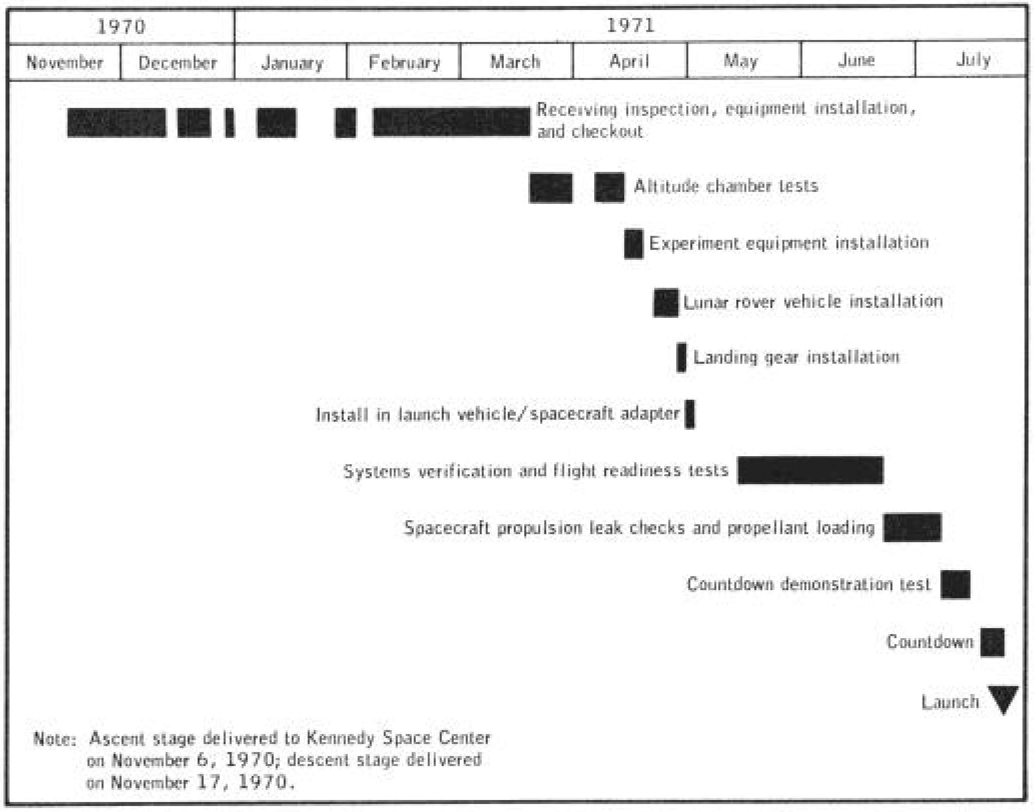


Figure B-4.- Lunar module checkout history at Kennedy Space Center.

APPENDIX C - POSTFLIGHT TESTING

Postflight testing and inspection of the command module and crew equipment for evaluation of the inflight performance and investigation of the flight irregularities were conducted at the contractor's and vendor's facilities and at the Manned Spacecraft Center in accordance with approved Apollo Spacecraft Hardware Utilization Requests (ASHUR's). The tests performed as a result of inflight problems are described in **Table C-I part 1**, **part 2**, and **part 3**; and discussed in the appropriate systems performance sections of this report. Tests being conducted for other purposes in accordance with other ASHUR's and the basic contract are not included.

TABLE C-I.- POSTFLIGHT TESTING SUMMARY

ASHUR no.	Purpose	Tests performed	Results
		Environmental Control	
112004 112037	Evaluate the potable water supply for excess gas content.	Perform analysis of water sample and conduct functional tests on gas separator cartridge.	Only air was detected in one flight sample and no gas was found in the other. The gas separator operated satisfactorily.
112021	Investigate water leakage from water panel chlorination port.	Perform visual inspection and dimensional analysis.	See sec. 14.1.2
112027	Determine the cause of discrepant CM tunnel delta pressure readings and possible faulty valve operation.	Perform leak check of valve, gage and tubing.	Spacecraft and lab testing did not disclose any malfunction. Since there was a lack of position indication, it is suspected that the valve may have been placed in some interim position.
112030	Determine the cause of failure of the potable water tank to refill	Perform visual inspection, functional tests and failure analysis of check valve.	See sec. 14.1.7
112035	Determine the cause of noise in cabin fans.	Perform visual inspection and electrical performance test.	See sec. 14.1.13
112036	Determine the cause of several water droplets coming from the suit supply hose.	Analyze the command module lunar orbit temperature data and test separator plate flow on the suit heat exchanger.	Analyses indicate that water condensation resulted from the temperature transient in the water/glycol circuit at the suit heat exchanger.
112507	Determine the cause of failure of the toggle arm pivot pin for the main oxygen regulator shutoff valve.	Perform failure analysis.	See section 14.1.17
		Structures	
112006 112019 112022 112025 112512 112514 101557 CTH630	Determine why one main parachute collapsed during descent.	Perform visual inspection, reaction control system electrical leak and operational tests, riser cutting test, and link strength test.	See sec. 14.1.9
CTH629	Determine why mass spectrometer boom would not fully retract.	Perform functional checks to locate cause of failure.	See sec. 14.1.6
		Guidance and Navigation	
112043	Determine the cause of intermittent entry monitor system scroll scribing after drogue parachute deployment.	Perform investigation and analysis.	The analysis verified that the problem was caused by an improper mix of scribecoat before application to the scroll.

TABLE C-I.- POSTFLIGHT TESTING SUMMARY - Continued

ASHUR no.	Purpose	Tests performed	Results
		Guidance and Navigation	
112048	Determine why the roll axis did not align during a gyro display coupler alignment.	Perform physical inspection and conduct electrical checks.	See sec. 14.1.15
112053	Determine why visibility through the scanning telescope was low.	Perform visual inspection and light transmissibility testing.	See sec. 14.1.14
		Electrical	
112013	Determine why the battery relay bus measurement read erroneously.	Perform continuity and power-on testing to isolate cause.	See sec. 14.1.5
112014 CTH629	Determine why circuit breaker 33 on panel 226 opened during flight.	A check of the primary and secondary circuits failed to locate the problem, and a 115-Vac power-on test was performed.	See sec. 14.1.4
112015	Determine what caused the service propulsion system thrust light on the entry monitor system to illuminate.	Perform continuity measurements to isolate cause.	See sec. 14.1.3
11201T 11205T	Determine why tape deteriorated in data recorder/reproducer.	Perform a complete acceptance test, except vibration, on the data recorder/reproducer. Physically and electrically examine the data recorder/reproducer tape for deterioration.	See sec. 14.1.10
112018	Determine the cause of stoppage of the panel 2 mission timer.	Inspect wiring and perform power testing while monitoring with an oscilloscope. Perform functional, vibration and thermal check at the vendor's.	See sec. 14.1.8
112045	Determine the cause of the seconds window on the digital event timer becoming obscured.	Perform physical examination as to cause.	See sec. 14.1.11
112509	Determine the cause of stuck battery charger-main A circuit breaker during postflight testing.	Apply distilled water to area of corrosion and perform chemical analysis on corrosion sample.	See sec. 14.1.16
		Crew Equipment	
112004 112020 112026	Determine why the lunar surface 16-mm camera magazines jammed.	Perform visual inspection and functional tests to verify failure mode. Conduct failure analysis.	See sec. 14.5.3

TABLE C.I.- POSTFLIGHT TESTING SUMMARY - Concluded

ASHUR no.	Purpose	Tests performed	Results
		Crew Equipment	
112005	Determine the cause of the lunar module pilot's 70-mm camera film advance stoppage.	Perform operational tests, disassembly and inspection, and battery charge measurement.	See sec. 14.5.4
112008 112016 112024	Determine cause of commander's personal radiation dosimeter reading high.	Evaluate radiation dosage and perform failure analysis.	A small sliver scraped off the 10-volt electrode apparently induced erroneously high counts.
112051	Determine the cause of the restraint harness coming apart.	Perform failure analysis.	See sec. 14.1.12

APPENDIX D - DATA AVAILABILITY

Tables D-I part 1 and **D-I part 2**; and **D-II** are summaries of the data made available for systems performance analyses and anomaly investigations. **Table D-I** lists the data for the command and service module, and **Table D-II**, the lunar module. The following table contains the times that experimental data were made available to the principal investigator for scientific analyses.

Time, hr:min		Time, hr:min	
From	To	From	To
73:43	78:30	174:13	220:50
79:00	82:20	222:18	223:00
83:40	95:50	224:10	238:34
105:30	165:00	245:57	271:30
165:20	168:17	273:00	288:20

For additional information regarding data availability, the status listing of all mission data in the Central Metric Data File, building 12, should be consulted.

TABLE D-I.- COMMAND AND SERVICE MODULE DATA AVAILABILITY

Time, hr:min		Data Source (a)	Bandpass plots or tabs	Bilevels	Computer word tabs	Oscillo-graph records	Brush records	Special plots or tabs	Special programs
From	To								
-34:00	00:30	ALDS	X	X					
00:00	00:10	MIL	X	X	X	X	X	X	X
00:02	00:13	BDA	X	X	X	X	X	X	
00:10	00:18	BDA	X	X			X		
00:23	01:29	BDA	X	X			X		
01:26	01:35	GDS		X					
01:33	01:44	MIL		X					
01:40	01:52	VAN	X	X	X				
02:22	02:34	CRO		X					
02:40	03:34	GDS	X	X	X	X	X	X	
03:50	06:55	MSFN	X	X	X				
04:18	08:10	GDS	X	X					
07:16	10:26	MSFN	X	X	X				
08:09	11:58	GDS		X					
11:01	15:25	MSFN	X	X	X				
15:34	31:21	MSFN	X	X	X				
26:51	28:43	MAD	X	X	X	X		X	
31:26	74:54	MSFN	X	X	X				
72:43	75:43	MAD	X	X	X	X			
74:54	78:30	MSFN	X	X	X				
77:06	78:20	MAD	X	X	X				
78:30	82:14	MSFN	X	X	X				
78:30	79:16	GDS	X	X	X				
79:12	80:12	MAD		X					
80:11	82:25	GDS	X	X	X				
82:14	87:22	MSFN	X	X	X				
82:30	89:10	GDS	X	X	X	X	X	X	X
87:22	90:32	MSFN	X	X	X				
88:08	90:00	HSK	X	X	X		X	X	X
90:20	96:30	HSK	X	X	X				X
90:52	99:42	MSFN	X	X	X		X	X	
95:56	99:26	MSFN	X	X	X				
95:56	95:58	HSK	X	X	X	X	X	X	
96:10	97:23	MAD		X				X	
97:35	98:28	ACN	X	X	X		X		
98:25	99:24	MAD	X	X				X	
99:26	102:40	MSFN	X	X	X				
99:30	103:25	MAD	X	X	X				
103:40	104:10	GDS	X	X	X				
104:06	107:16	MSFN	X	X	X				
104:08	105:05	GDS		X	X				
105:31	106:36	ACN	X	X	X		X		
106:05	107:24	GDS			X		X	X	
107:16	111:04	MSFN	X	X	X				
107:22	108:05	HSK	X	X	X		X	X	
108:00	110:02	GDS	X	X	X		X	X	
111:05	114:09	MSFN	X	X	X				
111:14	112:00	GDS	X	X	X				
113:06	114:08	HSK	X	X	X				
114:13	116:00	HSK	X	X	X				
115:37	119:29	MSFN	X	X	X				
116:10	119:08	HSK	X	X	X				
119:00	123:00	MSFN	X	X	X				
119:15	121:05	HSK		X	X		X	X	
121:10	123:03	MAD		X	X		X	X	
123:04	127:00	MSFN	X	X	X				
123:13	127:47	MAD	X	X	X		X	X	
127:00	130:51	MSFN	X	X	X				
127:00	128:56	MAD		X	X		X		
128:59	132:07	GDS	X	X	X		X	X	
131:42	134:46	MSFN	X	X	X				
132:06	134:50	ACN	X	X	X				
134:46	137:15	MSFN		X	X				
135:18	136:50	ACN		X	X				
136:40	137:53	HSK	X	X	X			X	
137:46	141:37	MSFN	X	X	X				
137:51	142:05	HSK	X	X	X		X	X	X
141:37	146:39	MSFN	X	X	X				

TABLE D-I.- COMMAND AND SERVICE MODULE DATA AVAILABILITY - Continued

Time, hr:min		Data Source (a)	Bandpass plots or tabs	Bilevels	Computer word tabs	Oscillo-graph records	Brush records	Special plots or tabs	Special programs
From	To								
141:45	143:48	HSK	X	X	X		X	X	X
143:31	146:41	MSFN	X	X	X				
143:37	146:40	HSK	X	X	X		X	X	
146:38	147:31	MAD	X	X	X		X	X	
146:41	150:37	MSFN	X	X	X				
147:08	151:22	MAD	X	X	X		X	X	
152:10	155:19	MSFN	X	X	X				
151:21	154:22	MAD	X	X	X		X	X	X
153:30	156:09	GDS	X	X	X				
155:19	158:23	MSFN	X	X	X				
156:07	158:30	GDS	X	X	X				
158:23	161:17	MSFN	X	X	X				
158:40	162:39	GDS	X	X	X		X		
162:30	163:22	HSK	X	X	X		X	X	
162:42	166:19	MSFN	X	X	X				
163:12	166:22	HSK	X	X	X		X	X	
166:19	171:28	MSFN	X	X	X				
166:20	172:27	HSK	X	X	X		X		
171:28	175:01	MSFN	X	X	X				
172:14	175:55	MAD	X	X	X	X	X	X	
175:01	179:10	MSFN	X	X	X				
175:30	178:10	MAD	X	X	X		X		
178:10	179:20	GDS	X	X	X	X	X		
179:10	183:09	MSFN	X	X	X				
179:21	183:44	GDS	X	X	X		X	X	
183:09	187:21	MSFN	X	X	X				
183:43	186:01	GDS	X	X	X				
186:57	187:59	HSK	X	X	X				
187:30	191:33	MSFN	X	X	X				
187:56	191:42	HSK	X	X	X		X	X	
191:33	195:22	MSFN	X	X	X				
191:41	195:07	HSK	X	X	X		X	X	
194:52	198:50	MSFN	X	X	X				
195:05	195:56	HSK		X	X		X	X	
195:50	199:35	MAD	X	X	X		X	X	
199:09	202:53	MSFN	X	X	X				
199:34	202:54	MAD	X	X	X		X	X	
202:53	207:16	MSFN	X	X	X				
202:53	207:40	GDS	X	X	X				
207:16	210:51	MSFN	X	X	X				
207:52	211:02	GDS	X	X	X	X			
210:51	214:36	MSFN	X	X	X				
211:50	216:20	HSK	X	X	X		X	X	X
215:35	219:30	MSFN	X	X	X				
216:18	220:27	HSK	X	X	X		X	X	
219:30	223:03	MSFN	X	X	X				
220:12	221:26	HSK	X	X	X		X	X	
221:28	222:45	MAD	X	X	X		X	X	
223:03	226:54	MSFN	X	X	X				
223:42	227:20	MAD	X	X	X		X	X	
226:54	230:59	MSFN	X	X	X				
227:20	228:20	MAD	X	X	X		X		
230:59	238:25	MSFN	X	X	X				
236:43	239:51	HSK					X	X	
239:46	243:17	MSFN	X	X	X				
239:48	243:20	HSK		X	X		X	X	X
243:17	246:23	MSFN	X	X	X				
245:00	245:55	HSK					X		
247:00	271:12	MSFN	X	X	X				
268:13	271:30	HSK						X	
271:12	275:12	MSFN	X	X	X				
271:50	274:03	MAD		X	X			X	
275:12	295:11	MSFN	X	X	X				
291:40	292:08	HSK	X	X	X	X			
293:57	294:45	HSK	X	X	X	X	X	X	X
294:50	295:11	DSE	X	X	X	X	X	X	X

TABLE D-II.- LUNAR MODULE DATA AVAILABILITY

Time, hr:min From	Time, hr:min To	Data Source (a)	Bandpass plots or tabs	Bilevels	Computer word tabs	Oscillo-graph records	Brush records	Special plots or tabs	Special programs
-04:00	00:00	ALDS	X	X					
34:21	34:49	MSFN	X	X					
57:00	58:00	MSFN	X	X					
98:24	99:19	MSFN	X	X	X				
98:30	99:30	MAD	X	X	X			X	
99:26	102:40	MSFN	X	X	X				
99:33	104:15	MAD	X	X	X	X		X	X
104:06	107:16	MSFN	X	X	X				
104:20	107:00	GDS	X	X	X	X		X	X
107:16	111:04	MSFN	X	X	X				
108:30	109:35	GDS						X	
111:05	127:00	MSFN	X	X	X				
123:20	127:20	MAD					X	X	
127:00	130:51	MSFN	X	X					
129:14	131:12	GDS						X	
132:56	142:39	MSFN	X	X					
141:49	142:53	HSK	X	X	X	X		X	
143:31	150:37	MSFN	X	X					
150:20	151:22	MAD					X		
151:10	155:19	MSFN	X	X					
151:20	153:20	MAD					X	X	
155:19	166:19	MSFN	X	X					
163:20	166:30	HSK	X	X					
166:19	171:28	MSFN	X	X	X				
166:30	171:28	HSK	X	X	X	X	X	X	X
171:28	175:01	MSFN	X	X	X				
171:28	175:55	MAD	X	X	X	X	X	X	X
175:01	179:10	MSFN	X	X	X				
175:54	177:37	MAD	X	X	X				
178:58	179:20	GDS				X	X		
179:10	181:35	MSFN	X	X	X				X
179:21	181:35	GDS	X	X	X		X	X	

[a]Data sources:

MSFN - Manned Space Flight Network
MSFN station call letters and location:
- ACN - Ascension Island
- BDA - Bermuda Islands
- CRO - Carnarvon (Australia)
- GDS - Goldstone (California)
- HSK - Honeysuckle (Canberra, Australia)
- MAD - Madrid (Spain)
- MIL - Merrit Island (Florida) - launch area
- VAN - Vanguard (Atlantic Ocean) - ship

Other:
- ALDS - Apollo launch data system (Kennedy Space Center, Florida)
- DSE - Spacecraft data storage equipment

APPENDIX E - MISSION REPOPT SUPPLEMENTS

Table E-I contains a listing of all reports that supplement the Apollo 7 through Apollo 15 mission reports. The table indicates the present status of each report not yet completed and the publication date of those which have been published.

TABLE E-I.- MISSION REPORT SUPPLEMENTS

Supplement number	Title	Publication date/status
	Apollo 7	
1	Trajectory Reconstruction and Analysis	May 1969
2	Communication System Performance	June 1969
3	Guidance, Navigation, and Control System Performance Analysis	November 1969
4	Reaction Control System Performance	August 1969
5	Cancelled	
6	Entry Postflight Analysis	December 1969
	Apollo 8	
1	Trajectory Reconstruction and Analysis	December 1969
2	Guidance, Navigation, and Control System Performance Analysis	November 1969
3	Performance of Command and Service Module Reaction Control System	March 1970
4	Service Propulsion System Final Flight Evaluation	September 1970
5	Cancelled	
6	Analysis of Apollo 8 Photography and Visual Observations	December 1969
7	Entry Postflight Analysis	December 1969
	Apollo 9	
1	Trajectory Reconstruction and Analysis	November 1969
2	Command and Service Module Guidance, Navigation, and Control System Performance	November 1969
3	Lunar Module Abort Guidance System Performance Analysis	November 1969
4	Performance of Command and Service Module Reaction Control System	April 1970
5	Service Propulsion System Final Flight Evaluation	December 1969
6	Performance of Lunar Module Reaction Control System	August 1970
7	Ascent Propulsion System Final Flight Evaluation	December 1970
8	Descent Propulsion System Final Flight Evaluation	September 1970
9	Cancelled	

Part 1

Part 2

TABLE E-I.- MISSION REPORT SUPPLEMENTS - Continued

Supplement number	Title	Publication Date/status
	Apollo 12	
1	Trajectory Reconstruction and Analysis	September 1970
2	Guidance, Navigation, and Control System Performance Analysis	September 1970
3	Service Propulsion System Final Flight Evaluation	Publication
4	Ascent Propulsion System Final Flight Evaluation	Publication
5	Descent Propulsion System Final Flight Evaluation	Publication
6	Apollo 12 Preliminary Science Report	July 1970
7	Landing Site Selection Processes	Final Review
	Apollo 13	
1	Guidance, Navigation and Control System Performance Analysis	September 1970
2	Descent Propulsion System Final Flight Evaluation	October 1970
3	Entry Postflight Analysis	Cancelled
	Apollo 14	
1	Guidance, Navigation, and Control System Performance Analysis	Publication
2	Cryogenic Storage System Performance Analysis	Preparation
3	Service Propulsion System Final Flight Evaluation	Publication
4	Ascent Propulsion System Final Flight Evaluation	Publication
5	Descent Propulsion System Final Flight Evaluation	Publication
6	Apollo 14 Preliminary Science Report	June 1971
7	Analysis of Inflight Demonstrations	Preparation
8	Atmospheric Electricity Experiments on Apollo 13 and 14 Launches	Preparation

Part 3

Part 4

APPENDIX F – GLOSSARY

Anorthosite: A granular, textured igneous rock regarded as having solidified at considerable depth. It is composed almost entirely of a soda-lime feldspar.

Apocynthion: The point in the orbit of a moon satellite which is farthest from the moon.

Apolune: See apocynthion.

Bow shock: The shock wave produced by the interaction of the solar wind with the earth's dipole magnetic field. It is also the outer boundary of the magnetosheath (transition region).

Breccia: A course-grained rock composed of angular fragments of pre-existing rocks in a fine-grained matrix.

Caldera: A broad crater-like basin surrounding a volcanic vent and having a diameter many times that of the vent.

Circadian rhythm: Relating to biological variations with a cycle of about 24 hours.

Cislunar: Pertaining to the space between the earth and moon.

Clast: A fragment of rock or mineral, commonly included in a larger rock.

Comprehensive sample: A 1-kilogram collection of rocks representative of a given area. Desired sample diameters range from approximately 3/8 inch to 1 1/2 inches.

Contingency sample: Approximately 2 kilograms of lunar material collected in the immediate vicinity of the lunar module during the early part of the first extravehicular period. This is done to increase the probabaility of returning a lunar sample to earth if early termination of extravehicular operations is necessary.

Densitometric: Relating to determining the degree of opacity of any translucent medium.

Diamagnetic cavity: An area having a magnetic permeability less than one.

Diurnal: Recurring daily. On earth, diurnal processes repeat themselves every 24 hours; on the moon, every 28 days.

Documented sample: A sample that is photographed before being picked up, the area photographed after sample removal, and a reference photograph taken to identify the location.

Double core tube sample: A sample obtained using two drive core tubes connected end to end.

Earthshine: Illumination of the moon's surface by sunlight reflected from the earth's surface and atmosphere.

Ecliptic: The plane defined by the earth's orbit about the sun.

Ergometry test: A test performed to measure muscular fatigue under controlled conditions.

Front: The outer slopes of a mountain range that rises above a plain or plateau.

Geomagnetic tail: An elongation of the earth's magnetic field whereby it is drawn in the anti-solar direction to an undetermined distance. It is also called the nagnetotail.

Gnomon: A rod mounted on a tripod in such a way that it is free to swing in any direction and indicate the local vertical.

Hummocky: Multiple low, rounded hills or knolls.

J-missions: A classification of Apollo lunar exploration missions for which provisions are made for extended lunar surface stay time, surface vehicular mobility and communications, and more extensive science data acquisition.

Kilocalorie: An amount of food having an energy-producing value of one large calorie (equivalent to 1000 gram calories).

Limb: The outer edge of the apparent disc of a celestial body, as the moon or earth, or a portion of the edge.

Lunar libration: A point in space which, from the viewpoint of an observer on earth, is about 60 degrees from the earth-moon axis in the direction of the moon's travel and on its orbital path.

Lunation: The average period of revolution of the moon about the earth with respect to the sun. A period of 29 days 12 hours 44 minutes 2.8 seconds. Also called a synodical month.

Magnetosheath: The region between the solar wind bow shock and the earth's dipole magnetic field. It varies in size and, within the region, the solar wind is reduced and the magnetic field is poorly defined. It is also called the transition region.

Magnetosphere: The region of the earth's atmosphere where ionized gases contribute to the dynamics of the atmosphere and where the forces of the earth's magnetic field are predominant.

Magnetospheric plasma: Plasma evolved in the magnetosphere.

Magnetotail: See geomagnetic tail.

Magnetopause: The boundary between the magnetosheath (transition region) and the earth's dipole magnetic field.

Mare: A large, dark, flat area on the lunar surface (lunar sea).

Mascons: Large mass concentrations beneath the lunar surface. They are believed to be large bodies that have impacted the lunar surface.

Meru: Milli earth rate unit. One thousandth of the earth's rotational rate.

Metric photography: Photography having an appropriate network of coordinates or reference points to permit accurate measurements.

Monoscopic photograph: A single photograph of a given area, or subject obtained with a camera having one lens system and shutter.

Morphological: Relating to the shapes and contours of objects or areas.

Moulton Point: A theoretical point on the sun-earth axis thought to be located about 940 000 statute miles from the earth in the anti-solar direction. It is also designated as the LI libration point of the earth.

Noble gases: Monatomic gases that are relatively inert.

Olivine: An igneous mineral that consists of a silicate of magnesium and iron.

Pericynthion: The point in the orbit of a moon satellite that is nearest to the moon, or the point in the trajectory of a vehicle that is nearest to the moon.

Perilune: See pericynthion.

Phenocrysts: Crystals in igneous rocks that are larger than the crystalline matrix in which they are imbedded.

Planar: Two-dimensional.

Plasma: An electrically conductive gas comurised of neutral particles, ionized particles, and free electrons, but which as a whole, is electrically neutral.

Plasma sheet: As used in this report, the term refers to a region in the center of the geomagnetic tail, approximately 10 earth radii in width, in which there is a marked increase in particle flux.

Porphyritic: The texture of rocks which contain distinct crystals imbedded in a relatively fine-grained groundmass.

Pyroclastic rocks: Rocks formed by fragmentation as a result of volcanic action.

Pyroxene: A mineral occurring in short, thick, prismatic crystals, or in crystals of square cross section; often laminated, and varying in color from white to dark green or black (rarely blue).

Radial sample: A sample consisting of material taken from a crater's ejecta field at a crater's rim, at a distance equal to the crater's radius, and at a distance equal to the crater's diameter.

Radon: A radioactive gaseous element with atomic number 86 and atomic masses of 220 and 222. Formed by the radioactive decay of radium.

Regolith: The surface layer of unsorted fragmented material on the earth or moon that overlies solid material

Rille: A long, narrow valley on the moon's surface.

Scoriaceous: Having the characteristics of rough, vesicular, cindery, usually dark lava.

Selenodetic: Relating to the branch of applied mathematics that determines by observation and measurement the positions of points on the moon's surface and the size and shape of the moon.

Selenological: Relating to the branch of astronomy that deals with the moon.

Slikensides: Smooth, grooved and polished surfaces of rocks produced by friction on fault planes and joint faces.

Solar corona: The outer visible envelope of the sun.

Solar wind: Streams of particles (plasma) emanating from and flowing approximately radially outward from the sun.

Spectrometric: Relating to the measurement of wavelengths of rays of a spectrum.

Stereoscopic photographs: Two photographs obtained of a given area or subject from different angles so that the images, when viewed through a stereoscope, appear as a three-dimensional reproduction of the area or subject photographed.

Talus: An accumulated mass of angular rock debris on a hill side or at the foot of a mountain.

Terminator: The border between the illuminated and dark portions of the moon or planets

Transition region: See magnetosheath.

Umbra: The darkest portion of the shadow of a large body such as the earth or moon wherein light is completely blocked.

Vesicular: Containing small spherical cavities.

Zodiac: An imaginary belt that extends 8 degrees on either side of the ecliptic. It includes the paths of the moon and principal planets.

Zodiacal light: A faint glow seen along the zodiac in the west after sunset and in the east before sunrise.