MSC- 02575

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MISSION REQUIREMENTS
SA-510/CSM-112/LM-10
J-1 TYPE MISSION

LUNAR LANDING

~~JANUARY 4, 1971~~

with Change "A" and "B"

July 8, 1971

with Change "C" — 22 July

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

MSC-02575

NASA

National Aeronautics and Space Administration

MISSION REQUIREMENTS
J-1 TYPE MISSION

January 4, 1971

Contract NAS 9-8166

MISSION REQUIREMENTS

J-1 TYPE MISSION

Contract NAS 9-8166

Prepared by TRW Systems

for

Systems Engineering Division
Apollo Spacecraft Program Office
Manned Spacecraft Center
Houston, Texas

Submitted by James M. Peacock
James M. Peacock
Mission Staff Engineer

Approved by R. L. Kubicki
Ronald L. Kubicki, Acting Chief
Systems Engineering Division

Approved by James A. McDivitt
James A. McDivitt, Manager
Apollo Spacecraft Program

Concurrence Philip B. Deans
for Maxime A. Faget, Director
Engineering and Development

Concurrence Sigurd A. Sjoberg
Sigurd A. Sjoberg, Director
Flight Operations

Concurrence D. K. Slayton
Donald K. Slayton, Director
Flight Crew Operations

Concurrence A. J. Calio
Anthony J. Calio, Director
Science and Applications

Concurrence Charles A. Berry M.D.
Charles A. Berry, Director
Medical Research and Operations

CCBD NUMBERS	ECP NUMBERS
PCN	
MSC 1C0302	
MSFC	
KSC	

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PROGRAM OFFICE

CONFIGURATION CONTROL BOARD DIRECTIVE

CHANGE PRIORITY

IMPACT ON ☐ CSM ☐ LM ☐ GFE ☐ LV ☐ LF ☐ EXP ☐ GSE ☐ OTHER

DATE 22 July 1971

PAGE 1 OF 1

CHANGE TITLE

Change C to MSC-02575

NOMENCLATURE AND PART NO. OF AFFECTED END ITEM

Mission Requirements, J-1 Type Mission, Lunar Landing

PRODUCTION EFFECTIVITY	MODIFICATION EFFECTIVITY

ESTIMATED COST

FY71	FY72	FY73	TOTAL
	None	None	None

SCHEDULE IMPACT

None

CHANGE IMPACT SUMMARY

- GSE ☐
- SPARES ☐
- TRAINERS ☐
- SOFTWARE ☐
  - FLIGHT PROGRAMS ☐
  - RTCC PROGRAMS ☐
  - AOH ☐
  - STOWAGE LIST ☐
  - COMAT ☐
  - TCRD ☐
  - ERD ☐
- RETEST ☐
- OTHER ☐

WEIGHT
LM
CSM
OTHER

ICDS AFFECTED

INTERCENTER

INTRACENTER

CSM
LM

CONTRACT SPECIFICATIONS AFFECTED

DISPOSITION AND DIRECTED ACTION:
CHANGE TO BE IMPLEMENTED ONLY WHEN ALL INTERFACE ACTIONS HAVE BEEN AUTHORIZED

- The Test Conditions for objectives EVA Communications With the LCRU/GCTA, CM Photographic Tasks and Visual Light Flash Phenomenon are modified.
- The Composite Casting in-flight demonstration is deleted.
- The LM ascent stage lunar impact coordinates are changed.

J. M. Peacock

RVB 7/21

AUTHORIZATION

- APPROVED ☒
- APPRD WITH REVS ☐
- DISAPPROVED ☐

CHANGE CATEGORY

MANDATORY		PRODUCT IMPROVEMENT	
MISSION REQUIREMENT	☒	COST SAVINGS	☐
COMPATIBILITY	☐	SCHEDULE IMPROVEMENT	☐
RECORD	☐	IMPROVE FIELD CHECKOUT	☐
DOCUMENTATION	☐	ENHANCE MISSION CAPABILITY	☐

ENDORSEMENTS ☐ LM ☐ CSM ☐ OTHER

Alan Shepard — 7/22/71
SIGNATURE — DATE
CPCB Chairman

SIGNATURE — DATE

SIGNATURE — DATE

Aaron Cohen for — 7/22/71
SIGNATURE — DATE
CHAIRMAN CONFIGURATION CONTROL BOARD

TD5/R.R. Baldwin

CCBD NUMBERS	ECP NUMBERS	MANNED SPACECRAFT CENTER APOLLO SPACECRAFT PROGRAM OFFICE CONFIGURATION CONTROL BOARD DIRECTIVE CHANGE PRIORITY ______	DATE July 8, 1971 PAGE 1 OF 1
PCN			
MSC 1C0287		IMPACT ON ☐ CSM ☐ LM ☐ GFE ☐ LV ☐ LAUNCH FACILITIES ☐ OTHER	
MSFC		CHANGE TITLE Change B to MSC-02575	
KSC			

CHANGE IMPACT SUMMARY

- GSE ☐
- SPARES ☐
- TRAINERS ☐
- SOFTWARE ☐
  - FLIGHT PROGRAMS ☐
  - RTCC PROGRAMS ☐
  - AOH ☐
  - STOWAGE LIST ☐
  - COMAT ☐
  - TCRD ☐
  - TSCD ☐
- RETEST ☐
- OTHER ☐

WEIGHT
LM ______
CSM ______

ICDS AFFECTED

INTERCENTER ______

INTRACENTER
CSM ______
LM ______
G&N ______
EMU ______
POE ______
SCIENTIFIC ______

CONTRACT SPECIFICATIONS AFFECTED

NOMENCLATURE AND PART NO. OF AFFECTED END ITEM
Mission Requirements, J-1 Type Mission, Lunar Landing

PRODUCTION EFFECTIVITY	MODIFICATION EFFECTIVITY

ESTIMATED COST

FY70	FY71	FY72	TOTAL
	None	None	None

SCHEDULE IMPACT
None

DISPOSITION AND DIRECTED ACTION:
CHANGE TO BE IMPLEMENTED ONLY WHEN ALL INTERFACE ACTIONS HAVE BEEN AUTHORIZED

- Objective Visual Light Flash Phenomenon is added.
- Objective Visual Observations From Lunar Orbit is added.
- The Composite Casting in-flight demonstration is added.
- Section 3.4 is modified to show changes and additions to the photographic hardware and film development processes.
- The Test Conditions for objectives Lunar Rover Vehicle Evaluation, SM Orbital Photographic Tasks and CM Photographic Tasks are changed.
- The Test Conditions for experiments Lunar Geology Investigation, Soil Mechanics, Gamma-Ray Spectrometer, X-Ray Fluorescence, Alpha Particle Spectrometer, Mass Spectrometer, UV Photography-Earth and Moon, Gegenschein from Lunar Orbit and Solar Wind Composition are modified.
- Section 6.4 is expanded to show alternate mission guidelines.
- Miscellaneous changes are provided throughout the remainder of the document.

AUTHORIZATION
- APPROVED ☒
- APPRD WITH REVS ☐
- DISSAPPROVED ☐

CHANGE CATEGORY KWK 6/30/71

MANDATORY		PRODUCT IMPROVEMENT	
MISSION REQUIREMENT	☒	COST SAVINGS	☐
COMPATIBILITY	☐	SCHEDULE IMPROVEMENT	☐
RECORD	☐	IMPROVE FIELD CHECKOUT	☐
		ENHANCE MISSION CAPABILITY	☐

ENDORSEMENTS ☐ LM ☐ CSM ☐ OTHER

Thomas L. McGuire — SIGNATURE — 7/7/71 DATE
CPCB Chairman
______ SIGNATURE ______ DATE
______ SIGNATURE ______ DATE

James A. McDivitt — SIGNATURE — 6/30/71 DATE
CHAIRMAN CONFIGURATION CONTROL BOARD

MSC Form 1156A (Rev Sep 69) NASA — MSC

TDS/BALDWIN

CCBD NUMBERS	ECP NUMBERS
PCN	
MSC 1C0302	
MSFC	
KSC	

MANNED SPACECRAFT CENTER

PROGRAM OFFICE

CONFIGURATION CONTROL BOARD DIRECTIVE

CHANGE PRIORITY

IMPACT ON ☐ CSM ☐ LM ☐ GFE ☐ LV ☐ LF ☐ EXP ☐ GSE ☐ OTHER

DATE 22 July 1971

PAGE 1 OF 1

CHANGE TITLE

Change C to MSC-02575

NOMENCLATURE AND PART NO. OF AFFECTED END ITEM

Mission Requirements, J-1 Type Mission, Lunar Landing

PRODUCTION EFFECTIVITY | MODIFICATION EFFECTIVITY

ESTIMATED COST

FY71	FY72	FY73	TOTAL
	None	None	None

SCHEDULE IMPACT

None

CHANGE IMPACT SUMMARY

- GSE ☐
- SPARES ☐
- TRAINERS ☐
- SOFTWARE ☐
  - FLIGHT PROGRAMS ☐
  - RTCC PROGRAMS ☐
  - AOH ☐
  - STOWAGE LIST ☐
  - COMAT ☐
  - TCRD ☐
  - ERD ☐
- RETEST ☐
- OTHER ☐

WEIGHT

LM

CSM

OTHER

ICDS AFFECTED

INTERCENTER

INTRACENTER

CSM

LM

CONTRACT SPECIFICATIONS AFFECTED

DISPOSITION AND DIRECTED ACTION:

CHANGE TO BE IMPLEMENTED ONLY WHEN ALL INTERFACE ACTIONS HAVE BEEN AUTHORIZED

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- The Composite Casting in-flight demonstration is deleted.
- The LM ascent stage lunar impact coordinates are changed.

J. M. Peacock

RVB 7/21

AUTHORIZATION

- APPROVED ☒
- APPRD WITH REVS ☐
- DISAPPROVED ☐

CHANGE CATEGORY

MANDATORY

- MISSION REQUIREMENT ☒
- COMPATIBILITY ☐
- RECORD ☐
- DOCUMENTATION ☐

PRODUCT IMPROVEMENT

- COST SAVINGS ☐
- SCHEDULE IMPROVEMENT ☐
- IMPROVE FIELD CHECKOUT ☐
- ENHANCE MISSION CAPABILITY ☐

ENDORSEMENTS ☐ LM ☐ CSM ☐ OTHER

Alan Shepard 7/22/71

SIGNATURE DATE

CPCB Chairman

SIGNATURE DATE

SIGNATURE DATE

Aaron Cohen 7/22/71

SIGNATURE DATE

for CHAIRMAN CONFIGURATION CONTROL BOARD

MISSION REQUIREMENTS

J-1 TYPE MISSION

CHANGE B

REVISION INSTRUCTION SHEET

Update this document in accordance with the following instructions.

1) Insert page iiia.1 behind signature page iiia.

2) Insert page iiic.1 behind page iiic.

3) Replace the following pages from the basic document with the corresponding Change B pages:

v	4-33	5-43	5-132
vii	4-37	5-45	5-133
ix	4-38	5-48	5-134
2-1	4-39	5-58B	5-139
2-2	4-40	5-61	5-140
2-4	4-40A	5-64	5-141
2-6	4-40B	5-65	5-144
2-8	4-41	5-66	5-153
3-4	4-42	5-70	5-154
3-5	4-44	5-75	5-155
3-6	4-45	5-76	5-156
3-7	4-46	5-83	6-1
3-8	4-47	5-84	6-2
3-9	4-48	5-91	A-1
3-10	4-51	5-111	A-2
4-3A	4-52	5-112	A-3
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4-6	5-17	5-114	D-2
4-7	5-24	5-115	D-3
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4) Add pages 2-9, 4-8, 4-52A, 4-71, 4-72, 4-73, 4-74, 4-75, 4-77, 4-78, 4-79, 4-81, 4-82, 4-83, 5-40 and 6-3.

MISSION REQUIREMENTS

J-1 TYPE MISSION

CHANGE C

REVISION INSTRUCTION SHEET

Update this document in accordance with the following instructions: C

1) Insert page iiia.3 behind page iiia.1.

2) Insert page iiic.3 behind page iiic.1.

3) Replace the following pages from the basic document with the corresponding Change C pages:

v	4-52
2-5	4-52A
2-9	4-77
4-9	5-8
4-10	

4) Delete page D-7.

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1.0 PURPOSE

This document defines the mission objectives and experiments for Apollo Mission J-1. The detailed objectives and experiments are derived from the Mission Implementation Plan (Reference 1). A

This Mission Requirements document provides mission planning support for the implementation and accomplishment of the detailed objectives and experiments.

This document will control spacecraft mission requirements used in mission planning and has precedence over all MSC or contractor documents in this respect.

2.0 INTRODUCTION

2.1 MISSION PURPOSE

The primary purposes of this mission are to investigate the lunar surface environment, to emplace Apollo 15 ALSEP, to obtain lunar material samples, to perform experiments in lunar orbit, to obtain orbital photography and to enhance the capability for manned lunar exploration.

2.2 FLIGHT MISSION DESCRIPTION

Launch to Earth Orbit:

The countdown will allow a launch on time using flight azimuth limits of 80 to 100 degrees. The launch vehicle will place the spacecraft with three crewmen aboard into a 90-NM circular earth parking orbit. Launch vehicle and spacecraft checkout will be accomplished in this orbit.

Translunar Injection:

The launch vehicle S-IVB stage will be reignited during the second revolution of the space vehicle in the earth parking orbit. The space vehicle will be placed on a translunar trajectory, targeted such that transearth return to an acceptable entry corridor can be achieved without the use of the SPS or DPS for at least 5 hours after TLI cutoff (i.e., up to the time of CSM docking with the LM), and such that an acceptable earth return can be achieved using the SPS or DPS until at least pericynthion plus 2 hours if LOI is not performed.

Translunar Coast:

Shortly after injection the CSM will be separated from the S-IVB/SLA/LM by use of the SM RCS. The CSM will turn around and dock to the LM. Separation of the combined LM/CSM from the S-IVB nominally will be achieved within 2-1/2 hours after injection. The S-IVB will then perform an evasive maneuver to alter its circumlunar coast trajectory clear of the spacecraft trajectory. At a GET of approximately 5-3/4 hours after launch the S-IVB will perform a mid-course correction for the purpose of entering a trajectory that will result in S-IVB impact on the lunar surface at latitude 3.65° S and longitude 7.58° W as B shown by Orbiter IV photo on A-14 Orbit Monitor Chart. A second midcourse correction will be performed by the S-IVB at a GET of approximately 9-1/2 hours to reduce the error uncertainty from a 3 sigma value of $\pm$335 km to a 3 sigma value of $\pm$60 km.

During the translunar coast, midcourse corrections will be made if required. These corrections will utilize the MSFN for navigation.

The SIM door will be jettisoned approximately 4.5 hours prior to LOI.

Lunar Orbit Insertion:

The SPS will be used to insert the spacecraft into lunar orbit.

Following the initial insertion burn, the spacecraft orbit will be approximately 60 by 170 NM.

Lunar Module Descent:

The CSM will be used to transport the LM into an orbit of approximately 8 by 60 NM. Two astronauts will subsequently enter the LM and perform LM checkout. The CSM will be separated from the LM using the SM RCS. The LM descent profile design shall provide the capability to land at a small smooth area proximate to primary selenological features of the site.

The lunar surface at the landing site shall be in the astronauts' field of view for approximately two minutes prior to touchdown.

CSM Orbit Circularization:

The CSM orbit will be circularized at approximately 60 NM shortly after CSM/LM separation and before PDI.

Lunar Landing Site:

Mission planning will allow launch attempts during each of three consecutive months in accordance with the dates shown below. During the first and second months, mission planning will allow for a T-0 launch and a T+24 hour launch. The planning for the third month will include launches at T-24 hours, T-0 and T+24 hours.

Launch Opportunity	Approximate Sun Elevation Angles (referenced to local horizontal at the landing site) and Sun Relative Azimuths for Launch Dates as indicated in parenthesis.					
	T-24 Hours		T-0		T+24 Hours	
	SEA	SRA	SEA	SRA	SEA	SRA
First Month	-	-	*12°to13.5° (7/26/71)	6.7° (7/26/71)	23.2° (7/27/71)	12.7° (7/27/71)
Second Month	-	-	11.3° (8/24/70)	7.1° (8/24/71)	22.5° (8/25/71)	12.5° (8/25/71)
Third Month	12° (9/22/71)	7.8° (9/22/71)	12° (9/23/71)	7.8° (9/23/71)	23° (9/24/71)	13.9° (9/24/71)

*Varies during launch window to maintain LM rescue SPS ΔV reserves.

The approach azimuth will be -91 degrees and the flight path elevation angle will be 25 degrees.

Launch opportunities will be provided using the following site:

Designation	Center Coordinates		Source Data
Hadley-Apennine	Latitude	26°04'26"N (26.07389°)*	Lunar Orbiter V-26.1 control data of January 29, 1971
	Longitude	3°39'14"E (3.65389°)*	
	Radius Vector	1,734,540 m (936.5767 NM)	

*The same physical location of the Hadley Rille target point is also located on the 1:250,000 scale V-26.1 Photomap, first edition, December 1970, at latitude 26°04'54"N and 3°39'30"E.

Lunar Surface Operations:

The stay time on the lunar surface is open-ended and the planned maximum will not exceed approximately 67 hours. After checkout of the LM to assess its launch capability, the LM will be depressurized to allow a stand-up EVA by the CDR. A verbal description of recognizable craters and the surface features will be provided to MCC to assist in locating the position of the landed LM. A stereo panoramic will be obtained using the HEDC with 60 mm lens. Landmarks will be initially located for normal and emergency return to the LM. A far-field visual examination will be conducted to provide a description of the visible portions of the Apennine Front, the rille wall, the

North Complex, the mare surface and boulder fields. Photographs of selected targets will be obtained by use of the HEDC with 500 mm lens. A near-field visual examination will be conducted to provide a description of any effects of the descent engine, and of fragment distribution, craters, boulders and soil. The proposed ALSEP deployment site will be examined to determine its suitability. The cabin will then be repressurized for a rest period prior to egress of astronauts to the surface. The nominal plan will provide for three periods of simultaneous EVA by both astronauts. The first two EVA periods will be approximately 7 hours in duration. The third EVA period will be approximately 6 hours in duration.

Traverse planning will provide for returning the crew to the LM under each of the following single-failure conditions.

- Use of the buddy-secondary life support system due to an inoperative PLSS anytime during a riding traverse (based on the assumption that the LRV will operate properly during the return to the LM).
- Use of two PLSS's for a walking return to the LM from an inoperative LRV anytime during a riding traverse (based on the assumption that both PLSS's will operate properly during the return to the LM).

Traverse planning will not provide for dual failure conditions such as two PLSS failures or an LRV failure combined with a PLSS failure.

ALSEP deployment operations will be accomplished as defined in the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Vol. V, ALSEP Data Book, as revised by Appendix D for Apollo 15 ALSEP. B

Television transmission will be provided as early as practicable during the EVA period. Television coverage will include an astronaut descending to the lunar surface, an external view of the landed LM, a panorama of distant terrain features and an astronaut during lunar surface activities. Television coverage will be provided by the GCTA during major science stops when using the LRV. B

Photography will be employed throughout the EVA to document the activities and observations.

Lunar Module Ascent:

Prior to LM liftoff, the CSM will complete the required plane change to permit a nominally coplanar rendezvous.

Powered ascent will be accomplished using the APS. Insertion conditions will be such that the LM will be in approximately a 9 by 48 NM elliptical orbit. LM liftoff will occur about 2-1/2 minutes prior to the nominal time for a coelliptic rendezvous to permit use of the early rendezvous technique. The TPI maneuver will utilize the APS. Other LM maneuvers will be made using the LM RCS. After docking, both LM crewmen will transfer to the CSM with the lunar surface samples and the exposed film. The LM will be separated from the CSM using the SM RCS.

LM Ascent Stage Lunar Impact:

The spent LM ascent stage will be targeted to impact at latitude 24°24'N and longitude 1°06'E (as shown on Lunar Topographic Map, Rima Hadley, Orbiter V Site 26.1, first edition, January 1971). This is to be executed approximately 2 revolutions after CSM/LM docking. C

Lunar Orbital Operations:

The SIM equipment will be placed in operation. The subsatellite will be ejected from the SIM bay just prior to TEI. The SIM cameras and booms will be retracted into the SIM bay prior to TEI. If any boom fails to retract, it will be jettisoned prior to SPS thrusting.

Transearth Injection:

The SPS will be used to boost the CSM out of lunar orbit. The nominal return flight will not exceed 110 hours and the return inclination will not exceed 70 degrees (relative to the earth's equator).

Transearth Coast:

During transearth coast, midcourse corrections will be made if required. These corrections will utilize the MSFN for navigation.

SIM data retrieval will be accomplished during an EVA. Preparations for the EVA will start no later than 6 hours after crew wakeup on the EVA day.

Selected SIM experiments will operate during portions of the trans-earth coast period.

Entry and Recovery:

Prior to atmospheric entry, the CM will be separated from the SM using the SM RCS. The nominal range from 400,000 feet altitude to touchdown will be approximately 1190 NM. B

Earth touchdown will be in the Pacific within ±35 degrees latitude and will occur within approximately 12.5 days after launch from earth.

Immediate recovery of the crew and the CM will be effected.

Post Landing Operations:

Following splashdown, the crew will egress the CM after the flotation collar has been attached, and transfer to the recovery ship by helicopter. Biological isolation garments will be available for use in case of unexplained crew illness. The crew will be returned to MSC for debriefing. The sample return containers, film, tapes and astronaut logs will be transported to the LRL.

2.3 DEFINITIONS

1) The Test Conditions stated in the Detailed Objectives (Section 4) and Detailed Experiments (Section 5) are those required conditions that must exist for the objective or experiment to be satisfied.

2) The priorities as assigned to each item in Data Requirements of the Detailed Objectives (Section 4) and Detailed Experiments (Section 5) are based on the following definitions:

a) Mandatory (M) - A mandatory item is essential for evaluation of the objective or experiment.

b) Highly Desirable (HD) - A highly desirable item furnishes information which aids evaluation of the objective or experiment. These items supply information which is available from alternate sources or which is not required for evaluation of the essential parts of the objective or experiment.

3) The numbers appearing in the "Mode" column of the telemetry listings in the Detailed Objectives (Section 4) and the Detailed Experiments (Section 5) indicate the following:

a) "1" - Telemetry available in high bit rate format only.

b) "2" - Telemetry available in high bit rate and low bit rate formats.

4) Deleted

5) The best estimate of trajectory (BET) data (as shown under the Data Requirements for various Detailed Objectives and Detailed Experiments) will be prepared for the users in accordance with the details specified in Reference 5. Unless specified otherwise in the specific Detailed Objectives or Detailed Experiments, the frequency of data output will be once per minute for lunar orbit periods and once per ten minutes for translunar and transearth coast periods. Table II of Reference 5 describes the format of the BET data which are available in three forms: 1) magnetic tape; 2) microfilm; and 3) tab listing.

Whenever spacecraft attitude data are requested as an optional parameter along with the standard BET data, the following additional parameters are provided: A

Data Word Number	
35	CDUX Degrees - Platform IMU gimbal angle
42	CDUY Degrees - Platform IMU gimbal angle
49	CDUZ Degrees - Platform IMU gimbal angle
113	Look Angle to Sun - Alpha Degrees
114	Look Angle to Sun - Beta Degrees
115	Look Angle to Earth - Alpha Degrees
116	Look Angle to Earth - Beta Degrees
117	Look Angle to Moon - Alpha Degrees
118	Look Angle to Moon - Beta Degrees
120	Local Horizontal, Theta Degrees
121	Local Horizontal, Psi Degrees
122	Local Horizontal, Phi Degrees

Data Word Number	
124	Look Angle to Inertial Velocity Vector - Alpha Degrees
125	Look Angle to Inertial Velocity Vector - Beta Degrees

B

Words 120, 121, and 122 are vehicle attitude (Euler angles) with respect to the local horizontal coordinate system and apply only to lunar orbit periods.

6) Apollo Photographic Evaluation (APE) program data (as shown under Data Requirements for the SM Orbital Photographic Tasks and the CM Photographic Tasks detailed objectives) will be prepared for the users in accordance with the details specified in Reference 6. Section 6 of Reference 6 describes the format of the APE data which are available in the form of microfilm. The APE program will utilize trajectory data generated by the TRW Houston Operations Predictor-Estimator (HOPE) program as defined in Reference 7. B

2.4 CONFIGURATION CONTROL

1) Configuration control of this document will be exercised in accordance with Apollo Spacecraft Program Configuration Management Manual SB07-C-001 (Reference 2).

2) The spacecraft configuration is identified in the latest issue of the Apollo Spacecraft Configuration, Weight and Performance Summary, D2-118078 (Reference 3).

3) The equipment stowage list for the CM and LM is identified in the latest issue of the Apollo Stowage List, Mission J-1, CSM 112/LM-10, Apollo 15 (Reference 4).

2.5 OPERATIONAL TESTS

The following operational tests will be conducted to provide for the acquisition of technical data. These tests will not be required by the objectives of this mission. They will not affect the nominal mission timeline, will add no payload weight and will not jeopardize the accomplishment of primary objectives, experiments or detailed objectives.

1) Lunar Gravity Measurement - The test will consist of obtaining data at two different times on the magnitude of lunar gravity. The first portion of the test will be conducted for 10 minutes after the initial checkout of the LM on the lunar surface. Power-down of the LGC to the standby mode will then be accomplished. The second portion of the test will be conducted for about 38 minutes prior to ascent. Coupling data unit and command module computer idling program (P00) data will be obtained via telemetry. B

2) LM Voice and Data Relay - The test will consist of recording voice and PLSS data at various MSFN stations as transmitted via LM from the LM commander (EVC-1) during LRV traverses. The test will not require that these data via the LM be provided in real-time at MCC since the option exists to use the LCRU for communications with MCC during LRV traverses. A post-mission signal strength analysis will be accomplished to compare pre-mission computed and actual signal strength levels of both the LCRU and LM-transmitted data with respect to distances traversed by the astronauts. Voice and PLSS data as transmitted via the LM will also be evaluated to determine the quality of the data as a function of VHF signal strength. The intent of the analysis is to provide a better understanding of the capability to transmit voice and PLSS data from EVC-1 to MSFN via the LM in case of an LCRU failure during traverses.

2.6 IN-FLIGHT DEMONSTRATIONS

Deleted

C

3.0 SUMMARY OF MISSION OBJECTIVES AND EXPERIMENTS

3.1 GENERAL

The following primary mission objectives have been assigned to this mission by the Office of Manned Space Flight (OMSF) in the Mission Implementation Plan (Reference 1). A

1) Perform selenological inspection, survey, and sampling of materials and surface features in a pre-selected area of the Hadley-Apennine region.

2) Emplace and activate surface experiments.

3) Evaluate the capability of the Apollo equipment to provide extended lunar surface stay time, increased EVA operations, and surface mobility.

4) Conduct in-flight experiments and photographic tasks from lunar orbit.

The following experiments have been assigned to this mission by OMSF (Reference 1).

1) M-078 Bone Mineral Measurement

2) M-515 Lunar Dust Detector (ALSEP)

3) S-031 Passive Seismic (ALSEP)*

4) S-034 Lunar Surface Magnetometer (ALSEP)* A

5) S-035 Solar Wind Spectrometer (ALSEP)*

6) S-037 Heat Flow (ALSEP)*

7) S-036 Suprathermal Ion Detector (ALSEP)

8) S-058 Cold Cathode Ion Gauge (ALSEP)* A

9) S-059 Lunar Geology Investigation

10) S-078 Laser Ranging Retro-Reflector

11) S-160 Gamma Ray Spectrometer (SIM)

12) S-161 X-Ray Fluorescence (SIM)

13) S-162 Alpha Particle Spectrometer (SIM)

14) S-164 S-band Transponder (CSM/LM)

15) S-164 S-band Transponder (Subsatellite)

16) S-165 Mass Spectrometer (SIM)

17) S-170 Downlink Bistatic Radar Observations of the Moon* A

18) S-173 Particle Shadows/Boundary Layer (Subsatellite)

19) S-174 Magnetometer (Subsatellite)

20) S-176 Apollo Window Meteoroid

21) S-177 UV Photography-Earth and Moon

22) S-178 Gegenschein from Lunar Orbit

23) S-200 Soil Mechanics

24) Deleted

25) S-080 Solar Wind Composition

*These requirements are currently identified in Reference 1 as Lunar Passive Seismology (S-031), Lunar Tri-Axis Magnetometer (S-034), Medium Energy Solar Wind (S-035), Lunar Heat Flow (S-037), Cold Cathode Ionization Gauge (S-058) and Bistatic Radar (S-170). The experiment titles as used throughout this Mission Requirements Document and related MSC mission planning documents will, however, not be changed to the titles in Reference 1. A

Experiments 2) through 8) are part of the Apollo 15 ALSEP package.

Detailed objectives have been derived from the OMSF-assigned primary objectives, placed in order of priority, and detailed to the extent necessary for mission planning. Passive objectives such as Apollo Time and Motion Study will be listed in Section 4.0, but will not appear elsewhere in this document.

Experiments are detailed and assigned priority in this document only in the event that they require crew action or otherwise impact the mission timeline. Passive experiments such as M-078 (Bone Mineral Measurement), S-176 (Apollo Window Meteoroid) and M-079 (Total Body Gamma Spectrometry) will be listed in Section 5.0, but will not appear elsewhere in this document. All of the detailed experiments are in support of the primary mission objectives or were assigned by OMSF as a numbered experiment. A

3.2 PRIORITIES

The detailed objectives and experiments are listed below in their order of priority. All detailed objectives and detailed experiments to be accomplished on the lunar surface take precedence over those to be accomplished in lunar orbit or in transearth coast. A

Priority	Detailed Objectives and Experiments
	Lunar Surface
1	Contingency Sample Collection
2	Documented Sample Collection at Apennine Front (Part of Lunar Geology Investigation)
3	Apollo 15 ALSEP
4	Drill Core Sample Collection (Part of Lunar Geology Investigation)
5	Laser Ranging Retro-Reflector
6	Lunar Geology Investigation (Portions other than priority items 2 and 4 above)
7	Lunar Rover Vehicle Evaluation
8	EVA Communications with the LCRU/GCTA
9	EMU Assessment on Lunar Surface
10	LM Landing Effects Evaluation
11	Solar Wind Composition
12	Soil Mechanics
N/A	LM Descent Engine Performance
	Lunar Orbit and Transearth Coast
1	Gamma-Ray Spectrometer
2	X-Ray Fluorescence
3	SM Orbital Photographic Tasks

A

A

Priority	Detailed Objectives and Experiments
	Lunar Orbit and Transearth Coast
4	Subsatellite
5	Down-Link Bistatic Radar Observations of the Moon
6	S-band Transponder (CSM/LM)
7	Alpha Particle Spectrometer
8	Mass Spectrometer
9	UV Photography-Earth and Moon
10	Gegenschein from Lunar Orbit
11	CM Photographic Tasks
12	SIM Thermal Data
13	SIM Bay Inspection During EVA
14	SIM Door Jettison Evaluation
15	Visual Observations from Lunar Orbit
16	Visual Light Flash Phenomenon

B

3.3 MSC POINTS OF CONTACT

The MSC points of contact for the detailed objectives, experiments and operational tests are identified below. B

Detailed Objectives	Point of Contact
Lunar Rover Vehicle Evaluation	J. H. Cooper/FC9 W. R. Perry/MSFC*
EVA Communications with LCRU/GCTA	
FTO 1), 3), 4), 5)	R. L. Sinderson/EE16*
FTO 2), 5)	W. E. Perry/EE2*
FTO 2) (for use of TV on lunar surface after LM lift-off)	W. C. Phinney/TN6*
EMU Assessment on Lunar Surface	
FTO 1), 2), 3), 4)	R. E. Mayo/EC*
FTO 5), 6)	G. F. Humbert/DD5*
LM Landing Effects Evaluation	W. F. Rogers/ES12*

Detailed Objectives (Continued)	Point of Contact
SM Orbital Photographic Tasks	S. N. Hardee/TD4
CM Photographic Tasks	S. N. Hardee/TD4
SIM Thermal Data	J. A. Smith/ES16*
SIM Bay Inspection During EVA	J. F. Ellis/CF5*
SIM Door Jettison Evaluation	G. W. Sandars/ES12*
LM Descent Engine Performance	W. R. Hammock/EP2*
Visual Observations from Lunar Orbit	S. N. Hardee/TD4 B
Visual Light Flash Phenomenon	R. E. Benson/DC7*

Detailed Experiments	Point of Contact
Contingency Sample Collection	M. L. Miller/TD4
Passive Seismic (ALSEP)	W. F. Eichelman/TD4
Heat Flow (ALSEP)	W. F. Eichelman/TD4
Lunar Surface Magnetometer (ALSEP)	T. T. White/TD4
Solar Wind Spectrometer (ALSEP)	M. L. Miller/TD4
Suprathermal Ion Detector (ALSEP)	M. L. Miller/TD4
Cold Cathode Ion Gauge (ALSEP)	M. L. Miller/TD4
Lunar Dust Detector (ALSEP)	J. R. Bates/TD5
Lunar Geology Investigation	M. L. Miller/TD4
Laser Ranging Retro-Reflector	T. T. White/TD4
Soil Mechanics	M. L. Miller/TD4
Gamma-Ray Spectrometer (SIM)	W. F. Eichelman/TD4
X-Ray Fluorescence (SIM)	W. F. Eichelman/TD4 B
Alpha Particle Spectrometer (SIM)	W. F. Eichelman/TD4
S-Band Transponder (Subsatellite)	P. E. Lafferty/TD4
Particle Shadows/Boundary Layer (Subsatellite)	P. E. Lafferty/TD4

Detailed Experiments (Continued)	Point of Contact
Magnetometer (Subsatellite)	P. E. Lafferty/TD4
Mass Spectrometer (SIM)	V. M. Dauphin/TD4
Down-Link Bistatic Radar Observations of the Moon	P. E. Lafferty/TD4
UV Photography-Earth and Moon	S. N. Hardee/TD4
Gegenschein from Lunar Orbit	S. N. Hardee/TD4
S-Band Transponder (CSM/LM)	P. E. Lafferty/TD4
Solar Wind Composition	W. F. Eichelman/TD4

Operational Tests	Point of Contact
Lunar Gravity Measurement	R. L. Nance/TF5
LM Voice and Data Relay	A. D. Travis/EE7*

B

*Written assessment reports are due three months after completion of the mission from the points of contact indicated for the detailed objectives and operational tests. The responsibility for providing the proper action for the remaining two detailed objectives, for the detailed experiments and for the remaining operational test is delegated to the Science and Applications Directorate.

3.4 PHOTOGRAPHIC HARDWARE AND FILM DEVELOPMENT

The requirements for the cameras, lens, film and development processes in support of each of the detailed objectives and experiments are as defined below. Sensitometric data curves for each development process are on file in the MSC Photographic Technology Division/BL. B

	Objective or Experiment	Type Camera*	Lens	Type Film*	Development Process
4.1	Lunar Rover Vehicle Evaluation	LDAC	10 mm	CEX	Hi-Speed/ME-2A/γ=1.8 (D Log E Curve L of 6/7/71)
		HEDC	60 mm	HCEX	Houston/ME-4A/γ=1.6 (D Log E Curve N of 6/7/71)
4.2	EVA Communications with the LCRU/GCTA	None	--	--	--
4.3	EMU Assessment on Lunar Surface	DAC	10 mm	CEX	Hi-Speed/ME-2A/γ=1.8 (D Log E Curve L of 6/7/71)
		or			
		LDAC	10 mm	CEX	Hi-Speed/ME-2A/γ=1.8 (D Log E Curve L of 6/7/71)
4.4	LM Landing Effects Evaluation	HEDC	60 mm	HCEX	Houston/ME-4A/γ=1.6 (D Log E Curve N of 6/7/71)
4.5	SM Orbital Photographic Tasks	Mapping	3 inch	BW (3400)	Fultron/MX-819/γ=1.9 (D Log E Curve B of 6/7/71)
		Stellar	3 inch	BW (3401)	Hi-Speed/D-19/γ=1.9 (D Log E Curve D of 6/7/71)
		Panoramic	24 inch	LBW	Fultron/MX-819/γ=1.9 (D Log E Curve E of 6/7/71) B
4.6	CM Photographic Tasks	HEC	250 mm	LBW	Versamat/G4-L/γ=1.8 (D Log E Curve F of 6/7/71)
		HEC	250 mm	VHBW	Versamat/MX-641/γ=1.6 (D Log E Curve G of 6/7/71)
		HEC	250 mm	CEX	Hi-Speed/ME-2A/γ=1.8 (D Log E Curve M of 6/7/71)
		HEC	80 mm	VHBW	Versamat/MX-641/γ=1.6 (D Log E Curve G of 6/7/71)
		HEC	80 mm	CEX	Hi-Speed/ME-2A/γ=1.8 (D Log E Curve M of 6/7/71)
		HEC	80 mm	LBW	Versamat/G4-L/γ=1.8 (D Log E Curve F of 6/7/71)
		DAC	18 mm	VHBW	Hi-Speed/D-19/γ=1.9 (D Log E Curve H of 6/7/71)
		DAC	Sextant	VHBW	Hi-Speed/D-19/γ=1.9 (D Log E Curve H of 6/7/71)
		35	55 mm	VHBW	Hi-Speed/D-19/γ=1.6 (D Log E Curve I of 6/7/71)
4.7	SIM Thermal Data	None	--	--	---
4.8	SIM Bay Inspection During EVA	DAC	18 mm	CEX	Hi-Speed/ME-2A/γ=1.8 (D Log E Curve L of 6/7/71)
4.9	SIM Door Jettison Evaluation	None	--	--	--

	Objective or Experiment	Type Camera*	Lens	Type Film*	Development Process
4.10	LM Descent Engine Performance	None	--	--	--
4.11	Visual Observations from Lunar Orbit	None	--	--	--
4.12	Visual Light Flash Phenomenon	None	--	--	--
5.1	Contingency Sample Collection	DAC	10 mm	CEX	Hi-Speed/ME-2A/γ=1.8 (D Log E Curve L of 6/7/71)
5.2	Passive Seismic	HEDC	60 mm	HCEX	Houston/ME-4A/γ=1.6 (D Log E Curve N of 6/7/71)
5.3	Heat Flow	HEDC	60 mm	HCEX	Houston/ME-4A/γ=1.6 (D Log E Curve N of 6/7/71)
5.4	Lunar Surface Magnetometer	HEDC	60 mm	HCEX	Houston/ME-4A/γ=1.6 (D Log E Curve N of 6/7/71)
5.5	Solar Wind Spectrometer	HEDC	60 mm	HCEX	Houston/ME-4A/γ=1.6 (D Log E Curve N of 6/7/71)
5.6	Suprathermal Ion Detector and Cold Cathode Ion Gauge	HEDC	60 mm	HCEX	Houston/ME-4A/γ=1.6 (D Log E Curve N of 6/7/71)
5.7	Lunar Dust Detector	HEDC	60 mm	HCEX	Houston/ME-4A/γ=1.6 (D Log E Curve N of 6/7/71)
5.8	Lunar Geology Investigation	HEDC HEDC LDAC	60 mm 60 mm 10 mm	BW (3401) HCEX CEX	Versamat/MX-641/γ=1.4 (D Log E Curve C of 6/7/71) Houston/ME-4A/γ-1.6 (D Log E Curve N of 6/7/71) Hi-Speed/ME-2A/γ=1.8 (D Log E Curve L of 6/7/71)

B

Objective or Experiment	Type Camera*	Lens	Type Film*	Development Process
	HEDC	500 mm	BW(3401)	Versamat/MX-641/γ=1.4 (D Log E Curve C of 6/7/71)
5.9 Laser Ranging	HEDC	60 mm	HCEX	Houston/ME-4A/γ=1.6 (D Log E Curve N of 6/7/71)
5.10 Soil Mechanics	HEDC	60 mm	BW (3401)	Versamat/MX-641/γ=1.4 (D Log E Curve C of 6/7/71)
	LDAC	10 mm	CEX	Hi-Speed/ME-2A/γ=1.8 (D Log E Curve L of 6/7/71)
5.11 Gamma-Ray Spectrometer	Mapping	3 inch	BW (3400)	Fultron/MX-819/γ=1.9 (D Log E Curve B of 6/7/71)
	Panoramic	24 inch	LBW	Fultron/MX-819/γ=1.9 (D Log E Curve E of 6/7/71)
5.12 X-Ray Fluorescence	Mapping	3 inch	BW (3400)	Fultron/MX-819/γ=1.9 (D Log E Curve B of 6/7/71)
	Panoramic	24 inch	LBW	Fultron/MX-819/γ=1.9 (D Log E Curve E of 6/7/71)
5.13 Alpha Particle	Mapping	3 inch	BW (3400)	Fultron/MX-819/γ=1.9 (D Log E Curve B of 6/7/71)
	Panoramic	24 inch	LBW	Fultron/MX-819/γ=1.9 (D Log E Curve E of 6/7/71)
5.14 Subsatellite	DAC	75 mm	CEX	Hi-Speed/ME-2A/γ=1.8 (D Log E Curve L of 6/7/71)
5.15 Mass Spectrometer	Mapping	3 inch	BW (3400)	Fultron/MX-819/γ=1.9 (D Log E Curve B of 6/7/71)
	DAC	18 mm	BW (SO-164)	Houston/D-19/γ=1.7 (D Log E Curve K of 6/7/71)
5.16 Down-Link Bistatic Radar Observations of the Moon	Mapping	3 inch	BW (3400)	Fultron/MX-819/γ= 1.9 (D Log E Curve B of 6/7/71)
	Panoramic	24 inch	LBW	Fultron/MX-819/γ=1.9 (D Log E Curve E of 6/7/71)
5.17 UV Photography-Earth and Moon	HEC	105 mm (UV transmitting)	IIa-O	Hi-Speed/D-76/γ=0.9 (D Log E Curve J of 6/7/71)
	HEC	105 mm	CEX	Hi-Speed/ME-2A/γ= 1.8 (D Log E Curve M of 6/7/71)

B

	Objective or Experiment	Type Camera*	Lens	Type Film*	Development Process
5.18	Gegenschein from Lunar Orbit	35	55 mm	VHBW	Hi-Speed/D-19/γ=1.6 (D Log E Curve I of 6/7/71)
5.19	S-Band Transponder (CSM/LM)	None	--	--	--
5.20	Solar Wind Composition	HEDC	60 mm	HCEX	Houston/ME-4A/γ=1.6 (D Log E Curve N of 6/7/71)

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*Camera Nomenclature:

DAC - 16 mm data acquisition camera
HEC - 70 mm Hasselblad electric camera
HEDC - Hasselblad electric data camera (with reseau)
LDAC - Lunar surface 16 mm data acquisition camera (battery operated)
35 - 35 mm camera

**Film Nomenclature:

BW - Black and white (3400, 3401 and SO-164)
CEX - Color exterior (SO-368)
Deleted B
HCEX - High speed color exterior (SO-168)
LBW - Low speed, high definition black and white (3414)
VHBW - Very high speed black and white (2485)
IIa-0 - Spectroscopic

4.0 DETAILED OBJECTIVES

This section provides the necessary details for incorporation of the mission objectives into the flight plan, the criteria for data retrieval and data evaluation, and the criteria for determining that the mission objective was successfully accomplished.

Implementation of the objectives presented in this section is described in the following MSC documents.

a) LM Lunar Surface Checklist (covers touchdown to lift-off)

b) Lunar Surface Procedures (covers EVA period only)

c) Photographic and Television Procedures

d) Flight Plan

e) CMP Solo Book

f) Lunar Orbit Activities

g) Orbital EVA Procedures

An Apollo Time and Motion Study objective will be conducted to evaluate the differences, correlation, and relative consistency between ground-based and lunar surface task dexterity and locomotion performance. Preflight data will be collected on astronauts and other subjects using various ground-based simulators during training. Lunar surface data will consist of data acquisition camera film and video recordings of operational tasks or tasks in support of other objectives or experiments. No specific crew tasks are required to support this objective. The Medical Research and Operation Directorate will evaluate the film and television data in terms of time and motion patterns of astronaut performance. Subjective evaluations will be based on astronaut debriefing data.

4.1 LUNAR ROVER VEHICLE EVALUATION

Obtain data on the operational characteristics of the LRV in the lunar environment.

Purpose

The purpose is to verify mission planning assumptions pertaining to use of the LRV on the lunar surface.

The functional test objectives are as follows:

FTO 1) Demonstrate that the astronauts can deploy the LRV from the landed LM and prepare it for a traverse.

FTO 2) Obtain data on the time required to deploy, checkout and prepare the LRV for a traverse.

FTO 3) Obtain data on the operational characteristics of the LRV during traverses.

FTO 4) Obtain data on the LRV navigation subsystem characteristics.

FTO 5) Obtain data on the crew lunar surface visibility during LRV operations.

Test Conditions

FTO 1)
FTO 2) The crew will deploy and prepare the LRV systems for traverse.

FTO 3) The crew will perform the following functions:

a) Drive the LRV at average nominal speed on various type surfaces and at average emergency safe speed on the mare surface.

b) Report the following data from the LRV Control and Display Console at the indicated time:

	Beginning of each EVA	Beginning of each major science stop separated by at least 1 km	End of a long stop of 45 to 60 minutes on EVA 1 and EVA 2	At each stop during traverses when navigation update is required	End of each major traverse when LRV has returned to LM
Amp-Hr 1	X	X			X
Amp-Hr 2	X	X			X
Battery °F 1	X	X	X		X*
Battery °F 2	X	X	X		X*
Motor Temp:					
(Forward) °F L	X	X	X		X
(Forward) °F R	X	X	X		X
(Rear) °F L	X	X	X		X
(Rear) °F R	X	X	X		X
Heading (Deg)	X	X		X (End of stop)	X
Bearing (Deg)		X			X
Distance (km)		X			X
Range (km)		X			X
Pitch U or D (Deg)	X			X (Beginning of stop)	
Roll L or R (Deg)	X			X (Beginning of stop)	
Sun Shadow (Deg)	X			X (Beginning of stop)	

*These battery temperature measurements will be made both before opening the battery dust covers and as late as possible before ingress to the LM.

c) At the discretion of the crew when driving the LRV on various types of terrain during all EVA's, report simultaneous steady state readings of speed (km/hr), Amps 1 and 2 from the LRV Control and Display Console. In order to support the power consumption prediction for EVA 2 and 3, these readings should be obtained during the outbound trip of EVA 1, during travel along the Apennine Front and during the inbound trip of EVA 1.

d) Comment on the effects of lunar dust generated at various speeds on visibility and equipment.

e) Provide a qualitative evaluation of steering, braking and drive control.

It is highly desirable that the following photographs be obtained:

a) Sequence photographs of the LRV crossing craters or obstacles, steering and braking. (Note: The LDAC will be used at 24 frames per second and will be panned, except on one pass, to following the moving LRV from a fixed location on the lunar surface. For optimum lighting of the LRV wheel reference marks and of the lunar surface, the LRV direction of travel during the photographic sequences should be as shown in Figure 1.)

b) Deleted B

c) HEDC photographs of the LRV at the termination of each traverse to record dust accumulation.

FTO 4) The crew will align the navigation system at the initiation of the traverses, and will perform navigation updates approximately twice during each traverse at times selected by MCC. For the navigation update, the heading error will be corrected when it exceeds two degrees. B

FTO 5) The crew will report the capability to observe obstructions while operating the LRV up-sun, down-sun and cross-azimuth to the sun during the first, second and third EVA periods, respectively, to determine the effects of sun azimuth and elevation angles on viewing conditions.

Success Criteria

FTO 1) Sufficient data shall be obtained to evaluate the LRV deployment system and the capability of the crew to prepare the LRV for lunar surface operations.

FTO 2) Sufficient data shall be obtained to evaluate the crew's capability to perform the deployment, LRV equipment stowage, and LRV preparation within the allotted timelines.

FTO 3) Sufficient data shall be obtained to determine the average nominal safe speed capability of the LRV on various types of terrain and the average emergency safe speed capability on a mare surface. A

Sufficient data shall be obtained to determine the power requirements of the drive motors and the adequacy of thermal control for all vehicle elements. A

Sufficient data shall be obtained to determine the effects of lunar dust generation on crew visibility and mechanical LRV operations.

FTO 4) Sufficient data shall be obtained to evaluate the capability of the navigation subsystem to direct the crew back to the LM within 0.6 km. A

FTO 5) Sufficient data shall be obtained to assess the capability to discern and avoid obstructions at various sun azimuth and elevation angles while LRV operations are being conducted up-sun, down-sun, and at cross-azimuths.

Evaluation

FTO 1) The adequacy of the hardware and procedures to accomplish the LRV deployment, loading, and preparation for lunar surface operations will be determined. (Astronaut records, television data, and photographs)

FTO 2) The adequacy of the planned timeline for LRV deployment and preparation will be evaluated. (Astronaut records, television data, and photographs)

FTO 3) A qualitative evaluation of steering, braking, and drive control characteristics will be accomplished. The LRV average nominal and average emergency safe speeds, power requirements, and component heat build-up will be determined. The effects of dust on visibility and equipment will be determined. (Astronaut records and photographs)

FTO 4) The adequacy of the navigation system hardware and procedures for determining the LRV position relative to the LM will be evaluated. (Astronaut records)

FTO 5) The capacity of the crew to discern obstacles from the LRV at various sun azimuth and elevation angles will be evaluated. (Astronaut records)

Data Requirements

1) Astronaut Voice Records: (M)

a) GET at start and end of LRV deployment.

b) GET at start and end of LRV loading and preparation of LRV systems for traverse.

c) Length of time spent riding the LRV (each interval of each traverse).

d) Average nominal speed on various types of terrain and average emergency safe speed on a mare surface. A

e) Description of changes or modifications, if any, made in real time to the procedures being used to perform the EVA timelines related to the LRV.

f) Qualitative description of handling characteristics of the LRV during riding phase. A

g) Crew comments regarding capability of reading LRV panel instruments while riding.

h) Record of all LRV instrument readings as defined under Test Conditions for FTO 3). A

i) Crew comments regarding the effects of lunar dust on visibility while riding the LRV.

j) Crew comments on surface visibility and obstacle discernment capability for various sun positions while riding the LRV.

2) Television: (HD)

a) LRV deployment.

b) LRV loading.

c) LRV operation in vicinity of LM.

3) Still Photographs: (HD)

   a) Deleted

   b) Photograph(s) of the LRV at termination of each traverse to record dust accumulation.

4) Sequence Photographs: (HD)

   a) LRV crossing craters or obstacles, steering and braking.

   b) Deleted B

   c) LRV traveling at average nominal safe speed.

5) MCC record of GET to nearest second for each of the LRV instrument readings as defined under the Test Conditions for FTO 3). (M)

4.1 LUNAR ROVER VEHICLE EVALUATION

Background and Justification

It is estimated that on the planned traverses the LRV will transport two astronauts and payload at an average speed of approximately 8 km/hr, and at a lower metabolic consumables rate than required for walking. The LRV therefore provides the capability for longer traverses and more time for lunar exploration and scientific experiments. B

Data are available through simulation testing on earth to determine operational characteristics of the LRV; however, the affect of the lunar environment upon the LRV operations must be determined.

Data will be obtained to allow a determination of LRV average speeds, power consumed, component heating, navigation subsystem characteristics, and handling characteristics in the lunar environment.

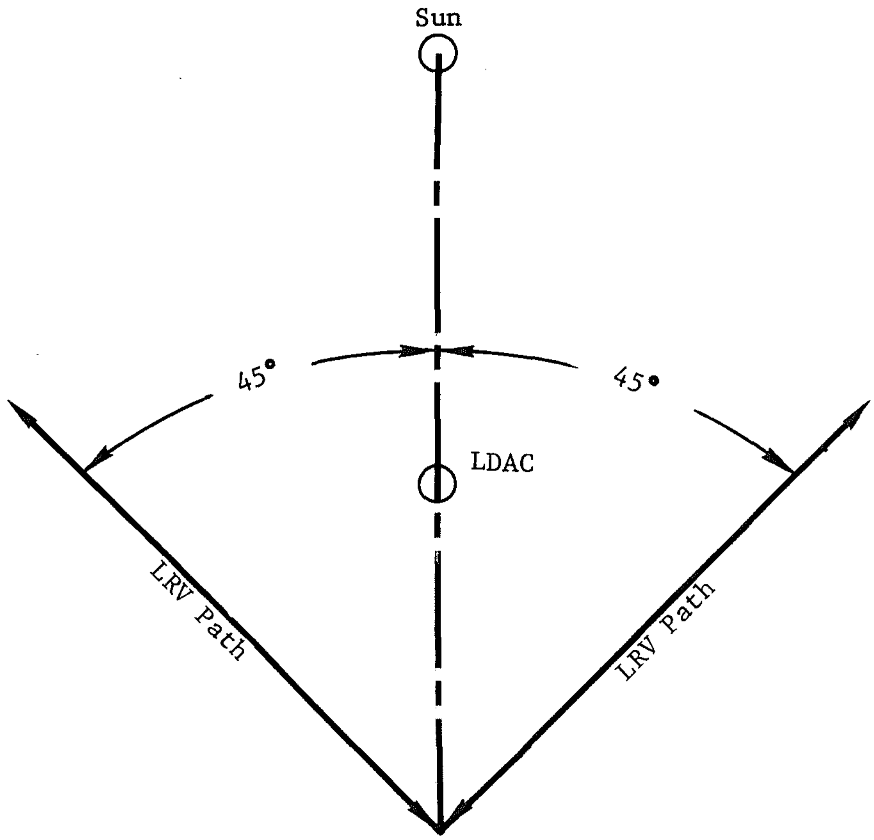
The sequence photographs of the LRV in motion will provide data for analysis of vehicle dynamics and wheel slippage. When the LDAC is being panned to follow the motion of the LRV, it will be necessary to have a distinguishable landmark (i.e., small crater or rock) in the field of view near the LRV to provide a frame-to-frame reference for the LRV motion. Holding the LDAC still on one pass will provide a reference for LRV motion in the remote possibility that distinguishable landmarks are not visible. B

Sufficient data will be obtained on this mission during the first EVA to allow an estimation of the maximum allowable traverses and LRV loading for the second and third EVA. In addition, the data obtained during all three EVA periods will be used to assist in planning traverses for subsequent Apollo J-Type missions.

The LRV will be used for the first time on Apollo Mission J-1.

Previous Flight Objectives

Objective Number	Title	Mission
None		



LRV direction of travel in either direction along either of these two tracks

B

Figure 1. Optimum LRV Direction of Travel During Sequence Photography

4.2 EVA COMMUNICATIONS WITH THE LCRU/GCTA

Operate the LCRU/GCTA during extended lunar surface exploration.

Purpose

The purpose is to demonstrate that the LCRU/GCTA will adequately support extended lunar surface exploration communications requirements.

The functional test objectives are as follows:

FTO 1) Demonstrate EVA-LCRU-MSFN voice/data and MSFN-LCRU-EVA voice communications, using the LCRU low gain and high gain S-band antennas.

FTO 2) Demonstrate television coverage by remote control of the GCTA by MSFN.

FTO 3) Demonstrate the capability to point the LCRU S-band high gain antenna, using the optical alignment, under varying light conditions.

FTO 4) Demonstrate the effectiveness of the LCRU radiator, thermal blanket and wax packages in maintaining thermal control of the LCRU.

FTO 5) Obtain data on the mechanical and thermal effects of the LCRU/GCTA and associated equipments when exposed to lunar dust.

Test Conditions

FTO 1) During lunar surface traverses using the LRV, and when not within RF line of sight of the LM, the normal voice/data downlink and voice uplink communications will be maintained using the LCRU low gain S-band antenna and the LCRU PM 1/WB mode. The secondary voice/data mode PM 1/NB, will be selected and the communications link established during the LCRU checkout prior to the first lunar surface traverse.

FTO 1)
FTO 2)
FTO 3) During science stops when RF line of sight to the LM does not exist and television coverage is planned, communications will be maintained by the EVA-LCRU/GCTA-MSFN using the LCRU high gain S-band antenna with the LCRU in the FM/TV mode. This mode will require optical alignment of the LCRU S-band high gain antenna and will provide downlink television and voice/data and uplink voice.

FTO 2) Following the last LRV traverse and prior to ingress, it is highly desirable that an astronaut drive the LRV eastward to a point approximately 0.1 kilometer from the LM, 180° from the launch azimuth, and park it facing at a heading of approxi- C mately 255 ±5 degrees as measured clockwise from north (i.e., 15 ±5 degrees south of west), with the TV camera on the northwest side and the high-gain antenna on the southeast side. It is highly desirable that the LRV be on high ground with a clear view of mountains to the east.

The astronaut will then configure the GCTA and LCRU to provide remote standby control of the television camera. The LCRU S-band high-gain antenna will be optically aligned. The astronaut will configure the LRV and LCRU to provide remote standby control of the television camera. This configuration requires that the LRV AUX CB be closed, the LCRU S-BD mode switch be in the TV-RMT position and the LCRU power switch be in the EXT position. MSFN will command the camera and the LCRU transmitter power ON prior to lift-off to provide coverage of the initial phase of the LM ascent, and to show the effects of the ascent engine plume on the descent stage and on the surrounding lunar surface.

After liftoff at 12:11 p.m., CDT, on 2 August and surveying the Hadley-Rille site for plume effects until 12:20 p.m., astronomical objects and nearby foreground objects will be viewed from 12:52 p.m., CDT, to 1:01 p.m.

On 4 August the camera will be used from 4:13 a.m., CDT, to 4:24 a.m. to view the lunar landscape and astronomical objects. This will be repeated from 1:00 a.m., CDT, to 1:11 a.m. on 5 August.

The eclipse of the sun by the Earth on 6 August will be viewed starting at 1:00 p.m., CDT, and ending at 4:10 p.m. In the early phases, brief views of the partially eclipsed sun will be interlaced with views of the lunar terrain; during totality (from 1:25 p.m., CDT, to 4:01 p.m.) the first 25 minutes will show the solar corona, zodiacal light, Earth-based lights, planets Venus, Mercury and Saturn, stars, and two views of the lunar surface. After 1:50 p.m., the view of the total eclipse will be continued to provide data on the Earth's atmosphere. C

On 7 and 8 August (and possibly on 9, 10, and 11 August, if TV reception remains good). The camera will be used to survey the lunar surface under western sunlight, and possibly to view fainter astronomical objects. The times of TV coverage will be from 5:00 a.m., CDT, to 5:23 a.m. on 7 August; from 12:32 a.m., CDT, to 12:48 a.m. on 8 August; from 5:00 a.m., CDT, to 5:25 a.m. on 9 August; from 6:00 a.m., CDT, to 6:25 a.m. on 10 August; and from 7:00 a.m., CDT, to 7:25 a.m. on 11 August.

FTO 4) Prior to, during and following each of the LRV traverses the LCRU thermal blanket will be positioned, as required, to provide thermal control.

FTO 5) During the lunar surface traverses, lunar dust may be deposited upon the LCRU/GCTA and associated equipments. A lunar dust brush will be used to remove any excessive dust deposits. The condition and extent of this dust deposit will be voice recorded by an astronaut. The telemetered LCRU thermal measurement will be recorded by MSFN.

Success Criteria

FTO 1) MSFN will record acceptable voice information from both astronauts as relayed by the LCRU.

Both astronauts will receive acceptable voice information from MSFN as relayed by the LCRU.

Valid EMU and LCRU telemetry data will be received by MSFN.

FTO 2) Television pictures of acceptable quality will be received by MSFN during the lunar surface science periods when television transmissions are planned.

Television pictures of the initial phase of the LM ascent from the lunar surface and the effect upon the descent stage and surrounding area will be received by MSFN and be of acceptable quality.

FTO 3) The optical alignment device shall allow the astronaut to point the LCRU S-band high gain antenna, under varying light conditions.

FTO 4) Thermal control of the LCRU will be maintained during and between LRV traverses.

FTO 5) Lunar dust deposited upon the LCRU and associated equipments will not cause excessive degradation of the thermal characteristic of the LCRU or produce mechanical problems in antenna deployment or pointings.

Evaluation

FTO 1) An assessment will be made of the voice quality for EVA-LCRU-MSFN and MSFN-LCRU-EVA. (Astronaut records and MSFN voice recordings)

The validity of the EMU telemetry data will be determined. (GT 9991 U)

FTO 1)
FTO 2)
FTO 3) An assessment will be made of the adequacy of procedures involved in the use of the LCRU and GCTA while on the lunar surface and in erecting and aligning the low and high gain antennas. (Astronaut records)

FTO 2) An assessment will be made of the general quality of MSFN video tape recordings to include the adequacy of TV camera design for remote controlled astrophysical and geophysical observations after LM ascent stage lift-off. Suggestions will be made for possible hardware modifications for Apollo Missions J-2 and J-3. An assessment will also be made of scientific data on earth's atmosphere and solar corona recorded during the eclipse, and of the potential scientific value of lunar surface surveys. (MSFN video tape recordings prior to and after the LM ascent stage lift-off)

FTO 4) An assessment will be made of the effectiveness of the LCRU radiator, wax packages and thermal blanket to maintain thermal control of the LCRU. (RT 8001 T)

FTO 5) The effects of lunar dust on the predicted thermal conditions of the LCRU will be assessed. (Astronaut records and RT 8001 T)

The effects of lunar dust on the mechanical properties of the LCRU/GCTA will be assessed. (Astronaut records)

Data Requirements

1) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority
GT 8100	EVCS No 1 Sync	FM/FM*	N/A	**
GT 8101 V	Volt, EVCS No 1 Calib 0 Pct	FM/FM*	N/A	**
GT 8102 V	Volt, EVCS No 1 Calib 100 Pct	FM/FM*	N/A	**
GT 8110 P	Press, PLSS Feed No 1 H_2O	FM/FM*	N/A	**
GT 8124 J	Electrocardiogram No 1	FM/FM*	N/A	**
GT 8140 C	PLSS Batt Curr No 1	FM/FM*	N/A	**
GT 8141 V	Volt, PLSS No 1 Battery	FM/FM*	N/A	**
GT 8154 T	Temp LCG H_2O Inlet No 1	FM/FM*	N/A	**
GT 8168 P	Press PGA O_2 No 1	FM/FM*	N/A	**
GT 8170 T	Temp PLSS No 1 Subl O_2 Outlet	FM/FM*	N/A	**
GT 8175 P	CO_2 Partial Press PLSS No 1	FM/FM*	N/A	**
GT 8182 P	Press PLSS O_2 Supply No 1	FM/FM*	N/A	**
GT 8196 T	Del T LCG H_2O In/Out No 1	FM/FM*	N/A	**
GT 8200	EVCS No 2 Sync	FM/FM*	N/A	**
GT 8201 V	Volt, EVCS No 2 Calib 0 Pct	FM/FM*	N/A	**
GT 8202 V	Volt, EVCS No 2 Calib 100 Pct	FM/FM*	N/A	**
GT 8210 P	Press, PLSS No 2 Feed H_2O	FM/FM*	N/A	**
GT 8224 J	Volt, PLSS No 2 EKG	FM/FM*	N/A	**
GT 8240 C	Curr, PLSS No 2 Battery	FM/FM*	N/A	**
GT 8241 V	Volt, PLSS No 2 Battery	FM/FM*	N/A	**
GT 8254 T	Temp, LCG No 2 H_2O Inlet	FM/FM*	N/A	**
GT 8268 T	Press, PGA No 2	FM/FM*	N/A	**
GT 8270 T	Temp, PLSS No 2 Subl O_2 Outlet	FM/FM*	N/A	**

Measurement Number	Description	TM	Mode	Priority
GT 8275 P	CO_2 Partial Press PLSS No 2	FM/FM*	N/A	**
GT 8282 P	Press, PLSS No 2 O_2	FM/FM*	N/A	**
GT 8296 T	Delta T, LCG No 2 H_2O In/Out	FM/FM*	N/A	**
GT 9991 U	EMU TM Outputs	FM/FM	N/A	M
RT 8001 T	Radiator Temperature	FM/FM	N/A	M

*These measurements are all part of measurement GT 9991 U.
**Any one of these measurements is M, others are HD.

2) Astronaut Voice Records in Real Time:

a) Comments on the adequacy of procedures involved in the use of the LCRU/GCTA and associated equipments. (M)

b) Record of GET anytime that lighting conditions degrade the ability to use the optical alignment device. (HD)

c) Comments on voice quality during MSFN-LCRU-EVA operations. (M)

d) Comment on lunar dust effects on mechanical properties of the LCRU and associated equipments (e.g., effects on ball joint assembly). (M)

3) MSFN recording of EVA-LCRU-MSFN voice. (M)

4) MSFN video tape recordings of television prior to LM ascent stage lift-off. (M) A

5) MSFN record of adequacy of the LCRU/GCTA to control the azimuth, elevation, zoom, power, iris and automatic light control of the television camera. (M) A

6) GET at beginning and end of each television transmission. (M)

7) Identity of the ground station(s) used to record video transmissions from the LCRU/GCTA. (M)

8) One copy of MSFN video tape recordings of all television after LM ascent stage lift-off. (HD) A

4.2 EVA COMMUNICATIONS WITH THE LCRU/GCTA

Background and Justification

Lunar surface communications will utilize the LCRU and GCTA which were not available in previous Apollo missions. A The LCRU will be used when the astronauts are not within RF line of sight of the LM and for periods of planned television coverage during the LRV traverses and will perform the communications functions normally performed by the LM during extravehicular activity.

The LCRU/GCTA will be stowed in the MESA of the LM. Prior to its use, it will be removed from the MESA and mounted on the LRV. Two LCRU S-band antennas will be used for transmission to MSFN. The LCRU low gain antenna will be used to transmit voice/data during periods when the LRV is in motion and during science stops not requiring television coverage. The LCRU high gain S-band antenna is composed of a parabolic reflector, feed, mounting fixtures and optical alignment device. It will be aligned by an astronaut when the LRV is stopped for science activity and television coverage is required. It provides a gain of approximately 23 db, and will be used for television and voice/data.

The LCRU VHF antenna is designed to radiate in a horizontal plane with omnidirectional azimuthal coverage. It will be deployed after the LCRU is mounted on the LRV and will be used to provide the astronaut-LCRU communications link.

The LCRU is battery operated with a backup mode of operating from the LRV batteries. A radiator, three wax packages and a thermal blanket are used to control the LCRU temperature.

The GCTA unit will be used primarily during the science stops for remote control by MSFN of the television camera. It will also be used to televise the initial phase of the ascent from the lunar surface to provide data on the effects of the ascent engine plume on the descent stage and surrounding lunar surface.

The total lunar eclipse of 6 August 1971 offers a unique advantage for observations from the lunar surface of the earth's atmosphere on the dark side during total eclipse of the sun. The solar corona, sunlight passing through 2000 miles of atmosphere, aurorae, and city lights in Australia, India, USSR, and Europe, will be of great public interest. Measured colors of the atmosphere in different latitudes will be of most scientific interest, together with the auroral activity and solar corona (viewed much longer than from ground-based telescopes). A

Quantitative colors of lunar rocks under different illumination (eclipsed sun and full sun angles of 64°, 38°, and 26°) may show layering or large differences in mineralogy over 300 or 400 square kilometers of lunar surface with resolution about 1.8 arc-minutes (about 3 feet at 1-mile distance).

The use of a 210-foot antenna for MSFN recording of the color television transmissions from the LCRU is highly desirable because the use of an 85-foot antenna would result in a negative margin of approximately 3 to 4 db.

Previous Flight Objectives

Objective Number	Title	Mission
None		

4.3 EMU ASSESSMENT ON LUNAR SURFACE

Assess EMU lunar surface performance, evaluate metabolic rates, crew mobility and difficulties in performing lunar surface EVA operation.

Purpose

The purposes are to demonstrate extravehicular mobility unit (EMU) performance on the lunar surface, evaluate metabolic rates and crew ability to accomplish lunar surface EVA operations.

The functional test objectives are as follows:

FTO 1) Demonstrate the capability of the EMU to provide a habitable environment during the EVA.

FTO 2) Demonstrate the capability of the EMU to provide sufficient mobility, dexterity and comfort to allow the crew to egress/ ingress the LM and perform useful work on the lunar surface.

FTO 3) Demonstrate the capability to recharge the PLSS while in the LM on the lunar surface.

FTO 4) Evaluate the capability of the crew to perform EVA tasks on the lunar surface.

FTO 5) Obtain data to provide an indication of the primary water reservoir usage.

FTO 6) Obtain data for determining the metabolic rates as a function of riding the LRV over different types of lunar surface.

Test Conditions

FTO 1)
FTO 2)
FTO 3)
FTO 4) Operational performance will be evaluated during scheduled EVA activities. No specific tasks are required other than those activities in support of the detailed objectives and experiments to be conducted on the lunar surface.

FTO 5) During each EVA period PLSS telemetry data from both crewmen will be used by MCC for real time prediction of EMU water remaining.

During each EVA period the crew will voice transmit to MCC when the low feedwater pressure warning signals come on.

FTO 6) During the EVA periods PLSS telemetry data from both crewmen and voice information concerning departure and arrival times between discrete points will be used for prediction of metabolic rates as a function of riding the LRV over different types of lunar surface. It is highly desirable that the pre-selected points be separated such that at least 6 minutes are required for the astronauts to ride from one point to another point. There is no requirement to maintain a constant or specific driving rate; however, it is highly desirable to obtain data for a period of at least 6 minutes with the LRV continuously in motion. There is no requirement for the riding traverse to be accomplished over any specific type of lunar surface.

In addition, it is highly desirable that the same type of data be obtained during any substantial period of walking traverse.

<u>Success Criteria</u>

FTO 1) The EMU shall provide a habitable environment for the extravehicular crewmen on the lunar surface.

Sufficient data shall be obtained to evaluate the performance of the -7 PLSS and to determine the consumables required to perform the EVA.

FTO 2) The lunar surface excursion will be accomplished and completed within the -7 PLSS consumables budget and time allowed. The EMU shall provide sufficient mobility, dexterity and comfort to allow the crew to egress/ingress the LM.

FTO 3) The PLSS recharge procedures and hardware interface shall be satisfactory to the crew.

The battery shall be replaced.

The LiOH cartridge shall be changed.

The oxygen system shall be filled to minimum pressure of 1380 pounds.

The primary and auxillary water reservoirs shall be filled.

FTO 4) Sufficient data shall be obtained to evaluate the astronaut's capability to unload storage compartments, deploy equipment and experiments, operate the TV and still cameras and gather surface samples while in the lunar surface EVA environment.

FTO 5)
FTO 6) Notification of when the low feedwater pressure warning signals come on and PLSS data required to determine metabolic rates shall be obtained along with crew comments and estimates.

Evaluation

FTO 1) The adequacy of the EMU to provide a habitable environment will be assessed. (Astronaut records, MSFN recording of EVA-LM-MSFN conference voice and GT 9991 U)

FTO 2) Mobility, dexterity and comfort of the crew will be assessed. (Astronaut records and TV coverage)

FTO 3) Initial conditions of the PLSS for recharge will be determined. (GT 9991 U)

The oxygen supply pressure available to accomplish the recharge will be determined. (GF 0584 P)

The availability of water to accomplish recharge will be determined. (GF 4501 P)

The quantity of water used to refill each PLSS will be determined from the change in descent stage water tank pressure. (GF 4501 P)

The adequacy of the hardware for battery and LiOH cartridge replacement will be determined. (Astronaut records)

The extent to which the fill was accomplished will be determined. (GT 9991 U)

FTO 4) The adequacy of the hardware and procedures to accomplish lunar surface EVA operations will be determined. (Astronaut records, photographs, TV and GT 9991 U)

FTO 5) The primary water reservoir usage during each EVA period, as determined by crew comment of when the low feedwater pressure warning signals come on, will be compared to the real time predictions. The results will be used to update the present real time prediction model. (Astronaut records, RTCC data, GT 8110 P, GT 8125 J, GT 8154 T, GT 8182 P, GT 8196 T, GT 8210 P, GT 8224 J, GT 8254 T, GT 8282 P and GT 8296 T)

FTO 6) The results will be used to determine metabolic rate as a function of walking rate and for riding on the LRV. (Astronaut records, RTCC data, topographical data, GT 8124 J, GT 8154 T, GT 8170 T, GT 8182 P, GT 8196 T, GT 8224 J, GT 8254 T, GT 8270 T, GT 8282 P and GT 8296 T)

Data Requirements

1) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority
GF 0584 P	Press, Descent O_2 Tank No 2	PCM	2	M
GF 4501 P	Press, Descent H_2O	PCM	1	M
GT 8100	EVCS No 1 Sync	FM/FM*	N/A	M
GT 8101 V	Volt, EVCS No 1 Calib 0 Pct	FM/FM*	N/A	M
GT 8102 V	Volt, EVCS No 1 Calib 100 Pct	FM/FM*	N/A	M
GT 8110 P	Press, PLSS Feed No 1 H_2O	FM/FM*	N/A	M
GT 8124 J	Electrocardiogram No 1	FM/FM*	N/A	M
GT 8140 C	PLSS Batt Current No 1	FM/FM*	N/A	M
GT 8141 V	Volt, PLSS No 1 Battery	FM/FM*	N/A	M
GT 8154 T	Temp, LCG H_2O Inlet No 1	FM/FM*	N/A	M
GT 8168 P	Press, PGA O_2 No 1	FM/FM*	N/A	M
GT 8170 T	Temp, PLSS No 1 Subl O_2 Outlet	FM/FM*	N/A	M
GT 8175 P	CO_2 Partial Press PLSS No 1	FM/FM*	N/A	M
GT 8182 P	Press, PLSS O_2 Supply No 1	FM/FM*	N/A	M
GT 8196 T	Delta Temp, LCG H_2O In/Out No 1	FM/FM*	N/A	M
GT 8200	EVCS No 2 Sync	FM/FM*	N/A	M
GT 8201 V	Volt, EVCS No 2 Calib 0 Pct	FM/FM*	N/A	M
GT 8202 V	Volt, EVCS No 2 Calib 100 Pct	FM/FM*	N/A	M
GT 8210 P	Press, PLSS No 2 Feed H_2O	FM/FM*	N/A	M
GT 8224 J	Volt, PLSS No 2 EKG	FM/FM*	N/A	M
GT 8240 C	Curr, PLSS No 2 Battery	FM/FM*	N/A	M
GT 8241 V	Volt, PLSS No 2 Battery	FM/FM*	N/A	M
GT 8254 T	Temp, LCG No 2 H_2O Inlet	FM/FM*	N/A	M
GT 8268 P	Press, PGA No 2	FM/FM*	N/A	M
GT 8270 T	Temp, PLSS No 2 Subl O_2 Outlet	FM/FM*	N/A	M
GT 8275 P	CO_2 Partial Press PLSS No 2	FM/FM*	N/A	M
GT 8282 P	Press, PLSS No 2 O_2	FM/FM*	N/A	M
GT 8296 T	Delta Temp, LCG No 2 H_2O In/Out	FM/FM*	N/A	M
GT 9991 U	EMU TM Outputs	FM/FM*	N/A	M

*Measurements GT 8100 through GT 8296 T are all parts of measurement GT 9991 U.

2) Astronaut Logs or Voice Records:

a) The crew will notify MSFN of the initial and final positions of the PLSS water diverter valve, primary oxygen shutoff valve, and water shutoff/relief valve each time they are changed. (M)

b) The crew will notify MSFN whenever the following PLSS remote control unit status indicators and audible warning tone come on. (M)

(1) High O_2 flowrate

(2) Low vent flow

(3) Low feed water pressure

(4) PGA pressure low

c) The crew will record EMU radiation dosimeter readings prior to and after completion of the extravehicular activities. (M)

d) The crew will notify MSFN whenever the following occur. (HD)

(1) Noxious odors, if any

(2) Condensation, if any, on the visor assembly

e) The crew will comment on their estimated energy expenditure and comfort as compared to their simulation experience. (HD)

f) Comments on the adequacy of procedures for oxygen refill, water refill, battery replacement and LiOH cartridge replacement. (M)

g) Comments on difficulties, if any, encountered during the use of LM and PLSS hardware for oxygen refill, water refill, battery replacement and LiOH cartridge replacement. (M)

h) Comments on the adequacy of hardware and procedures, and the time required to perform the egress from the LM, the lunar surface EVA operations and the ingress to the LM. Records may be obtained from postflight debriefings, from voice records recorded by MSFN, DSEA or DSE, or from written logs. (M)

i) Subjective comments on estimations of workload for EVA tasks. (HD)

j) Estimate of general surface conditions and maximum speed reached while riding the LRV between each set of discrete points. (M)

k) GET for departure and arrival times at discrete points in the riding traverse. (M)

l) GET for departure and arrival times at discrete points in any walking traverse. (HD)

m) GET for start and stop of any rest period during any riding traverse between discrete points. (M)

n) GET for start and stop of any rest period during any walking traverse between discrete points. (HD)

3) Sequence Photographs: (HD)

   a) A crew member descending to the lunar surface.

   b) A crew member walking on the lunar surface.

   c) A crew member performing lunar surface EVA operations.

4) Television: (HD)

   Ground recorded television signals of:

   a) A crew member descending to the lunar surface.

   b) A crew member performing lunar surface EVA operations to include:

      - Carrying and deploying the ALSEP
      - Mounting and demounting the LRV
      - Unstowing and preparing the LRV for traverse

   c) A crew member ascending the LM ladder and ingressing into the LM.

5) MSFN recording of EVA-LM-MSFN and EVA-MSFN conference voice. (M)

6) RTCC data: (M)

   RTCC data reduction of metabolic data for correlation to water flow data.

7) Topographical data: (M)

   Distance and terrain profile between the selected points in the traverse as determined from photomaps.

4.3 EMU ASSESSMENT ON LUNAR SURFACE

Background and Justification

This objective is essential on the mission since the success of the lunar surface operations is dependent on the capability of the extra-vehicular mobility unit to provide the astronauts a habitable environment. This is the first time the -7 PLSS's and the A7LB PGA will be used on the lunar surface.

The -7 PLSS is similar to the -6 PLSS with the following additions:

- Increased charge pressure and capacity of O_2. The initial nominal charge pressure is increased from 1020 psia to 1410 psia for a useable O_2 quantity of 1.35 pounds, as opposed to 0.96 pounds. A
- Increased H_2O capacity from 7.39 to 10.86 pounds. A
- Increased battery capability from 5.67 to 7.5 hours of PLSS operation.
- Increased LiOH

The LM recharge station has been modified to provide a regulated minimum output O_2 pressure at 1380 as compared to the previous 980. However, after the O_2 reservoir is depleted below 1380 psia the regulator locks up.

The A7LB PGA contains modifications to the A7L PGA as follows:

- Addition of a joint in the neck area to improve mobility and downward visibility.
- Addition of a bellows joint in the waist to allow forward bending mobility.
- Addition of a total bladder and convolute abrasion reinforcement to increase gas retention layer mobility.
- Movement of the torso zipper from the crotch to the chest area necessitated by the waist bellows. This results in better leg mobility.
- Modification of the shoulder area to reduce torque requirements for shoulder movement.
- Addition of a thumb joint for greater grasping ability.

- Enlargement of the wrist ring to permit easier and faster glove donning and doffing.
- Increase of the available liquids to be used for drinking.

One PLSS was recharged on Apollo 9 in an earth orbit zero-g environment with no problems reported. Although the mission provided flight experience it was not the -7 PLSS and it did not provide the combination of environmental factors experienced during a lunar surface PLSS recharge.

Apollo 11 and 12 missions provided data on metabolic rate and EMU operation during the lunar surface exploration, emplacement of experiments and performance of other lunar surface EVA tasks. Apollo Mission 12 provided additional data on recharging two PLSS's in the confinement of the LM cabin following an EVA on the lunar surface. However, both the PGA, PLSS and LM recharge stations have been modified from those used for Apollo Missions 11 and 12.

The major concern of the EMU is the heat loads that will be handled by the portable life support system (PLSS) which involve the removal of metabolic and equipment heat generated within the space suit system plus removal of thermal inputs from the lunar environment. The PGA designated for this mission (i.e., A7LB) has been designed to withstand PGA surface temperatures that will be encountered during extended EVA periods on the lunar surface. The portable life support system has also been designed to handle 300 BTU/hr heat leak inward over and above the anticipated crewman's metabolic rate.

Data obtained by this objective will enhance the planning of future missions and provide increased confidence in the models used for prediction of metabolic rates and EMU operation. The crew's ability to perform various EVA tasks and the expected time to perform these tasks will be determined for future missions.

Previous Flight Objectives

Objective Number	Title	Mission
20.35	Extravehicular Activity	9
14	LM ECS Performance	9
B	Lunar Surface EVA Operation	11
C	EMU Lunar Surface Operations	11
C	PLSS Recharge	12

4.4 LM LANDING EFFECTS EVALUATION

A

Obtain data on the lunar landing of the LM.

Purpose

The purpose of this objective is to evaluate the J-Mission modifications and the landing performance under lunar landing conditions.

The functional test objectives are as follows:

FTO 1) Determine the LM landing gear stroking performance for the modified LM.

FTO 2) Determine the effects of a lunar landing on specific structure and components.

FTO 3) Determine the condition of the descent engine skirt and the skirt ground clearance after lunar landing.

Test Conditions

FTO 1) Telemetry data will be obtained on spacecraft attitude and on vertical and lateral motion at touchdown. Crew observations and photographs of the LM landing gear will be obtained after landing.

FTO 2) After lunar landing, specific structure and components will be examined to determine the effects of the lunar landing environment. The data will include photographs and comments on the condition of the descent stage heat shield, the LRV retaining structure and deployment mechanism, the MESA and the modified RCS plume deflectors.

FTO 3) Data will be obtained on the descent engine skirt condition after touchdown.

Success Criteria

FTO 1) Data shall be obtained on the performance of the LM landing gear under the imposed lunar landing conditions.

FTO 2) Data shall be obtained to determine the lunar landing effects on specific structure and components.

FTO 3) Data shall be obtained to determine the condition of the descent engine skirt after a lunar landing.

Evaluation

FTO 1) LM landing gear stroking will be determined. (Astronaut records and photographs)

Foot pad-soil interaction will be determined. (Astronaut records and photographs)

Lunar surface characteristics at the landing site will be determined. (Astronaut records and photographs)

FTO 1)
FTO 2)
FTO 3) Touchdown conditions will be determined from lunar approach trajectory data, descent engine performance, RCS thrust and vehicle inertia properties. (LM moments of inertia, GG 0001 X, GG 2112 V, GG 2113 V, GG 2142 V, GG 2143 V, GG 2172 V, GG 2173 V, GH 1313 V, GH 1314 V, GH 1418 V through GH 1433 V, GH 1416 V through GH 1463 V, GQ 6510 P and GQ 6806 H)

FTO 2) The condition of the descent stage heat shield will be determined. (Astronaut records and photographs)

Data on the deployment of the LRV will be evaluated for lunar landing effects. (Astronaut records and photographs)

The effects of lunar landing on the MESA will be determined. (Astronaut records and photographs)

The effects of a lunar landing on the LM structure (including the modified RCS plume deflectors) will be determined. (Astronaut records, photographs and GH 1418 V through GH 1433 V)

FTO 3) The condition of the descent engine skirt after a lunar landing will be determined. (Astronaut records and photographs)

The descent engine skirt ground clearance after a lunar landing will be determined. (Astronaut records and photographs)

Data Requirements

1) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority
GG 0001 X	PGNS Down Link Data (To T/M)	PCM	1	M
GG 2112 V	Volt, IG 1X Res Output, Sin	PCM	1	M
GG 2113 V	Volt, IG 1X Res Output, Cos	PCM	1	M
GG 2142 V	Volt, MG 1X Res Output, Sin	PCM	1	M
GG 2143 V	Volt, MG 1X Res Output, Cos	PCM	1	M
GG 2172 V	Volt, OG 1X Res Output, Sin	PCM	1	M
GG 2173 V	Volt, OG 1X Res Output, Cos	PCM	1	M

Measurement Number	Description	TM	Mode	Priority
GH 1313 V	Volt, Pitch GDA Pos (Ret/Ext)	PCM	2	M
GH 1314 V	Volt, Roll GDA Pos (Ext/Ret)	PCM	2	M
GH 1418 V	Volt, Jet No 4U Driver Output	PCM	1	HD
GH 1419 V	Volt, Jet No 4D Driver Output	PCM	1	HD
GH 1420 V	Volt, Jet No 4F Driver Output	PCM	1	HD
GH 1421 V	Volt, Jet No 4S Driver Output	PCM	1	HD
GH 1422 V	Volt, Jet No 3U Driver Output	PCM	1	HD
GH 1423 V	Volt, Jet No 3D Driver Output	PCM	1	HD
GH 1424 V	Volt, Jet No 3F Driver Output	PCM	1	HD
GH 1425 V	Volt, Jet No 3S Driver Output	PCM	1	HD
GH 1426 V	Volt, Jet No 2U Driver Output	PCM	1	HD
GH 1427 V	Volt, Jet No 2D Driver Output	PCM	1	HD
GH 1428 V	Volt, Jet No 2F Driver Output	PCM	1	HD
GH 1429 V	Volt, Jet No 2S Driver Output	PCM	1	HD
GH 1430 V	Volt, Jet No 1U Driver Output	PCM	1	HD
GH 1431 V	Volt, Jet No 1D Driver Output	PCM	1	HD
GH 1432 V	Volt, Jet No 1F Driver Output	PCM	1	HD
GH 1433 V	Volt, Jet No 1S Driver Output	PCM	1	HD
GH 1461 V	Volt, Yaw RG Sig (.8 KC)	PCM	2	M
GH 1462 V	Volt, Pitch RG Sig (.8 KC)	PCM	2	M
GH 1463 V	Volt, Roll RG Sig (.8 KC)	PCM	2	M
GQ 6510 P	Press, Thrust Chamber	PCM	2	M*
GQ 6806 H	Pos, Variable Injector Actuator	PCM	2	M*

*One measurement is mandatory, the other is highly desirable.

Telemetry measurements GH 1418 V through GH 1433 V are desired during the entire landing operation. The remaining measurements are required only for the period immediately prior to touchdown until the LM comes to rest.

2) Astronaut Logs or Voice Records: (M)

a) Comments on any lunar dust observed during the final approach, the severity of the landing and vehicle stability after touchdown.

b) Comments on observations of slope and roughness of the landing terrain.

c) Comments describing any descent engine skirt damage and an estimate of any skirt ground clearance.

d) If for any reason the landing gear strut assembly photographs cannot be obtained, an estimate of the amount of stroking of each primary and secondary strut assembly will be made.

e) Comments on LM foot pad-lunar soil interactions to include estimates of the amount of penetration, soil displacement and foot pad skidding, if any.

f) Comments on the condition of the descent stage heat shield.

g) Comments on LRV stowage conditions and on mechanism used for LRV deployment.

h) Comments on the condition of the MESA.

i) Comments on the condition of the added support fittings for the modified RCS plume deflectors on Quads 1 and IV.

3) Photographs:

a) Photographs of the landing gear to show the stroking of the primary and secondary strut assemblies. One photograph is required for each of the eight secondary strut assemblies and the adjoining primary strut assembly. (The line of sight from the camera should be approximately perpendicular to the plane containing the strut assembly.) Each field of view should be as small as possible but should include all of the secondary strut assembly and all of the primary strut assembly at and below the attachment of the secondary assembly. In addition, these members must be photographed prior to the mission. (M)

b) Photographs of the LM exterior showing any structural damage. (M)

c) Photographs of each landing gear assembly along the Z axis and the Y axis. (HD)

d) Photographs of the descent engine skirt. (HD)

e) Photographs of the LM base heat shield before earth launch and after lunar landing. (HD)

f) Photographs of each LM foot pad and surrounding lunar soil exhibiting evidence of LM foot pad-lunar soil interaction. (HD)

4) LM mass, center of gravity and mass moment of inertias at touchdown as determined from preflight measurement and consumable usage. (M)

4.4 LM LANDING EFFECTS EVALUATION

A

Background and Justification

The data gathered will be correlated with dynamic analysis, drop test results and crushing tests to provide the necessary information to allow evaluation of the modified LM landing performance.

The LM 10 touchdown weight increase of approximately 1570 pounds (as compared to a typical H-series LM) and the increased length of the descent engine skirt are major changes which affect landing performance.

LM modifications that may be related to landing effects are as follows:

a) Propulsion:

- Increase the usable propellant by approximately 1140 pounds.
- Increase the supercritical helium load pressurization to 51.2 pounds and the pressurization standby time to 183 hours.
- Increase the descent engine nozzle extension width, and change the chamber material.

b) Ascent stage:

- Strengthen the mid-section deck for a third sample return container.
- Add support fittings for modularized stowage assemblies.

c) Descent stage:

- Redesign the descent stage structure to accommodate the larger propellant tanks.
- Add one descent stage battery and mount all five batteries on -Z bulkhead cold rails. Provide thermal protection for the battery installation.
- Provide a redesigned MESA support structure to accommodate a larger MESA.

- Provide scientific payload support, attach points and release mechanism in quadrant I for a LRV. (Support and deployment mechanism interface for an ALSEP-type payload will be retained in quadrant II).
- Provide a cold rail in quadrant IV for pyro battery mounting.
- Relocate the thermal insulation in quadrant I.
- Revise and add fluid and electrical line runs.
- Relocate the explosive devices relay box, pyro battery and GOX control module.
- Modify the RCS plume deflectors in quadrants I and IV and reduce exterior insulation to reduce weight.
- Add support structure and provide new H_2O and GOX tanks.

Pressures and temperatures imposed by the extended descent engine skirt may adversely affect the base heat shield structure and may cause adverse lunar surface erosion. Surface fragments could cause damage to the LM shielding and cabin pressure shell and dust may obscure astronaut visibility during landing.

Previous Flight Objectives

Objective Number	Title	Mission
17.9	Landing Gear Deployment/Thermal	9
D	Landing Effects on LM	11

4.5 SM ORBITAL PHOTOGRAPHIC TASKS

Obtain lunar surface photographs and altitude data from lunar orbit.

Purpose

The purpose is to obtain high resolution panoramic and high quality metric lunar surface photographs and altitude data from lunar orbit to aid in the overall exploration of the moon. A

The functional test objectives in order of priority are as follows:

FTO 1) Obtain high resolution panoramic photographs with stereoscopic and monoscopic coverage of the lunar surface. A

FTO 2) Obtain high quality metric photographs of the lunar surface and stellar photographs exposed simultaneously with the metric photographs. A

FTO 3) Obtain data on the altitude of the CSM above the lunar surface. A

Test Conditions

FTO 1)
FTO 2)
FTO 3) The three functional test objectives will be accomplished using the 24-Inch Panoramic Camera, 3-Inch Mapping Camera, and Laser Altimeter, respectively. To avoid contamination, liquid dumps (urine and waste water) and fuel cell purges will be prohibited for 3 hours prior to and during equipment operation, and RCS jets A2, A4, B1, and B4 will be disabled during equipment operation. All CSM maneuvers performed after jettisoning of the SIM door and prior to the end of the orbital science experiment period will be done in such a manner as to prevent direct sunlight from impinging on the camera lenses or the altimeter photocell. During periods of lunar surface photography using these instruments, the CSM attitude will be controlled to prevent direct sunlight from impinging on the camera lenses. A

FTO 1)
FTO 2) The fields-of-view (FOV) of both cameras will be unobstructed by booms during operation. A

Experiments which are deployed on booms will be retracted such that they cannot reflect light onto the camera lenses during periods of photography in support of this detailed objective, with one allowable exception. On one photographic sequence (i.e., revolution number 69) of the 3-Inch Mapping Camera, the Gamma Ray Spectrometer may be retracted only until it is out of the optical field of view. During camera operation, the SIM bay will be nadir-aligned (except where identified otherwise in Table 2) with the CSM +X axis directed along the velocity vector. The in-flight pointing accuracy requirements are ±2.5 degrees about all axes for the 24-Inch Panoramic Camera and ±2.0 degrees about all axes for the 3-Inch Mapping Camera, with no more than 0.05 degrees per second drift while the cameras are in operation. Postmission pointing knowledge requirements are ±2.0 degrees about all axes for both cameras. When the 24-Inch Panoramic Camera is operated, it is highly desirable that the 3-Inch Mapping Camera be operated concurrently. On at least one light side pass in support of the 24-Inch Panoramic Camera in which the western terminator is photographed, the 3-Inch Mapping Camera will be retracted 6 minutes prior to the western terminator. Initial warm-up of the Mapping Camera and Panoramic Camera will be in accordance with Paragraphs 3.7.3.4.1 and 3.4.3.4.1 of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Volume VI, CSM Experiments Data Book for J-Missions. Following completion of all photography, the crew will perform an EVA and retrieve film cassettes from both cameras and stow them in the CM. B

FTO 1) The 24-Inch Panoramic Camera will be operated during portions of lunar orbit light side passes in accordance with Table 1. The first of these will be conducted during a 60 x 170 nautical mile orbit and the second will be conducted during a 60 x 8 nautical mile orbit, overlapping the ground-track coverage of the first sequence. The remainder of the Panoramic Camera sequences will be conducted from 60 nautical mile circular orbits. The last sequence will finish at the western terminator of the last available orbit. The maximum Panoramic Camera sequence duration during a single light side pass will be no more than 30 minutes.

The Panoramic Camera will be used in the monoscopic mode for all photography between each terminator and 10 degrees from that terminator. The automatic exposure control of the Panoramic Camera will be tuned during the mission. B

FTO 2) The 3-Inch Mapping Camera will be operated in accordance with the requirements of Table 2. Concurrent operation of the Laser Altimeter is required except during oblique Mapping Camera passes. Mapping Camera operation on dark side passes, as indicated in Table 2, is required for the purpose of providing attitude data for the Laser Altimeter. The V/h bias for the Mapping Camera may be changed in real time following an evaluation of telemetry data at the MCC. B

FTO 3) The Laser Altimeter will be operated as specified in Table 3, which includes concurrent Laser Altimeter/Mapping Camera operation and independent Laser Altimeter operation. The Laser Altimeter will operate whenever the Mapping Camera is operating. B

For Laser Altimeter operation, the SIM bay will be nadir-aligned, except during portions of concurrent Laser Altimeter/Mapping Camera operation as indicated in Table 2. In-flight pointing accuracy requirements are ±2.0 degrees about all axes, with no more than 0.05 degrees per second drift. Pointing knowledge must be recoverable post-mission to within ±2.0 degrees about all axes. For highly desirable periods of Laser Altimeter operation, the inflight pointing accuracy requirements is ±6.5 degrees about all axes.

Success Criteria

FTO 1)
FTO 2)
FTO 3) Mandatory data defined under Data Requirements shall be acquired and returned to earth for evaluation.

Evaluation

FTO 1)
FTO 2) Photographs taken by the 3-Inch Mapping Camera, with the boom-mounted Gamma Ray Spectrometer retracted such that it cannot reflect light onto the camera lenses, will be compared with similar photographs taken while the boom-mounted Gamma Ray Spectrometer is retracted only until it is out of the optical field of view of the cameras. This comparison will permit a determination of the amount of veiling glare on the camera lenses due to sunlight reflected from the Gamma Ray Spectrometer. B

FTO 1)
FTO 2)
FTO 3) The photographic and altitude data will be evaluated to determine its suitability for operational and scientific applications. (Premission, experiment support, and experiment evaluation data as defined under Data Requirements)

Data Requirements

1) Premission Data (PD):

Premission sensitometry of the flight films in accordance with the standard procedures of the Photographic Technology Division. (M) B

2) Experiment Support Data (ESD):

Telemetry Measurements:

Telemetry measurements listed under 3)a). Display preference is indicated by (A) for analog and (D) for digital. B

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority PD*	ESD	EED
SL 1030 V	Pan Camera V/H Command Voltage	PCM	1		M(A)	HD
SL 1032 T	Pan Camera Film Mag Temp	PCM	1		HD	HD
SL 1038 H	Pan Camera Exposure Command	PCM	1		M	HD
SL 1039 T	Pan Camera Lens Barrel Temp	PCM	1		HD	HD
SL 1040 T	Pan Camera Fwd Lens Temp	PCM	1		HD	HD
SL 1041 T	Pan Camera Aft Lens Temp	PCM	1		HD	HD
SL 1042 T	Pan Camera Mech Temp	PCM	1		HD	HD
SL 1044 H	Pan Camera Slit Width	PCM	1		M(A)	HD
SL 1094 T	Laser Altimeter Cavity Temp	PCM	1		HD	HD
SL 1122 K	Laser Altimeter Output 24 Bit Ser	PCMD	1		M(D)	M B
SL 1160 T	Temp Metric Lens Front Element	PCM	1		HD	HD
SL 1161 T	Temp Metric Lens Barrel	PCM	1		HD	HD
SL 1162 T	Temp Stellar Lens Front Element	PCM	1		HD	HD
SL 1163 T	Temp Stellar Lens Barrel	PCM	1		HD	HD
SL 1164 T	Temp MC Supply Cassette	PCM	1		HD	HD
SL 1165 X	MC Image Motion Off/On Cmds	PCME	1		HD	HD
SL 1166 R	Metric Shutter Disc Speed	PCM	1		M	HD
SL 1173 X	Film Motion/Metric Exposure	PCME	1		HD	HD
SL 1176 Q	Metric Film Remaining	PCM	1		HD	HD
SL 1177 X	MC Cycle Rate/Metric Shtr Ctr Exp	PCME	1		HD	HD
SL 1181 V	Map Camera V/H Increase Level	PCM	1		M	HD

*There are no requirements for premission data (PD).

b) Telemetry Measurement Tapes:

One copy of tape** containing EED telemetered measurements listed under 3)a), recorded and correlated with GMT during periods of equipment operation.

c) Astronaut Logs or Voice Records: (HD)

One copy of astronaut logs or voice records containing the description and GET of manual control settings for the 24-Inch Panoramic Camera, the 3-Inch Mapping Camera, and the Laser Altimeter.

d) Astronaut Debriefings: (HD)

Two copies of astronaut postmission scientific and photographic debriefing transcripts pertaining to operation of the SIM bay cameras and the Laser Altimeter. B

e) Photographs: (M)

Five sets of Panoramic and Mapping Camera Photographs. B

f) Two copies of microfilm containing the output of the Apollo Photographic Evaluation (APE) program for the periods of operation of the SIM bay cameras and the Laser Altimeter. (M) B

g) Supporting Data: (HD)

(1) One copy of Laser Altimeter record listing of SL 1122 K. B

(2) One hard copy listing of the tapes listed under 3)b) and 3)f).

(3) One copy each, 16 mm microfilm of tape digital hard copy listing of tapes listed under 3)b) and 3)f).

**Magnetic tape produced is to be UNIVAC 1108 computer-compatible digital 7-track, 800-BPI tapes.

Background and Justification

24-Inch Panoramic Camera [FTO 1)]: A

The scientific productivity of manned landing missions can be enhanced by further photographs to complement and fill gaps in coverage obtained by earlier photographs. At lower altitudes, the Lunar Orbiter photographs provided limited film coverage, and at higher altitudes the resolution was insufficient for detailed analysis of the surface. Lunar Orbiter IV photography was generally poor in many areas east of about 40 degrees E. No satisfactory sites were photographed in the southern highlands.

A

Also, an insufficient number of near normal sun incidence photographs were obtained from the Lunar Orbiter. These photographs are necessary to study albedo variations necessary for geological classification of features.

The panoramic camera will have the capability of providing high resolution (1 to 2 meters) photographs for all areas overflown by the spacecraft during light side passes. This resolution will permit detailed geologic interpretation and classification of terrain characteristics. It will also support interpretation of the significance of other geochemical and geophysical experiments.

3-Inch Mapping Camera [FTO 2)]: A

For many years, positions of lunar features have been derived from earth-based observations. These observations have led to positional accuracies of some features on the near side of the moon on the order of 1000 meters. However, a number of recent reductions of Lunar Orbiter photography have shown inconsistencies of 1-5 kilometers in the positions of some features.

The Lunar Orbiter series, plus the Ranger series, have already provided a considerable amount of photographic detail of the moon. Although these photographs were obtained with a variety of resolution limits better than those obtained from earth-based observations, there was no plan for establishing a geodetic network and a cartographic display of the entire lunar surface. Because of limited stereoscopic coverage and errors introduced in the scanning, transmission and reconstruction of the film, the Orbiter photography does not provide a consistent base for cartographic and geodetic information.

A lunar geodetic network can only be achieved through use of photogrammetry. If the network is constructed piece-by-piece through use of strips of photographs from a succession of lunar missions, orbital and attitude information becomes increasingly important in the data reduction. Since there is no adequate ground control on the moon, control must be derived from the orbit. Attitude information must be derived from either stellar cameras or other auxiliary sensors.

Orbital theory subsequently becomes important, in conjunction with photogrammetry, for determining the gravity potential of the moon. Photogrammetric conditions between parallel passes of photography provide consistent positions of points on the lunar surface in a unified coordinate system. The corresponding positions of the exposure stations then become accurately known points on the spacecraft ephemeris. Variations in the orbital elements then serve to determine the spatial variations in the gravity field.

The mapping camera photographs will provide a means for establishing a lunar geodetic network. The extent of coverage will depend largely on the type of mission on which the experiment is flown. The ideal situation is to obtain complete lunar coverage so that a single photogrammetric adjustment of the entire lunar sphere can be performed. This network would fulfill all foreseeable requirements for positional reference on the moon, and would form the basis for subsequent photogrammetric determination of the gravitational field. The network is also essential to the utilization of the panoramic photographs for topographic mapping.

The mapping camera photographs will also form the basis of specialized cartographic maps, which will provide additional data on the form, distribution, and relative abundance of major lunar surface features, and provide terrain profile information that may assist in planning subsequent lunar exploration missions. Mapping camera photography will also support the A reduction of data from other lunar orbital experiments: Gamma-Ray Spectrometer (S-160), X-Ray Fluorescence (S-161), UV Photography-Earth and Moon (S-177), and Mass Spectrometer (S-165).

Laser Altimeter [FTO 3)]:

The determination of the lunar gravitational field from analysis of the Lunar Orbiter tracking data was of great importance to the study of the moon's structure and evolution. These data, in fact, resulted in the discovery of the mascons. However, the lack of accurate lunar topographic elevations makes it difficult to draw inferences as to the moon's internal structure because the contribution to the lunar gravitational field of the visible topography cannot be subtracted out accurately. Also, the spectrum of the long wave variations in topography is of significance to the study of the lunar structure itself.

Previous determinations of lunar topography from photographs taken by terrestrial telescopes have errors of several hundred meters in elevation.

The altitudes determined by laser data will be used with earth tracking data to determine the orbits of the Apollo spacecraft more accurately. The topographic variations will then be determined by subtracting the laser-measured altitudes from the orbital radial coordinates. This procedure should yield a measure of the topographic variations to within an accuracy approaching that of the instrument, because the wavelengths of topographic variations are much shorter than the wavelengths of variations in the error of the radial coordinates of the orbit.

The operation of the Laser Altimeter in the independent or Automatic Mode (i.e., when the Mapping Camera is OFF) will result in altitude data at a frequency of 3 data points per minute. The operation of the Laser Altimeter in the synchronized or Camera Mode (i.e., when the Mapping Camera is ON) will result in altitude data at a frequency of 2.50 data points per minute. In order to provide data with cross-track separation less than or approximately equal to down-track separation, the Laser Altimeter should be operated at least every second orbit as identified in Table 3. B

The laser altitudes will be coordinated with photographs taken with the 3-Inch Mapping Camera and will be used in the establishment of the control point network.

The amount of veiling glare on the SIM camera lenses, due to sunlight reflected from the Gamma Ray Spectrometer in a partially extended position boom-mounted, will be assessed by a comparison of 3-Inch Mapping Camera photographs taken with and without the conditions for possible glare production. Each sequence of photographs to be compared will be a full light side pass in order to encounter the complete range of sun incidence angles on the surfaces of boom-mounted instruments. This comparison will provide direct information as to the amount of veiling glare from these instruments, information which cannot be obtained from earth-based observations. This will determine the necessity, if any, for complete retraction of the boom-mounted Gamma Ray Spectrometer during operation of the SIM cameras in future Apollo missions. B

Previous Flight Objectives

Objective Number	Title	Mission
None		

Table 1. Photographic Requirements for the 24-Inch Panoramic Camera

Revolution Number*	Start Longitude (Degrees)	Stop Longitude (Degrees)	Camera Mode
2	Deleted		
4	179.5 W**	170.5 E	Mono
	170.5 E	142.5 E	Stereo
14	Deleted		
15	144.5 E	100.0 E	Stereo
	100.0 E	82.0 E	Mono
	82.0 E	74.0 E	Stereo
16	76.0 E	1.8 W	Stereo
	1.8 W	11.8 W***	Mono
22	Deleted		
27	5.7 E	1.7 E	Stereo
33	67.5 E	23.0 E	Stereo
38	134.0 E	77.5 E	Stereo
	77.5 E	65.5 E	Mono
	5.7 E	1.7 E	Stereo
50	5.7 E	0.3 W	Stereo
52	Deleted		
58	126.5 E**	116.5 E	Mono
	116.5 E	69.0 E	Stereo
	69.0 E	53.0 E	Mono
	53.0 E	36.5 E	Stereo
59	38.5 E	0.0	Stereo
	44.9 W	54.9 W***	Mono
70	42.0 E	20.0 E	Stereo
72	22.0 E	57.9 W	Stereo
	57.9 W	67.9 W***	Mono
73	Deleted		

*Revolution 4 is a 60 x 8 NM orbit; all other revolutions indicated in the table are 60 NM circular orbits.

**Eastern terminator

***Western terminator

Table 2. Photographic Requirements for the 3-Inch Mapping Camera

Revolution Number	Start Longitude (Degrees)	Stop Longitude (Degrees)	
2	Deleted		
3/4	179.5 W	142.5 E	
14	Deleted		
15	144.5 E	74.0 E	
15/16**	49.8 W	Full Rev*	B
22	162.7 E	Full Rev*	
23	143.7 E (with CSM pitched up 25 degrees)	18.8 W	
27	157.7 E	22.8 W	
33	151.6 E	Full Rev*	
34	150.6 E (with CSM pitched down 25 degrees)	11.8 W	B
35	149.6 E (oblique North 40 degrees)	30.8 W	
37/38	32.9 W	Full Rev*	
44	140.6 E	39.9 W	
50	134.6 E	45.9 W	B
52	Deleted		
58	126.6 E	Full Rev*	
62/63	57.9 W	Full Rev*	
69	115.6 E	Full Rev*	

Table 2. Photographic Requirements for the 3-Inch Mapping Camera (Continued)

Revolution Number	Start Longitude (Degrees)	Stop Longitude (Degrees)
71	113.5 E (oblique South 40 degrees)	66.9 W
71/72**	82.9 W	67.9 W
72/73	Deleted	
Post-TEI***	TEI + 30 minutes	To film depletion (At least 5 minutes running time as a minimum)

B

*The Mapping Camera will be operated on dark side portions of these revolutions in order that the Stellar Camera portion of the Mapping Camera system can provide attitude data for use in support of Laser Altimeter data reduction. A full revolution corresponds to 361 degrees in selenographic longitude due to lunar rotation.

**It is possible that light might be reflected from the extended Mapping Camera into the Panoramic Camera lens just prior to crossing the western terminator. To determine the extent of the reflections, if any, the Panoramic Camera will be operated both when the Mapping Camera is extended and when it is not extended for the 6-minute period prior to crossing the western terminator. During revolution 16, the Mapping Camera will remain extended through the western terminator crossing; during revolution 72, the Mapping Camera will be retracted 6 minutes prior to the western terminator and extended immediately following terminator passage. B

***Mapping Camera photographs after TEI are to be obtained in support of the CM Photographic Tasks detailed objective.

Table 3. Requirements for Operation of the Laser Altimeter

Laser Altimeter ON*		Laser Altimeter OFF		
Revolution Number	Longitude (Degrees)	Revolution Number	Longitude (Degrees)	
2	Deleted			
3	96 W	9**	73 E	
15	168 E	15	75 E	
15	37 W	16	91 W	
21	155 W	23**	24 W	
26	6 W	27**	83 W	
32	166 W	35**	32 W	
37	17 W	38	34 W	B
43	107 W	44	48 W	
49	130 W	50	74 W	
51	90 W	52	25 W	
57	7 W	59**	98 W	
61	106 E	64**	44 W	
69	134 E	70	92 W	
71	165 E	73**	2 W	

*The Laser Altimeter will operate whenever the Mapping Camera is operating. The Laser Altimeter will also operate independently when the SIM bay is nadir aligned. Portions of this operating schedule are coincident with scheduled Mapping Camera operations as shown in Table 2. B

**Operation of the Laser Altimeter is mandatory only for every second orbit and highly desirable for the remaining orbits.

4.6 CM PHOTOGRAPHIC TASKS

Obtain photographs of lunar surface features of scientific interest and photographs of low brightness astronomical and terrestrial sources.

Purpose

The purposes are to obtain photographs of lunar surface features of scientific interest from lunar orbit and transearth coast, and to obtain photographs of low brightness astronomical and terrestrial sources.

The functional test objectives in order of priority are as follows:

FTO 1) Obtain lunar photographs after TEI to permit extension of selenodetic control and mapping.

FTO 2) Deleted

FTO 3) Obtain photographs of solar corona after CSM sunset and prior to CSM sunrise.

FTO 4) Obtain photographs of the moon during lunar eclipse by the earth, and comet photographs if appropriate trajectory and celestial conditions exist.

FTO 5) Obtain photographs through the CM sextant of a star field. B

FTO 6) Obtain photographs of the L4 lunar libration region.

FTO 7) Obtain photographs of zodiacal light as the CSM approaches sunrise.

FTO 8) Obtain photographs of specific segments of the lunar surface in earthshine and in low light levels near the terminator.

FTO 9) Obtain photographs of lunar surface areas of prime scientific interest.

Test Conditions

FTO 1) After TEI, a sequence of photographs of the lunar surface will be obtained through the CM hatch window in accordance with Table 1. During periods of photography, the CSM will be kept in attitude hold such that the hatch window points toward the center of the visible surface of the moon. These post-TEI photographs from the CM will be supplemented by photographs of the lunar disc as obtained by the 3-Inch Mapping Camera, as specified in FTO 2) of the SM Orbital Photographic Tasks detailed objective. B

FTO 3)
FTO 4)
FTO 5)
FTO 6)
FTO 7)
FTO 8)

Type 2485 film will be used for these FTO's, in addition, type SO-368 film will be used in FTO 4). Due to high light sensitivity, a protective strip of film will be advanced after installation of a new magazine, before and after each photographic sequence, and prior to removal of a magazine, except for FTO 8). The protective film strip will consist of 1 frame for the HEC and for the 35 mm camera, and approximately 24 frames for the DAC. B Each magazine will have a set of special low-light-level calibration exposures along with the standard calibrations performed preflight and postflight. Control film strips are required from the flight film stock for similar calibrations, for assessment of best development processing and for analysis of emulsion base fog levels. Telemetry data are required relative to the time of shutter opening for the HEC and DAC. In all cases of simultaneous operation except FTO 3), the DAC will take precedence. In FTO 3), the HEC will take precedence.

FTO 6)
FTO 7)

Internal spacecraft lighting above 3×10^{-14} of the sun's surface brightness (= 2×10^{-9} lamberts) will be excluded from the camera's field-of-view. Consequently, a camera hood or a dark cabin with window shades will be used. Forward firing thrusters must not be actuated while the camera shutter is open, and in FTO 6) it is highly desirable that all thrusters be OFF. B Photographs will be taken from lunar orbit when both sun and earth are masked by the moon. The 35 mm camera will be mounted in the appropriate CM window with mode selector on TIME and with shutter speed and operation button actuations as specified for each of the FTO's. The aperture will be set to f/1.2 and the focus will be set to infinity. CSM attitude deadbands will be maintained within $\pm 0.5°$ for FTO 6).

FTO 2) Deleted

Deleted A

FTO 3) Three series of solar corona photographs will be obtained by bracket-mounted cameras through a CM window, one after CSM sunset and two prior to CSM sunrise. Each series will consist of seven HEC photographs with the 80 mm lens set at f/2.8 and infinity, and approximately 180 DAC frames with the camera running at 1 fps. For the two sunrise series of photographs, the CSM attitude rate will approximate the lunar orbital rate (~ 3°/min) to hold the +X-axis aligned near to the forward-looking local horizontal such that a small portion of the camera's field-of-view is fixed on the lunar surface. The two sunrise series will be separated by at least 50 hours. A A

The CSM will be pitched at approximately the orbital rate and the CSM attitude deadbands will be maintained within $\pm 5.0°$. For the sunset series of photographs, attitude and rates will be as specified above, except that the minus X-axis will be pointing along the velocity vector. DAC exposure periods and shutter speeds are as follows:

Time From CSM Sunset (Sec)	DAC Shutter Speed (Sec)	Time Prior to CSM Sunrise (Sec)	DAC Shutter Speed (Sec)
0 to 80	1/500	-180 to -80	1/125
80 to 180	1/125	- 80 to 0	1/500
180	OFF	0	OFF

Exposure periods and shutter speeds for the HEC are as follows:

Time From CSM Sunset (Sec)	Time Prior to CSM Sunrise (Sec)	Hasselblad Electric Shutter Speeds (Sec)
0	0	-
10	-10	1/125
20	-20	1/60
30	-30	1/30

Time From CSM Sunset (Sec)	Time Prior to CSM Sunrise (Sec)	Hasselblad Electric Shutter Speeds (Sec)
40	-40	1/15
50	-50	1/8
60	-60	1/4
70	-70	1.0

Anytime during transearth coast, three window calibration photographs of the moon will be obtained using the HEC bracket mounted in the right hand rendezvous window. The 80 mm lens will be set to f/2.8 and infinity. Exposure times for the three photographs will be 1/125, 1/60, and 1/30. B

FTO 3) FTO 4) FTO 5) Internal lighting above 3×10^{-12} of the sun's surface brightness ($=2 \times 10^{-7}$ lamberts) will be excluded from the camera's field-of-view by means of hood systems or a dark cabin with window shades. It is desirable that forward firing thrusters not be used if the required attitudes can be maintained without them. In FTO 3) and FTO 5), the DAC will be used with the 18 mm lens and with the aperture set to T1 and focus at infinity. In addition, FTO 3) and FTO 4) will require the HEC with the 80 mm lens.

FTO 4) Two series of HEC and 35 mm camera photographs of the moon will be obtained during lunar eclipse by the earth. The HEC with the 80 mm lens and the 250 mm lens will be used in the left-hand rendezvous window. The 250 mm lens will be used for the first two photographs of the first series and the last two photographs of the second series. The 80 mm lens will be used for all other HEC photographs. The HEC will be hand-held and will contain SO-368 film. The 35 mm camera will be mounted with a light shield in the right-hand rendezvous window, and will contain type 2485 film. Each series will consist of six photographs. The first series with each camera will be obtained during the time interval from 20 minutes before to 10 minutes after the moon becomes fully occulted by the earth. The second series with each camera will be obtained during the time interval from 10 minutes before to 20 minutes after the moon begins to leave the earth's umbra. The approximate times at which photographs will be taken are as follows:

First Series Time Relative to Moon Entering Earth's Umbra and Exposure Times				Second Series Time Relative to Moon Leaving Earth's Umbra and Exposure Times			
HEC (min)	Exposure Time(sec)	35 mm (min)	Exposure Time(sec)	HEC (min)	Exposure Time(sec)	35 mm (min)	Exposure Time(sec)
-15	1	-1	2	+ 1	120	-4	60
-12	2	0	4	+ 3	10	-3	30
- 9	1	+1	8	+ 6	2	-2	15
- 6	2	+2	15	+ 9	1	-1	8
- 3	10	+3	30	+12	2	0	4
- 1	120	+4	60	+15	1	+1	2

The 35 mm camera will be set to f/1.2 and infinity. For the HEC the 80 mm lens will be set to f/2.8 and infinity and the 250 mm lens will be set to f/5.6 and infinity.

If a comet is in favorable celestial position, time exposure DAC photographs through the sextant will be obtained using type 2485 film. Three photographs will be obtained sequentially with exposure times of 60 seconds, 20 seconds, and 5 seconds.

For lunar eclipse photographs and comet photographs, the CSM attitude rates will be allowed to damp automatically after acquisition of each photographic target.

FTO 5) Two sets of photographs of a star field will be obtained during transearth coast using the DAC connected by optical adapter to the CM sextant optics. The star field will be centered near RTCC catalog star number 61 (Shaula) at 18^h 28^m right ascension and -37 degrees 10 minutes declination. Each set will consist of four photographs obtained sequentially with exposure times of 60 seconds, 20 seconds, 5 seconds, and 1 second. One set will be obtained with the sextant optical axis approximately 90 degrees to the spacecraft/sun line, and one set will be obtained with the sextant optics shaded from the sun by the CM. During the period when photographs are obtained, electrical power to the sextant optic's internal lighting will be disconnected.

It is highly desirable to obtain two additional sets of photographs (as described above) during translunar coast.

FTO 6) The 35 mm camera will be used to obtain a series of four photographs of lunar libration region L4. Exposure times will be one of 240 seconds, two each of 90 seconds, and the last of 30 seconds. The libration point will be located at 23^h 13^m right ascension and -1.83 degrees declination.

FTO 7) A series of 23 photographs will be taken, using the 35 mm camera, as the CSM approaches sunrise. At the beginning of the series when the zodiacal light levels are lowest, sets of three time exposures taken one after the other will be used to bracket the expected light levels. Near sunrise the automatic exposure duration provided by the shutter speed selector will be used to compensate for the rapidly increasing light levels. The CSM attitude rate will approximate the lunar orbital rate (~ 3°/min) to hold the +X-axis aligned near to the forward-looking local horizontal such that a small portion of the camera's field-of-view is fixed on the lunar surface.

The CSM will be pitched at approximately the orbital rate and the CSM attitude deadband will be maintained within ±5.0°. It is acceptable to delete portions of the photographic sequence in order to make necessary adjustments to the spacecraft attitude. Times for initiation of each exposure set and their durations are as follows: B

Time Prior To CSM Sunrise (Min:Sec)	Shutter Speeds (Sec)
-25:00	120, 30
-21:40	120, 30
-18:20	90, 30, 10
-15:00	90, 30, 10
-11:40	60, 20, 8
- 8:20	60, 20, 8
- 5:00	30, 10, 4
- 1:00	1/8
- 0:45	1/15
- 0:30	1/30
- 0:15	1/60

FTO 8) Near-terminator photographs will be obtained using the HEC with the 80 mm lens and the 250 mm lens. The HEC will be pointed vertically. It is desirable, if possible, to photograph 10 terminator crossings. It is highly desirable to obtain near-terminator photographs on orbits on which a terminator is photographed by a SIM camera. Bracket mounting is desired, but bracing against a fixed object is acceptable. B

The HEC will be commanded by the intervalometer set to provide stereo strips with 55 to 60 percent forward overlap (approximately 20-second intervals). Prior to the start of the intervalometer, the shutter will be set to 1/250 and the aperture set to f/2.8 for the 80 mm lens and to 1/125 and f/5.6 for the 250 mm lens. The sequence will be started 1 minute before crossing the terminator (light side) and completed 40 seconds after crossing the terminator (dark side).

Earthshine photographs will be obtained on one pass using the 35 mm camera, pointed vertically. Bracket mounting is desirable, but bracing against a fixed object is acceptable. The camera will be commanded to provide stereo strips with 55 to 60 percent forward overlap (approximately 30-second intervals). Prior to the start of photography, the shutter will be set to 1/125 and the aperture set to f/1.2. The sequence will be started at the western terminator. About 1 minute after crossing the terminator, the exposure will be changed to 1/15 and continued at this setting for 2 minutes. The shutter speed will then be changed to 1/8 for a period of 5 minutes. It is highly desirable that CM cabin lighting be reduced during earthshine photography.

FTO 9) Low resolution, black and white photographs of particular areas of the lunar surface will be obtained using the HEC (hand-held) with the 80 mm lens. Where possible, without attitude maneuvers, the HEC will be bracket mounted. The frame cycle rate for the HEC will be set to provide 55 to 60 percent forward overlap. Medium resolution photographs of particular regions of the moon's surface will be obtained using the HEC with the 250 mm lens.

The photographic sequences and the number of frames per sequence will be as indicated in Table 2.

Success Criteria

FTO 1)
FTO 3)
FTO 4)
FTO 5)
FTO 6)
FTO 7)
FTO 8)
FTO 9)

Mandatory data defined under Data Requirements shall be acquired and returned to earth for evaluation.

Evaluation

FTO 1)
FTO 3)
FTO 4)
FTO 5)
FTO 6)
FTO 7)
FTO 8)
FTO 9)

The photographic and supporting data will be evaluated for general scientific interest. (Premission and experiment evaluation data as defined under Data Requirements)

Data Requirements

1) Premission Data (PD):

Premission sensitometry of the flight film, including special low-light-level calibration exposures of the type 2485 film to be used in FTO 3) through FTO 8), in accordance with the standard procedures of the Photographic Technology Division. (M) B

2) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority PD	ESD	EED
CK 1040 X	16 mm Event Sequence Camera	PCM	1	*	*	M
CK 1043 X	70 mm Camera Shutter Open	PCM	1	*	*	M

*There are no requirements for Premission Data (PD) or Experiment Support Data (ESD).

b) Telemetry Measurement Tapes: (M)

One copy of tape** containing EED telemetered measurements listed under 2)a), recorded and correlated with GMT during periods of camera operation. B

c) Astronaut Logs or Voice Records: (HD)

One copy of astronaut logs or voice records containing the record of GET, magazine number, frame number for each photograph or for the first photograph in each set of photographs, and exposure time.

d) Photographs: (M)

All photographs as defined by the Test Conditions.

e) Two copies of microfilm containing the output of the Apollo Photographic Evaluation (APE) program for the periods when photographs were obtained. (HD) B

**Magnetic tape produced is to be UNIVAC 1108 computer-compatible digital 7-track, 800-BPI tapes. B

4.6 CM PHOTOGRAPHIC TASKS

Background and Justification

FTO 1) is an extension of the Transearth Lunar Photography objective performed on Apollo 14 and will provide changes in perspective geometry due to variations in the transearth trajectory.

FTO 6) and FTO 7) will supplement similar dim light photographs obtained on Apollo 14, thus significantly increasing confidence in the photographic observations. Photographs of the solar corona [FTO 3)], from the vantage point of lunar orbit, will help achieve a better understanding of the pattern of energy outflow from the sun. Photographs of the moon obtained in accordance with FTO 4) will show color changes on the lunar surface due to selective transmission of sunlight by the earth's atmosphere. Stellar photographs through the CM sextant [FTO 5)] will help determine sources of stray light in Apollo 14 dim light photographs and further evaluate the usefulness of the extant optics for dim light photography.

The lunar surface photographs to be obtained in accordance with FTO 8) and FTO 9) will serve three purposes:

(a) Provide photographic coverage of specific features at pointing angles which are not attainable by the SIM cameras due to the attitude constraints imposed by other SIM experiments;

(b) Provide coverage during periods when the SIM cameras are not operating (e.g., during portions of the 60 by 8 nautical mile orbit); and

(c) Provide at least a limited number of lunar surface photographs in the event of no EVA for retrieval of SIM camera film.

Previous Flight Objectives

Objective Number	Title	Mission
20.115	Lunar Mission Photography from the CM	8
E	Selenodetic Reference Point Update	12
G	Photographs of Candidate Exploration Sites	12
4.4	Transearth Lunar Photography	14
4.10	CSM Orbital Science Photography	14
4.1	Photographs of a Candidate Exploration Site	14
4.3	Selenodetic Reference Point Update	14
4.11	Dim Light Photography	14

A

Table 1. Transearth Lunar Photographs

Approximate Time After TEI	Camera and Lens	Type Photographs
2 hours	HEC/250 mm lens with LBW film	4 frames, hand-held overlapping, in rapid sequence and covering the visible disc

B

Table 2. Targets for Scientific Interest Photography [FTO 9)]

Target Number	No. of Frames and Time Interval (Sec)	Lens (mm)/ Film Type	Start Longitude and Latitude (Deg)	Stop Longitude and Latitude (Deg)	Aim Longitude and Latitude (Deg)	Description
1	33 @ 15	250/CEX	170.0 E, 31.3 S	150.0 E, 26.3 S	160.0 E, 29.0 S	Sea of Ingenuity
4	5 @ 10	250/CEX	137.0 E, 8.5 S	135.0 E, 7.5 S	136.0 E, 8.0 S	Keyhole Crater
7	12 @ 10	250/CEX	125.0 E, 6.0 S	120.8 E, 4.2 S	123.0 E, 5.2 S	The Bright One
11	14 @ 20	250/CEX	94.0 E, 11.6 N	83.0 E, 16.2 N	88.5 E, 14.0 N	IBN Yunus
19	21 @ 20	250/CEX	46.2 E, 29.2 N	26.8 E, 31.5 N	36.6 E, 30.6 N	Newcomb and Posidonius
2	36 @ 5	250/CEX	153.8 E, 19.6 S	144.9 E, 17.3 S	149.3 E, 18.5 S	Gagarin
6	28 @ 5	250/CEX	126.8 E, 18.0 S	120.0 E, 15.4 S	123.3 E, 16.7 S	N.W. Tsiolkovsky
5	14 @ 5	250/LBW	130.0 E, 12.8 S	126.5 E, 11.5 S	128.2 E, 12.2 S	Crater Pair
18	19 @ 25	80/LBW	52.3 E, 21.2 N	29.0 E, 26.7 N	40.9 E, 24.3 N	N. W. Crisium
25	5 @ 35	80/LBW	8.4 E, 30.8 N	0.0, 31.0 N	4.3 E, 31.0 N	Caucasus Mts.
16	26 @ 20	80/LBW	53.5 E, 11.3 N	28.0 E, 21.0 N	40.9 E, 16.7 N	Lick and Littrow
9	19 @ 10	250/LBW	114.2 E, 11.0 S	105.0 E, 7.3 S	109.7 E, 9.3 S	Meitner
17	15 @ 35	80/LBW	53.5 E, 16.6 N	28.5 E, 24.0 N	41.2 E, 20.8 N	W. Crisium
14	14 @ 25	80/LBW	61.0 E, 0.6 N	44.0 E, 9.8 N	52.2 E, 5.5 N	S. Crisium
12	13 @ 20	80/LBW	91.5 E, 20.3 S	79.0 E, 15.0 S	86.7 E, 18.4 S	Schorr and Behaim
8	9 @ 5	250/CEX	118.4 E, 23.2 S	116.2 E, 22.7 S	117.3 E, 23.0 S	Izsak
10	38 @ 5	250/CEX	100.5 E, 18.8 S	91.2 E, 15.4 S	95.8 E, 17.3 S	Sklodowski

Table 2. Targets for Scientific Interest Photography [FTO 9)] (Cont'd)

Target Number	No. of Frames and Time Interval (Sec)	Lens (mm)/ Film Type	Start Longitude and Latitude (Deg)	Stop Longitude and Latitude (Deg)	Aim Longitude and Latitude (Deg)	Description
15	17 @ 5	250/CEX	58.5 E, 2.0 S	54.2 E, 0.5 N	56.3 E, 0.7 S	Luna 16
22	4 @ 15	250/CEX	25.0 E, 0.2 S	22.3 E, 1.2 N	23.7 E, 0.4 N	Tranquality Base
24	7 @ 10	250/CEX	11.6 E, 10.5 N	8.2 E, 12.0 N	9.9 E, 11.2 N	Boscovich
28	15 @ 20	80/LBW	40.0 W, 26.0 N	55.0 W, 25.7 N	51.0 W, 26.0 N	Aristarchus Plateau
13	15 @ 15	250/CEX	87.3 E, 28.9 S	76.5 E, 25.5 S	81.8 W, 27.3 S	Humboldt
27	33 @ 10	250/CEX	30.0 W, 38.5 N	46.5 W, 38.0 N	38.3 W, 35.0 N	Lunakhod

4.7 SIM THERMAL DATA

Obtain data on the SIM thermal environment.

Purpose

The purposes are to determine that adequate thermal conditions are maintained in the SIM bay and adjacent bays of the service module for all mission phases and to determine that the equipment within the SIM bay is provided the proper thermal environment for operating and nonoperating modes.

The functional test objectives are as follows:

FTO 1) Obtain data on the thermal environment of the SIM bay.

FTO 2) Obtain data on the thermal conditions of the experiments, cameras and laser altimeter within the SIM bay.

FTO 3) Obtain data on the thermal effect of the SIM bay on the service module.

Test Conditions

FTO 1)
FTO 2)
FTO 3) The CSM will be in lunar orbit with the SIM bay door jettisoned. Continuous telemetry data will be obtained as shown under Data Requirements for one complete lunar revolution during each twenty-four hour period. It is highly desirable that telemetry data be obtained continuously during three consecutive lunar revolutions.

There is no requirement in support of this objective for the equipment within the SIM bay to be turned ON anytime during the TLC, LO, or TEC phases other than the time periods that the equipment is to be operated in support of other objectives or experiments.

FTO 2) SIM equipment telemetry data and astronaut records of the operation times of the SIM equipment will be obtained.

FTO 3) While the CSM is in the TLC and TEC phases, thermal data will be obtained on an as available basis.

Success Criteria

FTO 1) Data shall be obtained on the thermal environment of the SIM bay during one lunar revolution each twenty-four hour period.

FTO 2) Data shall be obtained on the thermal conditions of the experiments, cameras and laser altimeter within the SIM bay during one lunar revolution each twenty-four hour period.

FTO 3) Data shall be obtained on the thermal conditions of the service module in the vicinity of the SIM bay during one lunar revolution each twenty-four hour period.

Evaluation

FTO 1) FTO 2) Postflight data evaluation will include correlation of spacecraft attitudes, RCS firings, crew comments and SIM bay temperatures. (Astronauts record and all telemetry data under Data Requirements)

FTO 2) SIM equipment thermal data will be evaluated to determine if the equipment was subjected to thermal conditions higher than the specification limits during operating and nonoperating periods. (Astronaut records and all SL telemetry measurements).

FTO 3) The service module thermal data will be evaluated to determine the effects of the SIM bay on adjacent bays. (All CA, SP and SR telemetry measurements in addition to SL 1202 T, SL 1204 T, SL 1205 T, SL 1206 T and SL 1217 T).

Data Requirements

1) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority
CA 1820 T	Temp Crew HS Ablator Surf Loc 1A	PCM	1	HD
CA 1821 T	Temp Crew HS Ablator Surf Loc 4A	PCM	1	HD
CA 1822 T	Temp Crew HS Ablator Surf Loc 7A	PCM	1	HD
CA 1823 T	Temp Crew HS Ablator Surf Loc 10A	PCM	1	HD
CH 3547 X	RCS Solenoid Activate A4/14/+X	PCME	1	HD
CH 3551 X	RCS Solenoid Activate B4/26/+X	PCME	1	HD
CH 3554 X	RCS Solenoid Activate B1/11/+Z	PCME	1	HD
CH 3561 X	RCS Solenoid Activate A2/-Y	PCME	1	HD
	Deleted			
	Deleted			
	Deleted			
	Deleted			
SL 1032 T	Pan Camera Film Mag Temp	PCM	1	M*
SL 1039 T	Pan Camera Lens Barrel Temp	PCM	1	M*
SL 1040 T	Pan Camera Fwd Lens Temp	PCM	1	M*
SL 1041 T	Pan Camera Aft Lens Temp	PCM	1	M*
SL 1042 T	Pan Camera Mech Temp	PCM	1	M*

A

Measurement Number	Description	TM	Mode	Priority
SL 1043 P	Pan Camera N_2 Tank Press	PCM	1	HD
SL 1056 T	X-Ray Processor Temp Monitor	PCM	1	M*
SL 1057 T	X-Ray Detector Temp Monitor	PCM	1	M*
SL 1059 T	X-Ray LVPS Temp Monitor	PCM	1	M*
SL 1060 T	X-Ray Lunar Detect Temp Monitor	PCM	1	M*
SL 1061 T	X-Ray Solar Detect Temp Monitor	PCM	1	M*
SL 1068 T	Alpha Part Det Temp Mon No 1	PCM	1	M*
SL 1070 T	Alpha Part Det Temp Mon No 2	PCM	1	M*
SL 1071 T	Alpha Part LVPS Temp Mon	PCM	1	M*
SL 1085 T	Temp Gamma-Ray Detector	PCM	1	M
SL 1086 T	Temp Gamma-Ray Electronics Pkg	PCM	1	M
SL 1094 T	Laser Altimeter Cavity Temp	PCM	1	M*
SL 1160 T	Temp Metric Lens Front Element	PCM	1	M*
SL 1161 T	Temp Metric Lens Barrel	PCM	1	M*
SL 1162 T	Temp Stellar Lens Front Element	PCM	1	M*
SL 1163 T	Temp Stellar Lens Barrel	PCM	1	M*
SL 1164 T	Temp MC Supply Cassette	PCM	1	M*
SL 1201 T	Temp Thrm Envir Shelf XS 236.5	PCM	1	M
SL 1202 T	Temp Thrm Envir -BM 1 XS 221, R62	PCM	1	M(1)
SL 1204 T	Temp Thrm Envir -BM 1 XS 278, R62	PCM	1	M(2)
SL 1205 T	Temp Thrm Envir -BM 6 XS 221, R62	PCM	1	M(1)
SL 1206 T	Temp Thrm Envir -BM 6 XS 257, R62	PCM	1	M(2)
SL 1208 T	Temp Thrm Envir -Gamma Ray Struct	PCM	1	M
SL 1211 T	Temp Thrm Envir -Pan C N_2 Line In	PCM	1	M(3)
SL 1212 T	Temp Thrm Envir -Pan Camera N_2 Tk	PCM	1	M(3)
SL 1215 T	Temp Thrm Envir -MOM Box	PCM	1	M
SL 1217 T	Temp Thrm Envir BM 6 XS 305, R62	PCM	1	M
SP 0017 T	SPS Lower He Tank	PCM	1	HD
SR 5013 T	He Temp Tank A	PCM+	2	M
SR 5014 T	He Temp Tank B	PCM+	2	M
SR 5015 T	He Temp Tank C	PCM+	2	HD
SR 5016 T	He Temp Tank D	PCM+	2	HD
SR 5069 T	Temp Oxid Feed Line Fltr Quad A	PCM	1	M
SR 5070 T	Temp Oxid Feed Line Fltr Quad B	PCM	1	M
SR 5071 T	Temp Oxid Feed Line Fltr Quad C	PCM	1	HD
SR 5072 T	Temp Oxid Feed Line Fltr Quad D	PCM	1	HD
SR 5073 T	Temp Pri Fuel Tk Out Surf Quad A	PCM	1	M
SR 5074 T	Temp Pri Fuel Tk Out Surf Quad B	PCM	1	M
SR 5075 T	Temp Pri Fuel Tk Out Surf Quad C	PCM	1	HD
SR 5076 T	Temp Pri Fuel Tk Out Surf Quad D	PCM	1	HD

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*These measurements are on the 64.0 KC downlink and cannot be decommutated in real time by MSFN while the LM telemetry is ON.

(1), (2), (3) One measurement out of each set is mandatory. The remaining measurement is highly desired. A

2) Astronaut Logs or Voice Records in Real Time. (HD)

GET (to nearest minute) each time any of the following switches on panel 230 are moved from any of the indicated positions to any of the other indicated positions.

Equipment	Switch Number	Switch Position Title				
		OFF	STBY	ON	HTRS	OPERATE
Mapping Camera	S6	X	X	X		
Laser Altimeter	S8	X		X		
Panoramic Camera	S10	X			X	
Panoramic Camera	S11	X	X			X
Alpha-Ray	S13	X		X		
Mass Spectrometer	S18	X	X	X		
X-Ray	S25	X	X	X		

A

4.7 SIM THERMAL DATA

Background and Justification

Data obtained for the objectives will be utilized to supplement 2TV-2 test data and thermal math model verification, for future mission analyses and to investigate potential mission constraints and anomolous conditions.

Flight verification of the integrated SM/experiments configuration will be accomplished.

This mission will be the first flight of the Scientific Instrument Module (SIM) and the pyrotechnically jettisonable door.

Previous Flight Objectives

Objective Number	Title	Mission
7.29	Exhaust Effects/CSM	9

4.8 SIM BAY INSPECTION DURING EVA

Inspect the SIM bay, and demonstrate and evaluate EVA procedures and hardware.

Purpose

The purposes are to determine the effects of SIM bay door jettison, to determine the presence of any contamination in the SIM bay, to evaluate EVA procedures and equipment and determine design adequacy of thermal protection. A

The functional test objectives are as follows:

FTO 1) Inspect the SIM bay.

FTO 2) Verify EVA procedures and evaluate the use of EVA hardware.

Test Conditions

FTO 1)
FTO 2) EVA preparation will be initiated not more than 6 hours after a rest period during TEC. The EVA will be conducted in accordance with the Orbital EVA Procedures. The experiment booms are to be retracted prior to EVA. The spacecraft will be positioned to prevent shafting of the sunlight through the CM hatch, to provide sunlight within the SIM bay, to allow telemetry transmission of voice and biomedical data, and if possible, to allow TV transmission. The allowable sun angle envelope relative to the spacecraft is as follows:

θ (Theta): 140° to 160° (as measured from +X axis)

Φ (Phi): 310° to 350° (as measured positively from the -Z axis to the projection of the sun vector in the spacecraft YZ plane)

Any damage to the SIM area will be described after the film cassettes are retrieved. The SIM bay white thermal coatings will be inspected for discoloration resulting from either contamination or overheating and for burn-through.

Surfaces having insulation and foils will be inspected for burn-through, tears, and attachment failures. The RCS plume protection foils (oxidized Inconel) are used on the Mapping Camera film cassette and top surface, Panoramic Camera sides and front and Mass Spectrometer cover. A

The outer surface coatings of the contamination covers are as follows: Mapping Camera (black anodized), Subsatellite Finch paint (silver gray), Gamma-Ray Spectrometer Z-93 (white), Mass Spectrometer oxidized Inconel foil (grayish black), X-Ray/Alpha Spectrometer [Dow Corning (white)]. A

FTO 2) EVA activities will be recorded by a data acquisition camera mounted on a pole attached to the CM hatch. The TV camera will be mounted on the same pole and will televise the EVA, provided the sun-spacecraft-earth angle will permit adequate lighting of the SIM bay simultaneous with SM high-gain S-band antenna operation. Comments by the EVA crewmen will be provided on the adequacy of the EVA procedures and related hardware.

Success Criteria

FTO 1) Crew comments will be obtained on the status of the SIM bay.

FTO 2) Crew comments will be obtained on the EVA procedures and related hardware.

Evaluation

FTO 1) The condition of the SIM bay door frame edges, hinges, all SIM equipment and thermal protective devices will be determined. (Astronaut records) A

FTO 2) The adequacy of the hardware and of the procedures (as used to retrieve the cassettes and to inspect the SIM area) will be determined. (Astronaut records, photographs and TV data)

Medical data from the crewmen during EVA will be evaluated to determine physiological functions. (CJ 0060 J, CJ 0061 J, CJ 0062 J, CJ 0200 R, CJ 0201 R and CJ 0202 R)

Data Requirements

1) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority
CJ 0060 J	EKG Commander LH Couch	PCM	1	HD
CJ 0061 J	EKG CMD Module Pilot Ctr Couch	PCM	1	HD
CJ 0062 J	EKG Lunar Module Pilot RH Couch	PCM	1	HD
CJ 0200 R	Resp Rate Commander LH Couch	PCM	1	HD
CJ 0201 R	Resp Rate CM Pilot Ctr Couch	PCM	1	HD
CJ 0202 R	Resp Rate LM Pilot RH Couch	PCM	1	HD

2) Astronauts Voice Records: (M)

a) Description of condition of SIM bay equipment (e.g., boom retracted partially or completely, position of thermal blankets, contaminates on surfaces, sharp edges, protruding objects, and evidence of excessive heat).

b) Comments on adequacy of EVA procedures, hardware and lighting conditions.

3) Photographs: (HD)

Data acquisition camera sequence coverage of the EVA.

4) TV camera coverage of EVA. (HD)

4.8 SIM BAY INSPECTION DURING EVA

Background and Justification

The recovery of SIM film cassettes in support of objective SM Orbital Photographic Tasks requires an EVA during the TEC period. Handrails, foot restraints, and other related hardware are provided to aid the crewman in the task of retrieving the film cassette from the 24-Inch Panoramic Camera and the cassette from the 3-Inch Metric Mapping/Stellar Cameras.

Apollo 9 included a test objective to evaluate extravehicular activity and equipment in a zero-g earth orbit environment.

Data obtained by this objective will validate physiological predictions and SIM status while performing the extravehicular activity in a zero-g TEC environment.

Several areas of the SIM bay are of particular importance from the design point of view. These are the experiment contamination covers, the plume protection foils, pan camera lens barrel, uninsulated surfaces of the experiments, foot restraints, edges of SIM walls, and wire cowlings.

The plume protection foils (oxidized Inconel outer sheet-grayish black) are utilized on the Mapping Camera film cassette area and the top surface of the package. The foils are also provided on the sides and front of the Panoramic Camera with the exception of the radiator plate which is white and the lens barrel and surrounding surface. The lens barrel is gray in appearance. The uninsulated experiment surfaces, as well as the wire cowlings and SIM walls, are coated white. A

These data in conjunction with data obtained from retrieved flight coating samples on Apollo 9 can be utilized to determine levels of coating degradation which might result in anomalous experiment performance.

Previous Flight Objectives

Objective Number	Title	Mission
20.34	Extravehicular Activity	9

4.9 SIM DOOR JETTISON EVALUATION

Demonstrate SIM door jettison.

Purpose

The purpose is to determine the effects of SIM door jettison in a lunar environment.

The functional test objectives are as follows:

FTO 1) Demonstrate jettisoning of the SIM door.

FTO 2) Determine the effect on the CSM when the SIM door is jettisoned.

Test Conditions

FTO 1) When the SIM door is jettisoned, the crew will attempt to observe the SIM door through the right-hand side window as the door moves away from the spacecraft. If the door is observed, the crew will provide comments relative to the approximate trajectory of the door with respect to the spacecraft.

FTO 2) The crew will record any changes in the SM RCS propellant and helium isolation valve indicator flags (as caused by SIM door jettisoning) and any perturbations of the spacecraft attitude. Telemetry data will be obtained on any changes in CSM acceleration resulting from SIM door jettisoning.

Success Criteria

FTO 1) The SIM door shall be jettisoned without recontacting the spacecraft.

FTO 2) Astronaut records will be obtained relative to any change in the SM RCS propellant and helium isolation valves as caused by SIM door jettisoning.

Evaluation

FTO 1) The data will be evaluated to determine that the door jettisoned without recontacting the CSM. (Astronaut records, CK 0026 A, CK 0027 A, and CK 0028 A)

FTO 2) The SIM door jettison data will be evaluated to determine any effects on the SM RCS propellant and helium isolation valves and to determine the extent of any spacecraft attitude perturbation. (Astronaut records and all specified telemetry measurements)

Data Requirements

1) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority
CG 2112 V	IG 1X Resolver Output Sin	PCM	1	HD
CG 2113 V	IG 1X Resolver Output Cos	PCM	1	HD
CG 2142 V	MG 1X Resolver Output Sin	PCM	1	HD
CG 2143 V	MG 1X Resolver Output Cos	PCM	1	HD
CG 2172 V	OG 1X Resolver Output Sin	PCM	1	HD
CG 2173 V	OG 1X Resolver Output Cos	PCM	1	HD
CH 3503 R	FDAI SCS Body Rate Pitch	PCM	1	HD
CH 3504 R	FDAI SCS Body Rate Yaw	PCM	1	HD
CH 3505 R	FDAI SCS Body Rate Roll	PCM	1	HD
CH 3546 X	RCS Solenoid Activate C3/13/+X	PCME	1	HD
CH 3547 X	RCS Solenoid Activate A4/14/+X	PCME	1	HD
CH 3548 X	RCS Solenoid Activate A3/23/-X	PCME	1	HD
CH 3549 X	RCS Solenoid Activate C4/24/-X	PCME	1	HD
CH 3550 X	RCS Solenoid Activate D3/25/+X	PCME	1	HD
CH 3551 X	RCS Solenoid Activate B4/26/+X	PCME	1	HD
CH 3552 X	RCS Solenoid Activate B3/15/-X	PCME	1	HD
CH 3553 X	RCS Solenoid Activate D4/16/-X	PCME	1	HD
CH 3554 X	RCS Solenoid Activate B1/11/+Z	PCME	1	HD
CH 3555 X	RCS Solenoid Activate D2/22/+Z	PCME	1	HD
CH 3556 X	RCS Solenoid Activate D1/21/-Z	PCME	1	HD
CH 3557 X	RCS Solenoid Activate B2/12/-Z	PCME	1	HD
CH 3558 X	RCS Solenoid Activate A1/+Y	PCME	1	HD
CH 3559 X	RCS Solenoid Activate C2/+Y	PCME	1	HD
CH 3560 X	RCS Solenoid Activate C1/-Y	PCME	1	HD
CH 3561 X	RCS Solenoid Activate A2/-Y	PCME	1	HD
CK 0026 A	CM Accelerometer X-axis	PCM	1	HD
CK 0027 A	CM Accelerometer Y-axis	PCM	1	HD
CK 0028 A	CM Accelerometer -Z axis	PCM	1	HD

2) Astronaut Logs or Voice Records:

a) Visual observations through the CM RH side window of the SIM door after jettisoning. (HD)

b) Comments on any changes to the primary and secondary SM RCS helium and propellant isolation valves position indicator flags at time of jettisoning (as indicated on panel 2; displays DS2, DS3, DS4, DS5, DS8, DS9, DS10, DS11, DS14, DS15, DS16, DS17, DS24, DS25, DS26 and DS27). (M)

c) Comments on the CSM perturbations during SIM door jettison. (HD)

d) Visual observations as noted during EVA of effects related to jettisoning of the SIM door. (M)

4.9 SIM DOOR JETTISON EVALUATION

Background and Justification

Apollo Mission J-1 is the first of the J-missions utilizing the SIM installed in Bay 1 of the CSM. The SIM door will be pyrotechnically separated from the SM. The door will move away from the SM at approximately 10 to 15 fps. A

SM RCS propellant isolation valves on Apollo 9, 11 and 12 and a helium isolation valve on Apollo 12 inadvertently went to the closed position at the time of operation of the pyrotechnics that separate the CSM from the S-IVB. The failure investigation test programs for Apollo 9, 11 and 12 led to the conclusion that valve closures can be expected because of separation shock levels produced by the pyrotechnics, and that these closures are not detrimental to the valves. The SM RCS helium and propellant isolation valves should be monitored on Apollo Mission J-1 during the firing of the pyrotechnics that release the door and during the completion of the jettisoning operation.

Ground testing of the SIM installation and door jettisoning operations will be accomplished in accordance with the following NR test request documents:

- Deleted A
- TR 322083 Design Verification Test
- TR 322084 Demonstration Test
- TR 332247 Service Module Static Test

Previous Flight Objectives

Objective Number	Title	Mission
None		

4.10 LM DESCENT ENGINE PERFORMANCE

Obtain data on the performance of the descent engine.

Purpose

The purpose is to verify the performance of the modified descent engine.

The functional test objective is as follows:

FTO 1) Verify the performance predictions of the modified descent engine.

Test Conditions

FTO 1) While the LM is in the descent phase obtain continuous data through touchdown.

Success Criteria

FTO 1) DPS performance will be within the limits specified in GAC specification "Master End Item Specification for Lunar Module," LSP-470-2E, paragraph 3.4.1.3.3.2.4. A

Evaluation

FTO 1) A postflight analysis will be performed to determine the DPS steady state performance. In addition to determining engine performance (thrust, specific impulse, mixture ratio, A and LM dynamics) this analysis will yield reconstructed consumable and stage weight histories. These results will provide information concerning DPS ΔV capabilities and performance propellant margins. A (All telemetry measurements)

Data Requirements

1) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority
GG 0001 X	PGNS Down Link Data (To T/M)	PCM	1	M
GQ 3018 P	Press, He Reg Out Manifold	PCM	2	HD
GQ 3435 P	Press, Super/Crit He Supply Tank	PCM	2	M
GQ 3603 Q	Quantity, Fuel Tank No 1	PCM	2	M
GQ 3604 Q	Quantity, Fuel Tank No 2	PCM	2	M
GQ 3611 P	Press Engine Interface Fuel	PCM	2	M
GQ 3718 T	Temp, Fuel Tank No 1 Surf	PCM	1	M
GQ 3719 T	Temp, Fuel Tank No 2 Surf	PCM	1	M
GQ 4103 Q	Quantity, Oxid Tank No 1	PCM	2	M
GQ 4104 Q	Quantity, Oxid Tank No 2	PCM	2	M
GQ 4111 P	Press Engine Interface Oxid	PCM	2	M
GQ 4218 T	Temp, Ox Tank No 1 Surf	PCM	1	M

Measurement Number	Description	TM	Mode	Priority
GQ 4219 T	Temp, Ox Tank No 2 Surf	PCM	1	M
GQ 4455 X	Propellant Tanks Lqd Level Low	PCM	1	M
GQ 6510 P	Press, Thrust Chamber	PCM	2	M
GQ 6806 H	Pos, Variable Injector Actuator	PCM	2	M

4.10 LM DESCENT ENGINE PERFORMANCE

Background and Justification

The descent engine modifications consist of lengthening the engine skirt, which will increase the specific impulse, and a change in the material of the thrust chamber. The thrust chamber has been relined to resist the increased erosion which will be encountered with the longer thrust duration due to the increase in descent engine burn time and the longer allowable hover time at low throttle setting.

Increased performance of the descent engine is necessary to provide the ΔV capability required for the heavier LM. Pressure measurements will verify that the engine is operating within specified limits and the PGNS downlink data will verify that the vehicle trajectory and velocity are also within limits.

Previous Flight Objectives

Objective Number	Title	Mission
11.6	LM PGNCS/DAP Performance and Thrust Performance	9
13.12	DPS Burn Duration Effects and Primary Propulsion/Vehicle Interactions	9

4.11 VISUAL OBSERVATIONS FROM LUNAR ORBIT

Record visual observations of particular lunar surface features and processes.

Purpose

The purpose is to make and record visual observations of particular lunar surface features and processes to complement photographic and other remote-sensed data.

The functional test objectives are as follows:

FTO 1) Obtain astronaut comments on observations of particular lunar farside features and processes by use of the onboard recorder.

FTO 2) Obtain astronaut comments on observations of particular lunar nearside features and processes in real time by use of voice communications.

Test Conditions

FTO 1)
FTO 2) While in lunar orbit the crew will make visual observations of particular lunar surface features and processes. On farside passes observations will be recorded with the onboard tape recorder, and on nearside passes observations will be recorded by real-time voice communications with the MCC. Observations will be made from the available CM windows without disturbing SIM operations. When appropriate, visual observations will be recorded by marking onboard graphics and charts. The targets to be observed are given in Table 1. B

FTO 2) During scheduled television transmissions from lunar orbit and transearth coast the crew will describe the part of the lunar surface which is visible on the television monitors.

Success Criteria

FTO 1)
FTO 2) Comments on the targets listed in Table 1 will be voice relayed in real time or recorded on tape.

Evaluation

FTO 1)
FTO 2) Transcripts of onboard tape and voice communications related to observations of lunar surface features will be studied before the postmission orbital science debriefing. The crew debriefing on visual observations will be evaluated for selenological interpretation and general scientific interest. (Astronaut Records and Debriefings)

Video tapes of television transmissions will be studied in conjunction with crew comments recorded during periods of television transmissions. (Video Tapes of television transmissions and Astronaut Records)

Data Requirements

Experiment Evaluation Data (EED):

a) Astronaut Logs or Voice Records: (M)

One copy of astronaut logs or voice records containing comments related to visual observations of lunar surface features and processes (should be supplied prior to the postmission orbital science debriefing).

b) Astronaut Debriefings: (M)

One copy of astronaut postmission scientific and photographic debriefing transcripts pertaining to visual observations of lunar surface features and processes.

B

c) Video Tapes (HD)

One copy of video tape recordings of television transmissions during which visual observations of the lunar surface were relayed.

d) Trajectory: (M)

One copy of tape* containing the best estimate of trajectory (BET) including spacecraft attitude data during periods when visual observations of lunar surface features are recorded or relayed.

*Magnetic tapes produced are to be UNIVAC 1108 computer-compatible digital 7-track, 800-BPI tapes.

4.11 VISUAL OBSERVATIONS FROM LUNAR ORBIT

Background and Justification

Use of the capabilities of the human eye in making observations from lunar orbit is an integral part of manned lunar exploration. This is based on (1) the fact that the human eye's extensive dynamic range and color sensitivities cannot be matched by any one film type or sensing instrument, and (2) the need, in special cases, for on-the-scene interpretation of the observed features or phenomena.

Visual observations from lunar orbit complement photographic and other remote sensing data. The resolving power of the unaided human eye is 0.0003 radian or an arc of approximately 1/60th of a degree. This corresponds to a resolution of approximately 30 meters from a 60 NM circular orbit, which is adequate for problems related to regional distributions and tectonic trends. The eye is also at an advantage because of the stereo viewing of a large field of view.

In regard to color sensitivity the unaided human eye, under good viewing conditions, can distinguish 10 million color surfaces, which represents a precision 2 to 3 times better than the most accurate photoelectric spectrophotometers. This capability is best utilized in deciphering subtle color differences between lunar surface units under varying sun angles and viewing directions. The dynamic range of the eye also allows visibility within what appears in photographs as "hard shadows" and "washout regions." Scene contrast does not affect the eye as much as it does photographic film. B

Most of these characteristics and unique abilities have been tested and demonstrated on previous manned flights. Lunar orbital periods of the Apollo missions provide an excellent opportunity to utilize human visual capability to supplement photographic, geochemical and geophysical data also to be gathered from lunar orbit. In addition to the recording of unexpected phenomena, visual observations will aid in the regional mapping and characterization of major units as well as the understanding of certain small scale features as follows:

- Color-tone of surface units: It has long been established by special photographic and photoelectric methods that there are subtle color differences in the lunar maria. Ground-truth data indicate that these tonal differences reflect compositional variations. The data are available for small areas in the near-side maria. Visual observations may extend the comparison to larger portions on the nearside as well as to the otherwise inaccessible farside maria. Subtle color differences in the highlands may also characterize these lunar surface materials.

- Global tectonic trends: Extensive fracture systems which delineate some of the major tectonic trends are decipherable in photographs. However, there appears to be global tectonic trends with subtle surface expressions. The delineation of such trends requires repetitive observations at varying sun angles and viewing.

- Small-scale features: A number of problems related to localized features of significant importance to our understanding of the moon could best be solved by visual observation from lunar orbit, such as the nature and extent of: a) the bright swirls of unknown origin recognized to date in three mare regions; b) the dark wall-like features such as those in the crater King; c) banding and possible layering on numerous mountain scarps; and d) the ray-excluded zones around a number of probable impact craters. B

To make and record scientifically valuable observations from lunar orbit, the crewman should be familiar with the orbit groundtracks and the critical characteristics of the observed features. Since the crew members become familiar with both in the course of their regular training for the mission, no special training is required. These observations constitute a significant complement to photographic data, and can only be accomplished by man.

<u>Previous Flight Objectives</u>

Objective Number	Title	Mission
None		

Table 1. Targets for Visual Observation

Target Number	Description	Start Longitude* (Degrees)	Stop Longitude* (Degrees)
1	N.W. TSIOLKOVSKI	135 E	125 E
2	PICARD	60 E	54 E
3	PROCLUS	53 E	45 E
4	CAUCHY	51 E	40 E
5	LITTROW	35 E	27 E
6	DAWES	31 E	26 E
7	SULPICIUS GALLUS	18 E	9 E
8	HADLEY RILLE	10 E	2 E
9	IMBRIUM FLOWS	15 W	24 W
10	HARBINGER MTS	35 W	44 W
11	ARISTARCHUS PLATEAU (IN EARTHSHINE)	46 W	52 W
11	ARISTARCHUS PLATEAU	44 W	54 W
12, 13	POST TEI AREAS	N/A	N/A

B

*Spacecraft nadir coordinates

4.12 VISUAL LIGHT FLASH PHENOMENON

Obtain data on the visual light flash phenomenon.

Purpose

The purpose is to obtain more definitive information on the characteristics and the cause of visual light flashes.

The functional test objective is as follows:

FTO 1) Obtain data during transearth coast relative to the frequency and description of light flashes and the degree of dark-adaptation required to see the flashes.

Test Conditions

FTO 1) During transearth coast, all crewmen will simultaneously don eye shields and face in the +X direction for a period of sixty minutes. C

During this test period, each crewman will report the following by voice communications to MCC (or, if necessary, will record the data on the CM tape recorder for subsequent playback to MSFN):

- GET to the nearest minute at time of donning and doffing eye shields.
- Frequency of flashes.
- Description of flashes.
- Location of crewmember in the CM.
- Approximate position and direction that the front of the head is pointed relative to the spacecraft X, Y, and Z axes.

During lunar orbit, on a non-interference basis, one crewman will don eye shields and report the following by voice communications to MCC or record the data on the CM tape recorder for subsequent playback to MSFN. The test period will consist of any one-half lunar orbit, which will provide 20 minutes for dark adaptation and two 20 minute data periods.

- GET to the nearest minute at time of donning and doffing eye shields.
- Frequency of flashes.

- Description of flashes.
- Location of the crewman in the CM.
- Approximate direction of the front of the head relative to the surface of the moon and the spacecraft X, Y, and Z axes.

It is preferred, but not mandatory, that the above one-half lunar orbit test period include crossing of a terminator approximately 40 minutes after donning eye shields. It is also preferred, but not mandatory, that the crewman be facing toward the lunar surface for the first 50 minutes and away from the lunar surface for the last 10 minutes. The reason for this procedure is to obtain data which will facilitate evaluation of the anisotropy of the phenomenon.

Success Criteria

FTO 1) The crew comments and corresponding spacecraft attitude data as specified under the Test Conditions for one transearth test period shall be obtained.

Evaluation

FTO 1) The frequency and description of flashes will be determined as a function of crewman's location within the spacecraft, direction head is facing, location and attitude of spacecraft with respect to sun, earth, and moon; differences between crewmen; and HZE radiation data. (MSFN tape recording of astronaut comments, astronaut debriefing comments, trajectory data, and HZE radiation dosimeter). B

Data Requirements

1) Astronaut Voice Records in Real Time:

   a) Comments defined under the Test Conditions for one test period during transearth coast. (M)

   b) Comments defined under the Test Conditions for one test period in lunar orbit. (HD)

2) MSFN tape recording of astronaut comments:

   a) For the transearth coast test period. (M)

   b) For the lunar orbit test period. (HD)

3) Astronaut Debriefings:

   a) One copy of astronaut postmission debriefing transcripts pertaining to comments on the transearth coast test period. (M)

   b) One copy of astronaut postmission debriefing transcripts pertaining to comments on the lunar orbit test period. (HD)

4) Trajectory: B

   a) One copy of tab listing containing the best estimate of trajectory including CSM attitude data during the transearth coast test period. (M)

   b) One copy of the tab listing containing the best estimate of trajectory including CSM attitude data during the lunar orbit test period. (HD)

4.12 VISUAL LIGHT FLASH PHENOMENON

Background and Justification

The crews of Apollo 11, 12, 13, and 14 have reported seeing light flashes and streaks of light when they were in the darkened CM, usually with their eyes closed, in translunar and transearth cost and in lunar orbit. The average frequency of occurrence has ranged from 0.5 to 2 events/minute.

The hypothesis set forth to explain this phenomenon is that the flashes are visual phosphenes induced by cosmic rays. There is, however, some controversy as to whether the cause is due to Cerenkov radiation produced by high-Z, high energy (HZE) particles traversing the eyeball, or whether the flashes result from ionizing collisions of these HZE particles in the retina, or visual centers of the cerebal cortex.

It is important to the future of long duration manned space flight that this phenomenon be satisfactorily explained. Cerenkov radiation is an electromagnetic analogue of a sonic boom; i.e., a sufficiently high-velocity charged particle, on entering a region whose refractive index is higher than that of space, moves more rapidly than its surrounding electrostatic field can propagate, so an electromagnetic shock wave is generated, propagating in a cone oriented in the direction of motion. The light flashes are harmless in this case, but the HZE particles that penetrate the retina or cerebal cortex may cause damage. There may be reason for more concern if the light flashes are due to ionizing collisions (rather than Cerenkov radiation) in the visual apparatus. The biological interactions of HZE ionizing radiation are not well understood, and some calculations have indicated that it is possible that as much as one to ten percent of the cells in the brain could be damaged during a three-year mission. Therefore, data should be obtained during the remaining Apollo missions to permit a better understanding of this phenomenon. B

Experiments have been conducted at the Lawrence Radiation Laboratory of the University of California at Berkeley which have demonstrated that neutrons can produce star-like phosphenes in dark-adaptated observers.

Neutrons, being uncharged, cannot produce Cerenkov radiation directly and, in some of these experiments, the neutron energies employed were so low that Cerenkov-emitting charged particles could not have been produced by means of interactions between the incident neutrons and atomic nuclei in the eye. Other mechanisms must be therefore considered as candidate explanations of the phenomenon observed in space.

The casual observations during previous missions will be replaced by more specific test conditions during Apollo Mission J-1 and follow-on missions. The intent is to obtain the maximum possible data within the constraints of the timeline and the available test equipment (i.e., eye shields and the HZE dosimeter).

The test during transearth coast is intended to determine the frequency and description of the light flashes and the degree of dark-adaptation required to see the flashes. Dark-adaptation is a retinal phenomenon. If the flashes are produced in the eyeball, anterior to the retina, it is probable that a considerable degree of dark-adaptation (approximately ten to twenty minutes) is required in order to see them, whereas, if they are produced in the retina or cerebal cortex, a dark visual field may be all that is necessary. During the test period, the crew will don eye shields (to prevent light from entering their eyes) and report how soon they begin seeing flashes, the frequency and description of the flashes. It is expected that a period of sixty minutes will be required for the observations in order to allow time for dark-adaptation and the collection of adequate statistics concerning the frequency and description of the light flashes. B

The test concerning observations in lunar orbit is designed to facilitate evaluation of anisotropic properties of the phenomena. The inclusion of a terminator passage during the observation period will provide data on the possibility of solar influence on the events. These evaluations will be made by examining the frequency of events under the changing conditions experienced during the lunar orbit. In addition, data bearing on the validity of the Cerenkov hypothesis may be obtained by analysis of the changes in frequencies of the different types of light flash events.

Previous Flight Objectives

Objective Number	Title	Mission
None		

B

5.0 EXPERIMENTS

Scientific experiments are those activities performed during and after a mission to better understand the moon or astronomical phenomena. This section is primarily concerned with the experiments recommended by the Manned Space Flight Experiments Board and assigned by the Office of Manned Space Flight (Reference 1). Other activities, which have not been assigned formal experiment numbers by the Manned Space Flight Experiments Board, are also included.

The necessary details for incorporation of the experiments into the flight plan, the criteria for data retrieval and evaluation, and the criteria for determining successful accomplishment are presented.

Implementation procedures are presented in the following documents:

a) Lunar Surface Procedures
b) Photographic and Television Procedures
c) Lunar Surface Checklist
d) Flight Plan
e) CMP Solo Book
f) Lunar Orbit Activities
g) Orbital EVA Procedures

The Bone Mineral Measurement Experiment (M-078) will be accomplished to investigate the phenomenon of body structure degradation due to reduced gravity. Of particular interest is the determination of the degree of bone mineral changes which might result from weightlessness and the extent to which the short exposure to 1/6 g on the lunar surface will modify these changes. An X-ray absorption technique will be used to measure the bone mineral content of the radius, ulna and os calcis preflight and postflight. No in-flight data nor specific in-flight crew tasks are required.

The Apollo Window Meteoroid Experiment (S-176) will be accomplished to determine the meteoroid cratering flux for particles responsible for the degradation of surfaces exposed to the space environment. No specific crew tasks are required to support this experiment. The requirements consist of returning the CM window to MSC following recovery of the spacecraft.

Every window meteoroid crater will be analyzed, photographed and measured in detail. These data may aid development of space hard materials and predictions of material lifetime in space.

The Total Body Gamma Spectrometry Experiment (M-079) will be accomplished to detect changes in total body potassium, total muscle mass (lean body mass) and to detect any induced radioactivity in the body of the crewmen. Preflight and postflight examination of each crew member will be performed by radiation detecting instruments in the Radiation Counting Laboratory at MSC. There are no in-flight requirements. A

5.1 CONTINGENCY SAMPLE COLLECTION

Collect a contingency sample.

Purpose

The purpose is to collect a small sample of loose material (approximately 2 kilograms) in the immediate vicinity of the LM during the early part of the first EVA period. This will increase the probability of returning a lunar sample to earth in the event of early termination of the EVA period.

The functional test objective is as follows:

FTO 1) Provide a contingency sample for postflight scientific investigations.

Test Conditions

FTO 1) A crewman will scoop up a loose sample of lunar material during the early part of the first EVA period. It is highly desirable that the sample be taken in the area already photographed through the LM window or during SEVA to assist in identifying the sample location. The sample container will be sealed and stowed in the LM ascent stage at the termination of the first EVA period. A

Success Criteria

FTO 1) Mandatory experiment evaluation data defined under Data Requirements shall be acquired and delivered to the Lunar Receiving Laboratory (LRL). A

Evaluation

FTO 1) Data returned to earth will be studied in the LRL and by the sample Principal Investigators. (Experiment evaluation data defined under Data Requirements) A

Data Requirements

1) Experiment Evaluation Data (EED): A

a) Astronaut Logs or Voice Records:

One copy each of astronaut logs or voice records describing the location of the sample area relative to the LM. (M)

b) Astronaut Debriefings:

One copy each of astronaut postmission scientific and photographic debriefing transcripts pertaining to the contingency sample collection activity. (HD)

c) Photographs:

Photographs of the sample area as viewed through the LM window. (HD)

d) Lunar Surface Sample:

Single sample of lunar surface material. (M)

5.1 CONTINGENCY SAMPLE COLLECTION

Background and Justification

The contingency sample will be collected as early as practicable during the initial EVA period. This will increase the probability of returning at least a minimal lunar sample should a contingency situation arise early during lunar stay which precludes any further EVA operations.

Apollo 11, 12, and 14 provided contingency samples and it is planned that Apollo Mission J-1 will also provide a contingency sample. It will be desirable to obtain such a sample at the new landing site for Apollo Mission J-1 in order to assess possible differences in the lunar surface material. A

Previous Flight Objectives/Experiments

Objective/Experiment Number	Title	Mission
A	Contingency Sample Collection	11
A	Contingency Sample Collection	12
5.1	Contingency Sample Collection	14

A

5.2 PASSIVE SEISMIC

Conduct the Passive Seismic Experiment (S-031).

Purpose

The purpose is to measure seismic signals from all external and internal sources of seismic energy on the moon. These data will be used to determine the internal structure of the moon, the rate of energy release, and the numbers and masses of meteoroids impacting the lunar surface.

The functional test objectives are as follows:

FTO 1) Obtain data on seismic activity due to tectonic disturbances and meteoroid impacts.

FTO 2) Measure seismic signals resulting from impact of the spent LM ascent stage.

FTO 3) Measure tidal tilt and change in gravity at the instrument location.

FTO 4) Measure seismic signals due to astronaut activities on the lunar surface.

Test Conditions

FTO 1)
FTO 2)
FTO 3)
FTO 4)

The Passive Seismic Experiment (PSE) is part of Apollo 15 ALSEP which will be deployed on the lunar surface during the first EVA. A

Astronaut activities will be as follows:

a) The astronaut will deploy the PSE.

b) The astronaut will coarse-level and rough-align the sensor assembly.

c) The astronaut will deploy the thermal shroud.

d) The astronaut will perform a fine leveling and report the azimuth reading to MCC.

e) The astronaut will take two photographs of the deployed PSE using the Hasselblad electric data camera as follows: one photograph of the PSE taken cross-sun from a distance of 3 feet and showing the bubble level and the gnomon shadow on the compass rose; and one photograph of the PSE taken from a distance of 7 feet and showing the central station in the background.

After the PSE is deployed and the ALSEP central station is activated, MCC will initiate commands to accomplish PSE TURN-ON. The PSE will then monitor seismic activity. Data will be transmitted to earth and recorded for as much of the planned 1-year ALSEP operational period as possible, consistent with equipment capabilities and operational requirements of other ALSEP experiments. Gain adjustments will be made as required during periods of MCC monitoring. The commands to be issued by MCC will be defined in Appendix D of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Vol. V, ALSEP Data Book.

FTO 2) The LM ascent stage will impact on the lunar surface at latitude 26°24'N and longitude 1°06'E after final CSM/LM separation, C and the resulting seismic signals will be monitored by the PSE.

Success Criteria

FTO 1)
FTO 2)
FTO 3)
FTO 4) Experiment data defined as mandatory under Data Requirements shall be provided to the Principal Investigator and shall include EED telemetry data for a minimum of one lunar day after activation of the ALSEP central station on the lunar surface.

Evaluation

FTO 1) Seismic activity due to tectonic disturbances and meteoroid impacts will be determined. (Premission, experiment support, and experiment evaluation data, including telemetry measurements AL-1, AL-2, AL-4, DL-1, DL-2, and DL-3)

FTO 2) Seismic signals resulting from impact of the spent LM ascent stage will be utilized to improve the existing lunar seismic data base. (Premission, experiment support, and experiment evaluation data, including telemetry measurements AL-1, AL-2, AL-4, DL-1, DL-2, and DL-3)

FTO 3) Tidal tilt and changes in gravity will be determined. (Premission, experiment support, and experiment evaluation data, including telemetry measurements DL-4 through DL-8)

FTO 4) Seismic signals due to astronaut activities on the lunar surface will be analyzed to verify validity of data in support of FTO's 1), 2), and 3). (Premission, experiment support, and experiment evaluation data, including telemetry measurements AL-1, AL-2, AL-4, DL-1, DL-2, and DL-3)

FTO 1)
FTO 2)
FTO 3)
FTO 4) Tapes will be reformatted at MSC for processing by the Principal Investigator. Data processing of the PSE magnetic tapes will be accomplished by the Principal Investigator. (Experiment evaluation data as defined under Data Requirements)

Data Requirements

1) Premission Data (PD): (M) A

Calibration and Checkout Data:

Premission experiment calibration data included in the Apollo 15 ALSEP Final Acceptance Data Package provided to NASA/MSC by the integration contractor. A

2) Experiment Support Data (ESD): (M)

a) Telemetry Measurements:

Telemetry measurements listed under 3)a). Display preference is indicated by (A) for analog. A

b) Voice Comments:

Azimuth reading at completion of PSE alignment.

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Priority PD*	ESD	EED
AL-1	Long Period Amplifier Gain X&Y	PCM		HD	M
AL-2	Long Period Amplifier Gain Z	PCM		HD	M
AL-4	Short Period Amplifier Gain Z	PCM		HD	M
DL-1	Long Period Seismic X	PCM		M(A)	M
DL-2	Long Period Seismic Y	PCM		M(A)	M
DL-3	Long Period Seismic Z	PCM		M(A)	M
DL-4	Tidal: X	PCM		M(A)	M
DL-5	Tidal: Y	PCM		M(A)	M
DL-6	Tidal: Z	PCM		M(A)	M
DL-7	Sensor Unit Temperature	PCM		HD	M
DL-8	Short Period Seismic Z	PCM		M(A)	M

*There are no requirements for Premission Data (PD). A

b) Telemetry Measurement Tapes: (M)

Three copies of 7-track, 800-BPI binary tapes containing EED telemetered measurements listed under 3)a), recorded and correlated with GMT during periods of experiment operation. The tapes are to be mutually compatible with the PDP 15 and IBM 1130 computers.

c) Astronaut Logs or Voice Records: (M)

One copy each of astronaut logs or voice records containing azimuth reading at completion of PSE alignment.

d) Astronaut Debriefings: (HD) A

One copy each of astronaut postmission scientific and photographic debriefing transcripts pertaining to experiment deployment.

e) Photographs: (HD) A

(1) One copy each of the photographs of the deployed PSE as defined under the Test Conditions.

(2) One copy of any lunar surface photographs which show the PSE.

4) Supporting Data: (M)

a) One copy of postflight data on ascent of the LM containing:

(1) APS ignition time.

(2) APS thrust chamber pressure at least every 2 seconds for the first 60 seconds of burn.

(3) BET data with spacecraft attitude every 2 seconds for the first 60 seconds of ascent flight.

b) One copy of postflight data on impact of the LM ascent stage containing: A

(1) Mass at impact.

(2) Velocity at impact.

(3) Heading at impact.

(4) Angle with respect to surface at impact.

(5) Mass of fuel remaining at impact.

(6) Location and time of impact.

(7) Distance and azimuth of impact point from ALSEP 12, 14, and 15.

5.2 PASSIVE SEISMIC

Background and Justification

The PSE is designed to monitor seismic activity and will additionally detect meteoroid impacts and free oscillations of the moon. It may also detect changes in gravity and surface tidal deformations resulting in part from periodic variations in the strength and direction of external gravitational fields acting upon the moon. A

Analysis of the velocity, frequency, amplitude and attenuation characteristics of the seismic waves should provide data on the number and character of lunar seismic events, the approximate azimuth and distance to their epicenters, the physical properties of subsurface materials and the general structure of the lunar interior.

No seismic signals with characteristics similar to terrestrial signals have been observed for the moon. The high sensitivity at which the lunar seismometers have been operated would have resulted in the detection of many such signals if the moon were as seismically active as the earth and had the same transmission characteristics as the earth. Thus, the data obtained to date indicates that either seismic energy release is far less for the moon than for the earth or that the interior of the moon greatly attenuates seismic waves.

The PSE has recorded prolonged signals with a gradual buildup and then a slow decrease in signal amplitude. Signals with these characteristics may imply transmissions with very low attenuation and intense wave scattering, conditions that are mutually exclusive on earth. Because of the similarity with the signal from the impact of the LM ascent stage, these recorded signals are thought to be produced by meteoroid impacts and shallow moonquakes. Most of the events that produced these signals appear to have originated within 300 km of the ALSEP.

A PSE was deployed during Apollo 11, 12, and 14, and is planned to be deployed during Apollo Mission J-1. It is planned to deploy additional passive seismic experiments on future lunar missions. Any increase in the number of active instruments will improve the directional information which may be collected. A

The two photographs described under Test Conditions are to provide a permanent record for verifying the PSE precise level condition, orientation with respect to the sun, location within the ALSEP array, and condition of the thermal shroud. These photographic data are important in interpreting and compensating for any off-nominal experiment operation or anomalous results. B

Previous Mission Experiments

Experiment Number	Title	Mission
S-031	Lunar Passive Seismology	11
S-031	Passive Seismic Experiment	12
S-031	Passive Seismic Experiment	14

5.3 HEAT FLOW

Conduct the Heat Flow Experiment (S-037).

Purpose

The purpose is to determine the rate of heat loss from the lunar interior.

The functional test objectives are as follows:

FTO 1) Measure the subsurface vertical temperature gradients in the lunar surface layer as a function of time.

FTO 2) Measure the absolute temperature of the lunar subsurface as a function of time.

FTO 3) Determine the thermal conductivity of the lunar subsurface material.

Test Conditions

FTO 1)
FTO 2)
FTO 3) The Heat Flow Experiment (HFE) is part of Apollo 15 ALSEP which will be deployed on the lunar surface during the first EVA. A

Astronaut activities will be accomplished as follows:

a) The astronaut will deploy and align the HFE electronics package.

b) Prior to use of the Apollo Lunar Surface Drill (ALSD) in support of the Lunar Geology Investigation, the astronaut will use the ALSD to drill two holes approximately 30 feet apart and approximately 10 feet deep in the lunar surface. This will be accomplished by drilling sections of hollow bore stems into the lunar surface with the ALSD. Upon completion of the drilling, the ALSD will be disengaged from the bore stem. The bore stem will remain in the lunar surface with approximately 6 to 8 inches of bore stem protruding above the surface. The astronaut will insert a sensor/heater probe into each bore stem and push the probe down into the bore stem using the emplacement tool. With the probe fully inserted, the astronaut will report the lowest visible alphanumeric marking on the emplacement tool to indicate the depth of penetration. After the probes have been emplaced and the depths of penetration recorded, the emplacement tool will be discarded on the lunar surface. A

c) After HFE deployment is completed, the astronaut will obtain photographs using the Hasselblad electric data camera as follows:

   (1) One photograph of each bore stem, with probe emplaced, taken down-sun at a distance of 7 feet.

   (2) One photograph of the electronics package taken from the North at a distance of 7 feet. A

   (3) One stereo pair of photographs of each bore stem with probe emplaced taken from the North at a distance of 11 feet.

After the HFE is deployed and the ALSEP central station is activated, MCC will initiate the commands to accomplish HFE TURN-ON as soon as possible. The HFE will be operated in the preset gradient test mode (mode 1) initially, and temperature gradient and absolute temperature data will be obtained. The HFE will normally be operated in the gradient mode during the planned 1-year ALSEP operational period except when the low conductivity and high conductivity tests are performed. The commands to be issued by MCC will be defined in Appendix D of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Vol. V, ALSEP Data Book. A

Each conductivity experiment in the low conductivity mode (mode 2) requires 24 hours, and each experiment in the high conductivity mode (mode 3) requires 10 hours. If a conductivity test is interrupted, the test must be repeated in its entirety. These tests will be initiated within the first 45-day period after ALSEP activation and during the last 2 months of the lunar year at times to be selected by the Principal Investigator.

Success Criteria

FTO 1)
FTO 2)
FTO 3) The experiment data defined as mandatory under the Data Requirements shall be provided to the Principal Investigator and shall include telemetry data for a minimum of one lunar day after activation of the ALSEP central station on the lunar surface.

Evaluation

FTO 1) Subsurface vertical temperature gradients in the lunar surface layer will be determined as a function of time. [Premission, experiment support, and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under 3)a)] A

FTO 2) The absolute temperature of the lunar subsurface will be determined as a function of time. [Premission, experiment A support, and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under 3)a)] A

FTO 3) The thermal conductivity of the lunar subsurface material will be determined. [Premission, experiment support, and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under 3)a)] A

FTO 1)
FTO 2)
FTO 3) Tapes will be reformatted at MSC for processing by the Principal Investigator. Data processing of the HFE magnetic tapes will be accomplished by the Principal Investigator. (Experiment evaluation data as defined under Data Requirements) A

Data Requirements

1) Premission Data (PD): (M)

Calibration and Checkout Data: A

Premission calibration data included in the Apollo 15 ALSEP Final Acceptance Data Package provided to NASA/MSC by the integration contractor.

2) Experiment Support Data (ESD): (M)

a) Telemetry Measurements: A

Telemetry measurements listed under 3)a). Display preference is indicated by (D) for digital.

b) Voice Comments:

Alphanumeric marking on the emplacement tool at completion of each HFE probe insertion.

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements: A

Measurement Number	Description	TM	Priority PD*	ESD	EED
DH-1	Temp Grad High Sens	PCM		M(D)	M
DH-2	Temp Grad High Sens	PCM		M(D)	M
DH-3	Temp Grad High Sens	PCM		M(D)	M
DH-4	Temp Grad High Sens	PCM		M(D)	M
DH-5	Temp Grad Low Sens	PCM		M(D)	M
DH-6	Temp Grad Low Sens	PCM		M(D)	M
DH-7	Temp Grad Low Sens	PCM		M(D)	M
DH-8	Temp Grad Low Sens	PCM		M(D)	M
DH-9	Probe Ambient Temp	PCM		M(D)	M
DH-10	Probe Ambient Temp	PCM		M(D)	M

Measurement Number	Description	TM	Priority PD*	ESD	EED
DH-11	Probe Ambient Temp	PCM		M(D)	M
DH-12	Probe Ambient Temp	PCM		M(D)	M
DH-13	Temp Ref Junction	PCM		M(D)	M
DH-14	Probe Cable Temp	PCM		M(D)	M
DH-15	Temp Ref Junction	PCM		M(D)	M
DH-16	Probe Cable Temp	PCM		M(D)	M
DH-24	Probe Cable Temp	PCM		M(D)	M
DH-26	Probe Cable Temp	PCM		M(D)	M
DH-34	Probe Cable Temp	PCM		M(D)	M
DH-36	Probe Cable Temp	PCM		M(D)	M
DH-44	Probe Cable Temp	PCM		M(D)	M
DH-46	Probe Cable Temp	PCM		M(D)	M
DH-50	Differential Temp	PCM		M(D)	M
DH-51	Ambient Temp	PCM		M(D)	M
DH-52	Differential Temp	PCM		M(D)	M
DH-53	Ambient Temp	PCM		M(D)	M
DH-56	Differential Temp	PCM		M(D)	M
DH-57	Ambient Temp	PCM		M(D)	M
DH-58	Differential Temp	PCM		M(D)	M
DH-59	Ambient Temp	PCM		M(D)	M
DH-60	Differential Temp	PCM		M(D)	M
DH-61	Ambient Temp	PCM		M(D)	M
DH-62	Differential Temp	PCM		M(D)	M
DH-63	Ambient Temp	PCM		M(D)	M
DH-66	Differential Temp	PCM		M(D)	M
DH-67	Ambient Temp	PCM		M(D)	M
DH-68	Differential Temp	PCM		M(D)	M
DH-69	Ambient Temp	PCM		M(D)	M
DH-70	Differential Temp	PCM		M(D)	M
DH-71	Ambient Temp	PCM		M(D)	M
DH-72	Differential Temp	PCM		M(D)	M
DH-73	Ambient Temp	PCM		M(D)	M
DH-76	Differential Temp	PCM		M(D)	M
DH-77	Ambient Temp	PCM		M(D)	M
DH-78	Differential Temp	PCM		M(D)	M
DH-79	Ambient Temp	PCM		M(D)	M
DH-80	Differential Temp	PCM		M(D)	M
DH-81	Ambient Temp	PCM		M(D)	M
DH-82	Differential Temp	PCM		M(D)	M
DH-83	Ambient Temp	PCM		M(D)	M
DH-86	Differential Temp	PCM		M(D)	M
DH-87	Ambient Temp	PCM		M(D)	M
DH-88	Differential Temp	PCM		M(D)	M
DH-89	Ambient Temp	PCM		M(D)	M

A

*There are no requirements for Premission Data (PD).

b) Telemetry Measurement Tapes: (M)

One copy of 7-track, 800-BPI binary tapes containing EED telemetry measurements listed under 3)a), recorded and correlated with GMT during periods of experiment operation. The tapes are to be compatible with an IBM 1130 computer. A

c) Astronaut Logs or Voice Records: (M)

One copy of each astronaut logs or voice records containing alphanumeric markings on the emplacement tool at completion of each HFE probe insertion.

d) Astronaut Debriefings: (HD)

One copy of each astronaut postmission scientific and photographic debriefing transcript pertaining to experiment deployment. A

e) Photographs: (HD)

(1) One copy each of the photographs defined under Test Conditions.

(2) LRL photographs of the drill core stems (returned to earth from Lunar Geology Investigation Experiment S-059) before and after they have been split for analysis.

f) Supporting Data: (HD) A

One copy of the Preliminary Evaluation Team's description of the core material from the drill core stems returned to earth from Lunar Geology Investigation Experiment S-059.

5.3 HEAT FLOW

Background and Justification

This experiment is designed to measure the heat flux through the upper 3 meters of the lunar surface. Two heat flow probes will be emplaced in the two boreholes drilled by the astronaut using the Apollo lunar surface drill. Each probe will measure the thermal conductivity and temperature gradient within each of the boreholes.

This experiment is expected to provide data on lunar soil thermal conductivity, contribute to the resolution of issues concerning the internal lunar heating processes, and establish constraints on the interior temperature and composition of the moon. Specifically, the HFE is expected to furnish the following:

a) A basis for comparison of the radioactive content of the moon's interior and the earth's mantle;

b) Boundary conditions of the thermal history of the moon;

c) Temperature versus depth profile of the outer layers of the moon;

d) Thermal properties in the first 3 meters of the moon's crust.

The seven photographs described under Test Conditions are to provide a permanent record of verification of the verticality of the probe holes, the gross appearance of the excavated soil, footprints or other soil disturbances near the HFE probes which affect local surface albedo and hence the amount of solar energy absorbed, location of the HFE within the ALSEP array, and the configuration of the deployed HFE (e.g., the lie of the cables). These photographic data are important in interpreting and compensating for any off-nominal experiment operation or anomalous results. B

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.4 LUNAR SURFACE MAGNETOMETER

Conduct the Lunar Surface Magnetometer Experiment (S-034).

Purpose

The purpose is to measure the magnitude and temporal variations of the lunar surface magnetic field vector in order to determine the internal electrical properties of the moon.

The functional test objectives are as follows:

FTO 1) Obtain data to determine the lunar magnetic field vector in the vicinity of the landing site.

FTO 2) Obtain data to determine the temporal variations of the lunar magnetic field vector.

Test Conditions

FTO 1)
FTO 2) The Lunar Surface Magnetometer (LSM) is part of Apollo 15 ALSEP which will be deployed on the lunar surface during the first EVA. A

Astronaut activities will be accomplished as follows:

a) The astronaut will deploy, level and align the LSM.

b) The astronaut will report the shadowgraph alignment reading (number of lines or degrees, plus or minus) to MCC prior to sunshade deployment and after completion of LSM emplacement. A

c) The astronaut will take two photographs of the deployed LSM using the Hasselblad electric data camera as follows: one of the LSM taken from a distance of 3 feet and focused directly on the shadowgraph prior to sunshade deployment; and one of the LSM taken from a distance of 7 feet with the central station in the background, if possible. A

After the LSM is deployed and the ALSEP central station is activated, MCC will initiate commands to accomplish LSM TURN-ON. The LSM will then obtain data on the lunar surface magnetic field. Data will be transmitted to earth and recorded by MSFN stations for as much of the planned 1-year ALSEP operational period as possible, consistent with equipment capabilities and operational requirements of other ALSEP experiments. LSM sensor range adjustments will be made as required during periods of MCC monitoring. The commands to be issued by MCC will be defined in Appendix D of the CSM/LM Spacecraft Operational Data Book SNA-8-D-027, Vol. V, ALSEP Data Book. A

FTO 1) The MCC will initiate commands to perform a site survey at a time specified by the Principal Investigator. The site survey will be performed only once and will occur after the astronauts have left the lunar surface. The site survey will be performed when a steady magnetic field condition exists as determined in real time. A

Success Criteria

FTO 1)
FTO 2) The experiment data defined as mandatory under the Data Requirements shall be provided to the Principal Investigator and shall include telemetry data for a minimum of one lunar day after activation of the ALSEP central station on the lunar surface.

Evaluation

FTO 1) The lunar magnetic field vector in the vicinity of the landing site will be determined. [Premission, experiment support, and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under 3)a)] A

FTO 2) The temporal variations of the lunar magnetic field vector will be determined. [Premission, experiment support, and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under 3)a)] A

FTO 1)
FTO 2) Tapes will be reformatted at MSC for processing by the Principal Investigator. Data processing of the LSM magnetic tapes will be accomplished by the Principal Investigator (Experiment evaluation data as defined under Data Requirements) A

Data Requirements

1) Premission Data: (M)

Calibration and Checkout Data: A

Premission experiment calibration data included in the Apollo 15 ALSEP Final Acceptance Data Package provided to NASA/MSC by the ALSEP integration contractor. A

2) Experiment Support Data (ESD): (M)

a) Telemetry Measurements:

Telemetry measurements listed under 3)a). Display preference is indicated by (A) for analog.

b) Voice Comments:

Shadowgraph alignment reading (number of lines or degrees, plus or minus) read prior to sunshade deployment and after completion of LSM emplacement.

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Priority PD*	ESD	EED
DM-1	Temperature #1 (X Sensor)	PCM		HD	M
DM-2	Temperature #2 (Y Sensor)	PCM		HD	M
DM-3	Temperature #3 (Z Sensor)	PCM		HD	M
DM-6	Level Sensor #1	PCM		M(A)	M
DM-7	Level Sensor #2	PCM		M(A)	M
DM-9	X Flip Position	PCM		M	M
DM-10	Y Flip Position	PCM		M	M
DM-11	Z Flip Position	PCM		M	M
DM-12	X Gimbal Position	PCM		M	M
DM-13	Y Gimbal Position	PCM		M	M
DM-14	Z Gimbal Position	PCM		M	M
DM-16	Measurement Range	PCM		M	M
DM-17	X Offset Field	PCM		M	M
DM-18	Y Offset Field	PCM		M	M
DM-19	Z Offset Field	PCM		M	M
DM-22	Filter In or Out	PCM		HD	M
DM-25	X-Axis Field	PCM		M(A)	M
DM-26	Y-Axis Field	PCM		M(A)	M
DM-27	Z-Axis Field	PCM		M(A)	M

A

*There are no requirements for Premission Data (PD).

b) Telemetry Measurement Tapes: (M)

One copy of 7-track, 800-BPI binary tapes containing EED telemetered measurements listed under 3)a), recorded and correlated with GMT during periods of experiment operation. The tapes are to be compatible with an IBM 7094 computer.

c) Astronaut Logs or Voice Records: (M)

One copy each of astronaut logs or voice records containing alignment reading at completion of LSM emplacement.

d) Astronaut Debriefings: (HD) A

One copy each of astronaut postmission scientific and photographic debriefing transcripts pertaining to the experiment.

e) Photographs: (HD) A

(1) One copy each of the two photographs of the deployed LSM as defined under the Test Conditions.

(2) One copy of any lunar surface photograph which shows the LSM.

5.4 LUNAR SURFACE MAGNETOMETER

Background and Justification

The Lunar Surface Magnetometer (LSM) Experiment is designed to measure the magnitude and temporal variations of the lunar surface magnetic field vector. Data from this experiment will also be used to derive information on the electrical properties of the deep interior of the moon and on the interplanetary magnetic field that diffuses through the moon.

Magnetometer measurements will be used to determine the lunar response to fluctuations in the interplanetary magnetic field and to measure the time invariant field associated with the whole moon and with local sources. Measurements of the induced lunar magnetic field permit the electrical conductivity of the lunar interior to be calculated. Because electrical conductivity is a function of temperature, these magnetic field measurements provide information on the thermal state of the lunar interior. Such information is crucial for differentiation between existing theories of lunar formation and history.

Considerable progress in the determination of the electrodynamic properties of the moon has been made as the result of recent experiments. A The Apollo 12 magnetometer detected a steady magnetic field of approximately 36 gammas superimposed upon the geomagnetic tail, transition region, and interplanetary fields through which the moon passes during each orbit. The 36-gamma field is considered to be the result of a localized source near the Apollo 12 landing site rather than a uniform dipole moment associated with the whole moon. Data from the Apollo 12 magnetometer during the lunar day and night and during large field transients as well as correlation with the Explorer XXXV magnetometer indicate a strong lunar inductive response to external magnetic fields.

Data from the Portable Magnetometer Experiment (S-198) conducted during Apollo 14 supplemented the Apollo 12 results by providing information on the size properties of the source of the Apollo 14 local magnetic field.

Measurements from Apollo Mission J-1 magnetometer experiments (S-034 and S-174) will be used for mapping the local static magnetic field. The lunar surface magnetometer data will be compared with Explorer XXXV magnetometer data and will be used to calculate the radial distribution of the electrical conductivity of the lunar interior. From the radial distribution data, the temperature of the lunar interior will be calculated.

The two photographs described under Test Conditions are to provide a permanent record of the LSM precise orientation with respect to the sun, location within the ALSEP array, and physical condition after deployment. These photographic data are important in interpreting and compensating for any off-nominal experiment operation or anomalous results. B

Previous Mission Experiments

Experiment Number	Title	Mission
S-034	Lunar Surface Mangetometer Experiment	12
S-198	Portable Magnetometer Experiment	14

5.5 SOLAR WIND SPECTROMETER

Conduct the Solar Wind Spectrometer Experiment (S-035).

Purpose

The purpose is to measure energies, densities, incidence angles, and temporal variations of the electron and proton components of the solar wind plasma that strikes the surface of the moon.

The functional test objectives are as follows:

FTO 1) Obtain data on the existence of solar wind plasma on the moon.

FTO 2) Obtain data on solar wind properties.

FTO 3) Obtain data on the interactions between the moon, solar wind, and magnetospheric tail of the earth.

Test Conditions

FTO 1)
FTO 2)
FTO 3) The Solar Wind Spectrometer (SWS) is part of the Apollo 15 ALSEP which will be deployed on the lunar surface during the first EVA. A

Astronaut activities will be accomplished as follows:

a) The SWS will be deployed on a relatively smooth flat surface to avoid thermal perturbations.

b) The SWS will be aligned.

c) The Hasselblad electric data camera will be used to obtain photographs of the deployed experiment as follows:

(1) One photograph, cross-sun, 3 feet from the SWS, looking north.

(2) One photograph, cross-sun, 3 feet from the SWS, looking south.

Upon completion of the SWS deployment and ALSEP central station activation, the Principal Investigator will direct MCC to send the commands to accomplish SWS TURN-ON. At some time after the astronauts have left the lunar surface MCC will send commands to release the dust cover. The SWS will then monitor the lunar surface environment and data will be transmitted to earth and recorded at MSFN stations for as much of the planned

1-year ALSEP operational period as possible, consistent with equipment capabilities and the operational requirements of other ALSEP experiments. Gain adjustments will be made as required during periods of MCC monitoring. The commands to be issued by MCC will be defined in Appendix D of the CSM/ LM Spacecraft Operational Data Book, SNA-8-D-027, Vol. V, ALSEP Data Book. A

Success Criteria

FTO 1) FTO 2) Experiment data defined as mandatory under Data Requirements shall be provided to the Principal Investigator and shall include telemetry data for a minimum of one lunar day after activation of the ALSEP central station on the lunar surface.

Evaluation

FTO 1) The existence of solar wind plasma at the surface of the moon will be determined. (Premission, experiment support, and experiment evaluation data, including all EED telemetry measurements listed under Data Requirements) A

FTO 2) The properties of the solar wind plasma at the lunar surface will be determined. (Premission, experiment support, and experiment evaluation data, including all EED telemetry measurements listed under Data Requirements) A

FTO 3) The interactions between the moon, solar wind, and magnetospheric tail of the earth will be determined. (Premission, experiment support, and experiment evaluation data, including all EED telemetry measurements listed under Data Requirements) A

FTO 1) FTO 2) FTO 3) Tapes will be reformatted at MSC for processing by the Principal Investigator. Data processing of the SWS magnetic tapes will be accomplished by the Principal Investigator. (Experiment evaluation data as defined under Data Requirements) A

Data Requirements

1) Premission Data: (M)

Calibration and Checkout Data:

Premission experiment calibration data included in the Apollo 15 ALSEP Final Acceptance Data Package provided to NASA/MSC by the ALSEP integration contractor.

2) Experiment Support Data (ESD): (M) A

Telemetry Measurements:

Telemetry measurements listed under 3)a). Display preference is indicated by (D) for digital.

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Priority PD*	ESD	EED
DY-1	Pos Ions - Sum - Lev 1	PCM		HD(D)	M
DY-2	Pos Ions - Cup 1 - Lev 1	PCM		HD(D)	M
DY-3	Pos Ions - Cup 2 - Lev 1	PCM		HD(D)	M
DY-4	Pos Ions - Cup 3 - Lev 1	PCM		HD(D)	M
DY-5	Pos Ions - Cup 4 - Lev 1	PCM		HD(D)	M
DY-6	Pos Ions - Cup 5 - Lev 1	PCM		HD(D)	M
DY-7	Pos Ions - Cup 6 - Lev 1	PCM		HD(D)	M
DY-8	Pos Ions - Cup 7 - Lev 1	PCM		HD(D)	M
DY-9	Pos Ions - Sum - Lev 2	PCM		HD(D)	M
DY-10	Pos Ions - Cup 1 - Lev 2	PCM		HD(D)	M
DY-11	Pos Ions - Cup 2 - Lev 2	PCM		HD(D)	M
DY-12	Pos Ions - Cup 3 - Lev 2	PCM		HD(D)	M
DY-13	Pos Ions - Cup 4 - Lev 2	PCM		HD(D)	M
DY-14	Pos Ions - Cup 5 - Lev 2	PCM		HD(D)	M
DY-15	Pos Ions - Cup 6 - Lev 2	PCM		HD(D)	M
DY-16	Pos Ions - Cup 7 - Lev 2	PCM		HD(D)	M
DY-17	Pos Ions - Sum - Lev 3	PCM		HD(D)	M
DY-18	Pos Ions - Cup 1 - Lev 3	PCM		HD(D)	M
DY-19	Pos Ions - Cup 2 - Lev 3	PCM		HD(D)	M
DY-20	Pos Ions - Cup 3 - Lev 3	PCM		HD(D)	M
DY-21	Pos Ions - Cup 4 - Lev 3	PCM		HD(D)	M
DY-22	Pos Ions - Cup 5 - Lev 3	PCM		HD(D)	M
DY-23	Pos Ions - Cup 6 - Lev 3	PCM		HD(D)	M
DY-24	Pos Ions - Cup 7 - Lev 3	PCM		HD(D)	M
DY-25	Pos Ions - Sum - Lev 4	PCM		HD(D)	M
DY-26	Pos Ions - Cup 1 - Lev 4	PCM		HD(D)	M
DY-27	Pos Ions - Cup 2 - Lev 4	PCM		HD(D)	M
DY-28	Pos Ions - Cup 3 - Lev 4	PCM		HD(D)	M
DY-29	Pos Ions - Cup 4 - Lev 4	PCM		HD(D)	M
DY-30	Pos Ions - Cup 5 - Lev 4	PCM		HD(D)	M
DY-31	Pos Ions - Cup 6 - Lev 4	PCM		HD(D)	M
DY-32	Pos Ions - Cup 7 - Lev 4	PCM		HD(D)	M
DY-33	Pos Ions - Sum - Lev 5	PCM		HD(D)	M
DY-34	Pos Ions - Cup 1 - Lev 5	PCM		HD(D)	M
DY-35	Pos Ions - Cup 2 - Lev 5	PCM		HD(D)	M
DY-36	Pos Ions - Cup 3 - Lev 5	PCM		HD(D)	M
DY-37	Pos Ions - Cup 4 - Lev 5	PCM		HD(D)	M
DY-38	Pos Ions - Cup 5 - Lev 5	PCM		HD(D)	M
DY-39	Pos Ions - Cup 6 - Lev 5	PCM		HD(D)	M
DY-40	Pos Ions - Cup 7 - Lev 5	PCM		HD(D)	M
DY-41	Pos Ions - Sum - Lev 6	PCM		HD(D)	M
DY-42	Pos Ions - Cup 1 - Lev 6	PCM		HD(D)	M
DY-43	Pos Ions - Cup 2 - Lev 6	PCM		HD(D)	M
DY-44	Pos Ions - Cup 3 - Lev 6	PCM		HD(D)	M
DY-45	Pos Ions - Cup 4 - Lev 6	PCM		HD(D)	M

A

Measurement Number	Description	TM	Priority PD*	ESD	EED
DY-46	Pos Ions - Cup 5 - Lev 6	PCM		HD(D)	M
DY-47	Pos Ions - Cup 6 - Lev 6	PCM		HD(D)	M
DY-48	Pos Ions - Cup 7 - Lev 6	PCM		HD(D)	M
DY-49	Pos Ions - Sum - Lev 7	PCM		HD(D)	M
DY-50	Pos Ions - Cup 1 - Lev 7	PCM		HD(D)	M
DY-51	Pos Ions - Cup 2 - Lev 7	PCM		HD(D)	M
DY-52	Pos Ions - Cup 3 - Lev 7	PCM		HD(D)	M
DY-53	Pos Ions - Cup 4 - Lev 7	PCM		HD(D)	M
DY-54	Pos Ions - Cup 5 - Lev 7	PCM		HD(D)	M
DY-55	Pos Ions - Cup 6 - Lev 7	PCM		HD(D)	M
DY-56	Pos Ions - Cup 7 - Lev 7	PCM		HD(D)	M
DY-57	Pos Ions - Sum - Lev 8	PCM		HD(D)	M
DY-58	Pos Ions - Cup 1 - Lev 8	PCM		HD(D)	M
DY-59	Pos Ions - Cup 2 - Lev 8	PCM		HD(D)	M
DY-60	Pos Ions - Cup 3 - Lev 8	PCM		HD(D)	M
DY-61	Pos Ions - Cup 4 - Lev 8	PCM		HD(D)	M
DY-62	Pos Ions - Cup 5 - Lev 8	PCM		HD(D)	M
DY-63	Pos Ions - Cup 6 - Lev 8	PCM		HD(D)	M
DY-64	Pos Ions - Cup 7 - Lev 8	PCM		HD(D)	M
DY-65	Pos Ions - Sum - Lev 9	PCM		HD(D)	M
DY-66	Pos Ions - Cup 1 - Lev 9	PCM		HD(D)	M
DY-67	Pos Ions - Cup 2 - Lev 9	PCM		HD(D)	M
DY-68	Pos Ions - Cup 3 - Lev 9	PCM		HD(D)	M
DY-69	Pos Ions - Cup 4 - Lev 9	PCM		HD(D)	M
DY-70	Pos Ions - Cup 5 - Lev 9	PCM		HD(D)	M
DY-71	Pos Ions - Cup 6 - Lev 9	PCM		HD(D)	M
DY-72	Pos Ions - Cup 7 - Lev 9	PCM		HD(D)	M
DY-73	Pos Ions - Sum - Lev 10	PCM		HD(D)	M
DY-74	Pos Ions - Cup 1 - Lev 10	PCM		HD(D)	M
DY-75	Pos Ions - Cup 2 - Lev 10	PCM		HD(D)	M
DY-76	Pos Ions - Cup 3 - Lev 10	PCM		HD(D)	M
DY-77	Pos Ions - Cup 4 - Lev 10	PCM		HD(D)	M
DY-78	Pos Ions - Cup 5 - Lev 10	PCM		HD(D)	M
DY-79	Pos Ions - Cup 6 - Lev 10	PCM		HD(D)	M
DY-80	Pos Ions - Cup 7 - Lev 10	PCM		HD(D)	M
DY-81	Pos Ions - Sum - Lev 11	PCM		HD(D)	M
DY-82	Pos Ions - Cup 1 - Lev 11	PCM		HD(D)	M
DY-83	Pos Ions - Cup 2 - Lev 11	PCM		HD(D)	M
DY-84	Pos Ions - Cup 3 - Lev 11	PCM		HD(D)	M
DY-85	Pos Ions - Cup 4 - Lev 11	PCM		HD(D)	M
DY-86	Pos Ions - Cup 5 - Lev 11	PCM		HD(D)	M
DY-87	Pos Ions - Cup 6 - Lev 11	PCM		HD(D)	M
DY-88	Pos Ions - Cup 7 - Lev 11	PCM		HD(D)	M
DY-89	Pos Ions - Sum - Lev 12	PCM		HD(D)	M
DY-90	Pos Ions - Cup 1 - Lev 12	PCM		HD(D)	M
DY-91	Pos Ions - Cup 2 - Lev 12	PCM		HD(D)	M
DY-92	Pos Ions - Cup 3 - Lev 12	PCM		HD(D)	M
DY-93	Pos Ions - Cup 4 - Lev 12	PCM		HD(D)	M

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Measurement Number	Description	TM	Priority PD*	ESD	EED
DY-94	Pos Ions - Cup 5 - Lev 12	PCM		HD(D)	M
DY-95	Pos Ions - Cup 6 - Lev 12	PCM		HD(D)	M
DY-96	Pos Ions - Cup 7 - Lev 12	PCM		HD(D)	M
DZ-1	Pos Ions - Sum - Lev 13	PCM		HD(D)	M
DZ-2	Pos Ions - Cup 1 - Lev 13	PCM		HD(D)	M
DZ-3	Pos Ions - Cup 2 - Lev 13	PCM		HD(D)	M
DZ-4	Pos Ions - Cup 3 - Lev 13	PCM		HD(D)	M
DZ-5	Pos Ions - Cup 4 - Lev 13	PCM		HD(D)	M
DZ-6	Pos Ions - Cup 5 - Lev 13	PCM		HD(D)	M
DZ-7	Pos Ions - Cup 6 - Lev 13	PCM		HD(D)	M
DZ-8	Pos Ions - Cup 7 - Lev 13	PCM		HD(D)	M
DZ-9	Pos Ions - Sum - Lev 14	PCM		M (D)	M
DZ-10	Pos Ions - Cup 1 - Lev 14	PCM		HD(D)	M
DZ-11	Pos Ions - Cup 2 - Lev 14	PCM		HD(D)	M
DZ-12	Pos Ions - Cup 3 - Lev 14	PCM		HD(D)	M
DZ-13	Pos Ions - Cup 4 - Lev 14	PCM		HD(D)	M
DZ-14	Pos Ions - Cup 5 - Lev 14	PCM		HD(D)	M
DZ-15	Pos Ions - Cup 6 - Lev 14	PCM		HD(D)	M
DZ-16	Pos Ions - Cup 7 - Lev 14	PCM		HD(D)	M
DZ-17	Elec - Sum - Lev 15	PCM		HD(D)	M
DZ-18	Elec - Cup 1 - Lev 15	PCM		HD(D)	M
DZ-19	Elec - Cup 2 - Lev 15	PCM		HD(D)	M
DZ-20	Elec - Cup 3 - Lev 15	PCM		HD(D)	M
DZ-21	Elec - Cup 4 - Lev 15	PCM		HD(D)	M
DZ-22	Elec - Cup 5 - Lev 15	PCM		HD(D)	M
DZ-23	Elec - Cup 6 - Lev 15	PCM		HD(D)	M
DZ-24	Elec - Cup 7 - Lev 15	PCM		HD(D)	M
DZ-25	Elec - Sum - Lev 16	PCM		HD(D)	M
DZ-26	Elec - Cup 1 - Lev 16	PCM		HD(D)	M
DZ-27	Elec - Cup 2 - Lev 16	PCM		HD(D)	M
DZ-28	Elec - Cup 3 - Lev 16	PCM		HD(D)	M
DZ-29	Elec - Cup 4 - Lev 16	PCM		HD(D)	M
DZ-30	Elec - Cup 5 - Lev 16	PCM		HD(D)	M
DZ-31	Elec - Cup 6 - Lev 16	PCM		HD(D)	M
DZ-32	Elec - Cup 7 - Lev 16	PCM		HD(D)	M
DZ-33	Elec - Sum - Lev 17	PCM		HD(D)	M
DZ-34	Elec - Cup 1 - Lev 17	PCM		HD(D)	M
DZ-35	Elec - Cup 2 - Lev 17	PCM		HD(D)	M
DZ-36	Elec - Cup 3 - Lev 17	PCM		HD(D)	M
DZ-37	Elec - Cup 4 - Lev 17	PCM		HD(D)	M
DZ-38	Elec - Cup 5 - Lev 17	PCM		HD(D)	M
DZ-39	Elec - Cup 6 - Lev 17	PCM		HD(D)	M
DZ-40	Elec - Cup 7 - Lev 17	PCM		HD(D)	M
DZ-41	Elec - Sum - Lev 18	PCM		HD(D)	M
DZ-42	Elec - Cup 1 - Lev 18	PCM		HD(D)	M
DZ-43	Elec - Cup 2 - Lev 18	PCM		HD(D)	M
DZ-44	Elec - Cup 3 - Lev 18	PCM		HD(D)	M
DZ-45	Elec - Cup 4 - Lev 18	PCM		HD(D)	M
DZ-46	Elec - Cup 5 - Lev 18	PCM		HD(D)	M

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Measurement Number	Description	TM	Priority PD*	ESD	EED
DZ-47	Elec - Cup 6 - Lev 18	PCM		HD(D)	M
DZ-48	Elec - Cup 7 - Lev 18	PCM		HD(D)	M
DZ-49	Elec - Sum - Lev 19	PCM		HD(D)	M
DZ-50	Elec - Cup 1 - Lev 19	PCM		HD(D)	M
DZ-51	Elec - Cup 2 - Lev 19	PCM		HD(D)	M
DZ-52	Elec - Cup 3 - Lev 19	PCM		HD(D)	M
DZ-53	Elec - Cup 4 - Lev 19	PCM		HD(D)	M
DZ-54	Elec - Cup 5 - Lev 19	PCM		HD(D)	M
DZ-55	Elec - Cup 6 - Lev 19	PCM		HD(D)	M
DZ-56	Elec - Cup 7 - Lev 19	PCM		HD(D)	M
DZ-57	Elec - Sum - Lev 20	PCM		HD(D)	M
DZ-58	Elec - Cup 1 - Lev 20	PCM		HD(D)	M
DZ-59	Elec - Cup 2 - Lev 20	PCM		HD(D)	M
DZ-60	Elec - Cup 3 - Lev 20	PCM		HD(D)	M
DZ-61	Elec - Cup 4 - Lev 20	PCM		HD(D)	M
DZ-62	Elec - Cup 5 - Lev 20	PCM		HD(D)	M
DZ-63	Elec - Cup 6 - Lev 20	PCM		HD(D)	M
DZ-64	Elec - Cup 7 - Lev 20	PCM		HD(D)	M
DZ-65	Elec - Sum - Lev 21	PCM		HD(D)	M
DZ-66	Elec - Cup 1 - Lev 21	PCM		HD(D)	M
DZ-67	Elec - Cup 2 - Lev 21	PCM		HD(D)	M
DZ-68	Elec - Cup 3 - Lev 21	PCM		HD(D)	M
DZ-69	Elec - Cup 4 - Lev 21	PCM		HD(D)	M
DZ-70	Elec - Cup 5 - Lev 21	PCM		HD(D)	M
DZ-71	Elec - Cup 6 - Lev 21	PCM		HD(D)	M
DZ-72	Elec - Cup 7 - Lev 21	PCM		HD(D)	M
DW-1	1 Bit per Sequence	PCM		HD(D)	M
DW-2	1 Bit per 256 Sequence	PCM		HD(D)	M
DW-3	9 mv ±2%	PCM		HD(D)	M
DW-4	90 mv ±2%	PCM		HD(D)	M
DW-5	900 mv ±2%	PCM		HD(D)	M
DW-6	3000 mv ±2%	PCM		HD(D)	M
DW-7	9000 mv ±2%	PCM		HD(D)	M
DW-11	Temperature Mod 100	PCM		HD(D)	M
DW-12	Temperature Mod 200	PCM		HD(D)	M
DW-13	Temperature Mod 300	PCM		HD(D)	M
DW-14	Temperature Sensor Cup Assembly	PCM		HD(D)	M
DW-15	Sun Angle Sensor	PCM		HD(D)	M
DW-16	Programmer Voltage	PCM		HD(D)	M
DW-17	Step Generator Voltage	PCM		HD(D)	M
DW-18	Modulation Monitor	PCM		HD(D)	M
DW-19	0 Ampere	PCM		HD(D)	M
DW-20	0 Ampere Cup 1	PCM		HD(D)	M
DW-21	0 Ampere Cup 2	PCM		HD(D)	M
DW-22	0 Ampere Cup 3	PCM		HD(D)	M
DW-23	0 Ampere Cup 4	PCM		HD(D)	M
DW-24	0 Ampere Cup 5	PCM		HD(D)	M
DW-25	0 Ampere Cup 6	PCM		HD(D)	M
DW-26	0 Ampere Cup 7	PCM		HD(D)	M

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Measurement Number	Description	TM	Priority PD*	ESD	EED
DW-27	$7x5.76x10^{-12}$ Ampere	PCM		HD(D)	M
DW-28	$5.76x10^{-12}$ Ampere Cup 1	PCM		HD(D)	M
DW-29	$5.76x10^{-12}$ Ampere Cup 2	PCM		HD(D)	M
DW-30	$5.76x10^{-12}$ Ampere Cup 3	PCM		HD(D)	M
DW-31	$5.76x10^{-12}$ Ampere Cup 4	PCM		HD(D)	M
DW-32	$5.76x10^{-12}$ Ampere Cup 5	PCM		HD(D)	M
DW-33	$5.76x10^{-12}$ Ampere Cup 6	PCM		HD(D)	M
DW-34	$5.76x10^{-12}$ Ampere Cup 7	PCM		HD(D)	M
DW-35	$7x5.76x10^{-11}$ Ampere	PCM		HD(D)	M
DW-36	$5.76x10^{-11}$ Ampere Cup 1	PCM		HD(D)	M
DW-37	$5.76x10^{-11}$ Ampere Cup 2	PCM		HD(D)	M
DW-38	$5.76x10^{-11}$ Ampere Cup 3	PCM		HD(D)	M
DW-39	$5.76x10^{-11}$ Ampere Cup 4	PCM		HD(D)	M
DW-40	$5.76x10^{-11}$ Ampere Cup 5	PCM		HD(D)	M
DW-41	$5.76x10^{-11}$ Ampere Cup 6	PCM		HD(D)	M
DW-42	$5.76x10^{-11}$ Ampere Cup 7	PCM		HD(D)	M
DW-43	$7x5.76x10^{-9}$ Ampere	PCM		HD(D)	M
DW-44	$5.76x10^{-9}$ Ampere Cup 1	PCM		HD(D)	M
DW-45	$5.76x10^{-9}$ Ampere Cup 2	PCM		HD(D)	M
DW-46	$5.76x10^{-9}$ Ampere Cup 3	PCM		HD(D)	M
DW-47	$5.76x10^{-9}$ Ampere Cup 4	PCM		HD(D)	M
DW-48	$5.76x10^{-9}$ Ampere Cup 5	PCM		HD(D)	M
DW-49	$5.76x10^{-9}$ Ampere Cup 6	PCM		HD(D)	M
DW-50	$5.76x10^{-9}$ Ampere Cup 7	PCM		HD(D)	M
DW-51	Level #1 (Proton)	PCM		HD(D)	M
DW-52	Level #2	PCM		HD(D)	M
DW-53	Level #3	PCM		HD(D)	M
DW-54	Level #4	PCM		HD(D)	M
DW-55	Level #5	PCM		HD(D)	M
DW-56	Level #6	PCM		HD(D)	M
DW-57	Level #7	PCM		HD(D)	M
DW-58	Level #8	PCM		HD(D)	M
DW-59	Level #9	PCM		HD(D)	M
DW-60	Level #10	PCM		HD(D)	M
DW-61	Level #11	PCM		HD(D)	M
DW-62	Level #12	PCM		HD(D)	M
DW-63	Level #13	PCM		HD(D)	M
DW-64	Level #14	PCM		HD(D)	M
DW-65	Level #15 (Electron)	PCM		HD(D)	M
DW-66	Level #16	PCM		HD(D)	M
DW-67	Level #17	PCM		HD(D)	M
DW-68	Level #18	PCM		HD(D)	M
DW-69	Level #19	PCM		HD(D)	M
DW-70	Level #20	PCM		HD(D)	M
DW-71	Level #21	PCM		HD(D)	M
DW-72	Level #1 (Proton)	PCM		HD(D)	M
DW-73	Level #2	PCM		HD(D)	M
DW-74	Level #3	PCM		HD(D)	M
DW-75	Level #4	PCM		HD(D)	M

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Measurement Number	Description	TM	Priority PD*	ESD	EED
DW-76	Level #5	PCM		HD(D)	M
DW-77	Level #6	PCM		HD(D)	M
DW-78	Level #7	PCM		HD(D)	M
DW-79	Level #8	PCM		HD(D)	M
DW-80	Level #9	PCM		HD(D)	M
DW-81	Level #10	PCM		HD(D)	M
DW-82	Level #11	PCM		HD(D)	M
DW-83	Level #12	PCM		HD(D)	M
DW-84	Level #13	PCM		HD(D)	M
DW-85	Level #14	PCM		HD(D)	M
DW-86	Level #15 (Electron)	PCM		HD(D)	M
DW-87	Level #16	PCM		HD(D)	M
DW-88	Level #17	PCM		HD(D)	M
DW-89	Level #18	PCM		HD(D)	M
DW-90	Level #19	PCM		HD(D)	M
DW-91	Level #20	PCM		HD(D)	M
DW-92	Level #21	PCM		HD(D)	M

A

*There are no requirements for Premission Data (PD).

b) Telemetry Measurement Tapes: (M)

One copy of 7-track, 800-BPI binary tapes containing EED telemetered measurements listed under 3)a), recorded and correlated with GMT during periods of experiment operation. The tapes are to be compatible with the UNIVAC 1108 computer.

c) Astronaut Debriefings: (HD) A

One copy of astronaut postmission scientific and photographic debriefing transcripts pertaining to the experiment.

d) Photographs: (HD) A

(1) One copy each of the photographs of the deployed SWS as defined under Test Conditions.

(2) Any lunar surface photographs which include the SWS.

5.5 SOLAR WIND SPECTROMETER

Background and Justification

The Solar Wind Spectrometer, following emplacement on the lunar surface, will monitor the flux, energy, streaming direction, and temporal variations of the solar wind plasma. The spectrometer utilizes an array of seven Faraday-cup sensors. The combined acceptance cones of all the cups include most of the upper hemisphere.

This experiment was first deployed on Apollo 12 and is not planned for missions beyond Apollo Mission J-1. A similar type experiment was flown on the lunar orbiter Explorer XXXV.

Prior to 1966, very little was known about the properties and characteristics of the solar wind flux and solar wind/lunar interactions. Explorer XXXV data on the solar wind and magnetic field near the moon indicated that there was no plasma shock ahead of the moon and that the distortion of the solar wind magnetic field by the moon was very small. The data imply that the solar wind strikes the lunar surface directly. Complex interactions near the lunar surface and near the lunar terminator plane are possible.

Preliminary analysis of Apollo 12 data indicate that solar plasma at the lunar surface is superficially indistinguishable from the more distant solar plasma. This is true whether the moon is ahead of or behind the plasma bow shock of the earth. In addition, no detectable plasma appears to exist in the magnetospheric tail of the earth or in the shadow of the moon.

Two generally expected types of positive-ion spectra have been observed:

a) Unperturbed solar wind corresponding to a proton velocity of 400 to 550 km/sec.

b) Perturbed solar wind corresponding to a proton velocity of 250 to 450 km/sec.

At times, detectable currents appear in only one energy step or in two adjacent energy steps. During most of the lunar night there is no detectable flux of solar wind particles within the 100 to 900 km/sec. range of the spectrometer. Highly variable spectra were also observed for which quantitative conclusions have not been reached. Plasma was also detected as the result of the impact of the S-IVB launch vehicle stage.

Data from Apollo Mission J-1 is expected to complement the Apollo 12 mission data. From these data the existence and general properties of the solar wind at the lunar surface and the properties of the magnetospheric tail of the earth can be inferred.

The two photographs described under Test Conditions are to provide a permanent record of the deployed SWS orientation with respect to the sun, precise level condition, and physical condition. These photographic data are important in interpreting and compensating for any off-nominal experiment operation or anomalous results. B

Previous Mission Experiments

Experiment Number	Title	Mission
S-035	Solar Wind Spectrometer	12

5.6 SUPRATHERMAL ION DETECTOR AND COLD CATHODE ION GAUGE

Conduct the Suprathermal Ion Detector Experiment (S-036) and Cold Cathode Ion Gauge Experiment (S-058).

Purpose

The purposes are to determine the energy level and mass spectrum of the ionic environment of the moon resulting from ultraviolet ionization of the lunar atmosphere, free streaming solar wind ions, and thermalized solar wind ions, and to determine the density of the lunar atmosphere.

The functional test objectives are as follows:

FTO 1) Obtain data on the energy and mass spectra of the positive ions close to the lunar surface.

FTO 2) Obtain data on the flux and energy spectrum of positive ions in the earth's magnetotail and magnetosheath during those periods when the moon passes through the magnetic tail of the earth.

FTO 3) Obtain data on the plasma interaction between the solar wind and the moon.

FTO 4) Obtain data on the density of the lunar atmosphere.

FTO 5) Obtain data on the rate of loss of contaminants left in the landing area by the lunar module and the astronauts.

FTO 6) Obtain data on the electric potential of the lunar surface.

Test Conditions

FTO 1)
FTO 2)
FTO 3)
FTO 4)
FTO 5)
FTO 6)

The Suprathermal Ion Detector Experiment (SIDE) and the Cold Cathode Ion Gauge (CCIG) are part of the Apollo 15 ALSEP which will be deployed on the lunar surface during the first EVA. A

Astronaut activities will be accomplished as follows:

a) The astronaut will select a relatively smooth surface to permit proper deployment of the SIDE ground screen.

b) The CCIG will be removed from the SIDE housing and both experiments will be deployed, leveled, and aligned.

c) The astronaut will obtain photographs of the deployed experiments using the Hasselblad electric data camera as follows:

(1) Deleted

(2) One photograph, cross-sun, 7 feet from the SIDE. A

NOTE: The above cross-sun photograph will show the CCIG aperture.

(3) One photograph showing SIDE and CCIG with the central station in the background.

(4) One close-up photograph of the SIDE bubble level, taken from 3 feet, to show the deviation of SIDE from local vertical.

After the SIDE and CCIG are deployed and the ALSEP central station is activated, MCC will initiate the commands to accomplish TURN-ON. After the astronauts leave the lunar surface, the Principal Investigator will advise MCC to initiate the commands to release the CCIG seal and the SIDE dust cover. The instruments will then monitor the lunar surface environment and data will be transmitted to earth and recorded by MSFN stations for as much of the planned 1-year ALSEP operational period as possible, consistent with equipment capabilities and operational requirements of other ALSEP experiments. Changes in the collection cycle will be made as required during periods of MCC monitoring. The commands to be issued by MCC will be defined in Appendix D of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Vol. V, ALSEP Data Book. A

Success Criteria

FTO 1)
FTO 2)
FTO 3)
FTO 4)
FTO 5)
FTO 6)

Experiment data defined as mandatory under Data Requirements shall be provided to the Principal Investigators and shall include telemetry data for a minimum of one lunar day after activation of the ALSEP central station on the lunar surface.

Evaluation

FTO 1) The energies and mass spectra of the positive ions close to the lunar surface will be determined. [Premission data and EED telemetry measurements AI-1, AI-2, DF-0 through DF-8, DF-29, DI-1, DI-2, DI-5, DI-6, DI-9 through DI-30, DI-40 through DI-66, DI-68 through DI-99, and DJ-0 through DJ-99 as listed under 3)a)] A

FTO 2) The flux and energy spectrum of positive ions in the earth's magnetotail and magnetosheath during those periods when the moon passes through the magnetic tail of the earth will be determined. [Premission data and EED telemetry measurements AI-1, AI-2, DF-0 through DF-8, DF-29, DI-1, DI-2, DI-5, DI-6, DI-9 through DI-30, DI-40 through DI-66, DI-68 through DI-99, and DJ-0 through DJ-99 as listed under 3)a)] A

FTO 3) The plasma interaction between the solar wind and the moon will be determined. [Premission data and EED telemetry measurements AI-1, AI-2, DF-0 through DF-8, DF-29, DI-1, DI-2, DI-5, DI-6, DI-9 through DI-30, DI-40 through DI-66, DI-68 through DI-99, and DJ-0 through DJ-99 as listed under 3)a)] A

FTO 4) The density of the lunar atmosphere will be determined. [Premission data and EED telemetry measurements DF-7, DF-8, DI-1, DI-3, DI-4, DI-7, DI-8, DI-22, DI-24, DI-27, and DI-63 through DI-71 as listed under 3)a)] A

FTO 5) The rate of loss of contaminants left in the landing area by the lunar module and the astronauts will be determined. [Premission data and EED telemetry measurements DF-7, DF-8, DI-1, DI-3, DI-4, DI-7, DI-8, DI-22, DI-24, DI-27, and DI-63 through DI-71 as listed under 3)a)] A

FTO 6) The electric potential of the lunar surface will be determined. [Premission data and EED telemetry measurements AI-1, AI-2, DF-0 through DF-8, DF-29, DI-1, DI-2, DI-5, DI-6, DI-9 through DI-30, DI-40 through DI-66, DI-68 through DI-99, and DJ-0 through DJ-99 as listed under 3)a)] A

FTO 1)
FTO 2)
FTO 3)
FTO 4)
FTO 5)
FTO 6)

Tapes will be reformatted at MSC for processing by the Principal Investigators. Data processing of the SIDE/CCIG magnetic tapes will be accomplished by the Principal Investigators. (Experiment evaluation data as defined under Data Requirements) A

Data Requirements

1) Premission Data: (M)

Calibration and Checkout Data:

Premission experiment calibration data included in the Apollo 15 ALSEP Final Acceptance Data Package provided to NASA/MSC by the ALSEP integration contractor. A

2) Experiment Support Data (ESD): (M)

Telemetry Measurements:

Telemetry measurements listed under 3)a).

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Priority PD*	ESD	EED
AI-1	Low Energy Detector Count Rate	PCM		HD	M
AI-2	High Energy Detector Count Rate	PCM		HD	M
DF-0 thru DF-4	LECPA Stepper Voltage	PCM		M	M
DF-5	LE Data - MSD	PCM		M	M
DF-6	LE Data - LSD	PCM		M	M
DF-7	Parity	PCM		HD	M
DF-8	Frame ID	PCM		HD	M
DF-29	One Time Command Register Status	PCM		HD	M
DI-1	SIDE Frame Number	PCM		HD	M
DI-2	+5 Volts Analog	PCM		HD	M
DI-3	CCIG Output	PCM		M	M
DI-4	Temp #1	PCM		HD	M
DI-5	Temp #2	PCM		M	M
DI-6	Temp #3	PCM		HD	M
DI-7	4.5 KV	PCM		M	M
DI-8	CCIG Range	PCM		M	M
DI-9	Temp #4	PCM		HD	M
DI-10	Temp #5	PCM		HD	M
DI-11	GND Plane Voltage	PCM		M	M
DI-12	Solar Cell	PCM		HD	M
DI-13	+60 Volts	PCM		HD	M
DI-14	+30 Volts	PCM		HD	M
DI-15	+5 Volts Digital	PCM		HD	M
DI-16	Ground Volts	PCM		HD	M
DI-17	-5 Volts	PCM		HD	M
DI-18	-30 Volts	PCM		HD	M
DI-19	Temp #6	PCM		M	M
DI-20	-3.5 KV	PCM		M	M
DI-21	+1.0 Volt Cal	PCM		HD	M
DI-22	+30 mV Cal	PCM		HD	M
DI-23	+A/D Ref Voltage	PCM		HD	M
DI-24	Dust Cover and Seal	PCM		HD	HD
DI-25	-A/D Ref Voltage	PCM		HD	M
DI-26	-1.0 Volt Cal	PCM		HD	M
DI-27	-12 Volt Cal	PCM		HD	M
DI-28	+12 Volt Cal	PCM		HD	M
DI-29	Pre Reg Duty Fact	PCM		HD	M
DI-30	-30 mV Cal	PCM		HD	M
DI-40 thru DI-60	HECPA Stepper Voltage	PCM		M	M
DI-61	HE Data - MSD	PCM		M	M
DI-62	HE Data - LSD	PCM		M	M
DI-63	Ground Plane Step Number	PCM		HD	M
DI-64	Command Register	PCM		HD	M

A

Measurement Number	Description	TM	Priority PD*	ESD	EED
DI-65	Mode Register	PCM		HD	M
DI-66	Dust Cover and Seal	PCM		HD	HD
DI-67	Electrometer Range	PCM		HD	M
DI-68	Cal Rate #1 Status	PCM		HD	M
DI-69	Cal Rate #2 Status	PCM		HD	M
DI-70	Cal Rate #3 Status	PCM		HD	M
DI-71	Cal Rate #4 Status	PCM		HD	M
DI-72 thru DI-99	Velocity Filter Voltage	PCM		M	M
DJ-0 thru DJ-97	Velocity Filter Voltage	PCM		M	M
DJ-98 & DJ-99	LECPA Stepper Voltage	PCM		M	M

*There are no requirements for Premission Data (PD).

b) Telemetry Measurement Tapes: (M) A

(1) One copy of 7-track, 556-BPI binary tapes containing SIDE EED telemetry measurements listed under 3)a), recorded and correlated with GMT during periods of experiment operation. The tapes are to be compatible with a Burroughs 5500 computer. [The tapes will include telemetry measurements AI-1, AI-2, DF-0 through DF-8, DF-29, DI-1, DI-2, DI-4 through DI-7, DI-9 through DI-30, DI-40 through DI-99, and DJ-0 through DJ-99 as listed under 3)a)]

(2) One copy of 7-track, 800-BPI binary tapes containing CCIG EED telemetry measurements listed under 3)a), recorded and correlated with GMT during periods of experiment operation. The tapes are to be compatible with an IBM 360/50 computer. [The tapes will include telemetry measurements DF-7, DF-8, DI-1, DI-3, DI-4, DI-7, DI-8, DI-22, DI-24, DI-27, and DI-63 through DI-71 as listed under 3)a)]

c) Astronaut Logs or Voice Records: (HD)

Two copies of astronaut logs or voice records containing comments on any deviation from the planned method of deployment, orientation, and leveling.

d) Astronaut Debriefings: (HD) A

Two copies of astronaut postmission scientific and photographic debriefing transcripts pertaining to the experiment.

e) Photographs: (HD) A

(1) Two copies of the photographs of the deployed SIDE/CCIG as defined under the Test Conditions.

(2) Two copies of any lunar surface photographs which include the SIDE/CCIG.

5.6 SUPRATHERMAL ION DETECTOR AND COLD CATHODE ION GAUGE

Background and Justification

The suprathermal ion detector and cold cathode ion gauge are integrated together in one experiment system. The experiment will measure the ionic environment of the moon by detecting the ions resulting from the ultra-violet ionization of the lunar atmosphere and the free streaming and thermalized solar wind. The suprathermal ion detector will measure the flux, number density, velocity and energy per unit charge of positive ions in the vicinity of the lunar surface. The cold cathode ion gauge will provide data that will allow a determination of the density of any lunar ambient atmosphere including any temporal variations either of a random character or associated with lunar local time or solar activity. In addition, the rate of loss of contaminants left in the landing area by the astronauts and lunar module will be measured.

Deleted A

Considerable data have been obtained from the Apollo 12 and Apollo 14 Suprathermal Ion Detector Experiment. Apollo Mission J-1 will provide additional data to complement the data from Apollo 12 and 14 and resolve observed ambiguities. A

One of these ambiguities was related to a lunar eclipse which occurred in February 1970, and a large magnetic storm which occurred in the same period. It could not be determined which phenomena caused a significant increase in the ionic flux.

Another ambiguity which occurred concerned the appearance and disappearance of an ion gas cloud late in the lunar night (predawn period). It could not be determined if this phenomenon was caused by a change in direction of the cloud or by the cloud passing out of the look direction of the detector. In an attempt to resolve this phenomenon, the look direction was varied for Apollo 14 and will be varied for Apollo Mission J-1 in order to increase the combined area coverage. These changes will contribute to the resolution of temporal variations and provide a measure of the magnitude of the phenomena.

The three photographs described under Test Conditions are to provide a permanent record of the SIDE precise level condition, the CCIG aperture pointing condition, the location of the SIDE and CCIG within the ALSEP array, and the physical condition of both instruments after deployment. These photographic data are important in interpreting and compensating for any off-nominal experiment operation or anomalous results. B

Previous Mission Experiments

Experiment Number	Title	Mission
S-036	Suprathermal Ion Detector Experiment	12
S-058	Cold Cathode Ion Gauge Experiment	12
S-036	Suprathermal Ion Detector Experiment	14
S-058	Cold Cathode Ion Gauge Experiment	14

5.7 LUNAR DUST DETECTOR

Conduct the Lunar Dust Detector Experiment (M-515).

Purpose

The purpose is to separate and measure high energy radiation damage to three solar cells, measure reduced solar cell output due to dust accumulation, and measure reflected infrared energy and temperatures for use in computing lunar surface temperatures.

The functional test objectives in order of priority are as follows:

FTO 1) Measure reduced solar cell output due to dust accumulations.

FTO 2) Separate and measure high energy radiation damage to solar cells.

FTO 3) Measure reflected infrared energy and temperature.

Test Conditions

FTO 1)
FTO 2)
FTO 3) The Lunar Dust Detector Experiment (LDDE), also known as the Dust Thermal Radiation Engineering Measurement (DTREM), is part of Apollo 15 ALSEP which will be deployed on the lunar surface during the first EVA. The LDDE is mounted atop the central station sunshade and is automatically deployed when the central station is deployed. A

MCC will initiate commands to accomplish LDDE TURN-ON. Data will be transmitted to earth and recorded by MSFN stations for as much of the planned 1-year ALSEP operational period as possible, consistent with equipment capabilities and operational requirements of other ALSEP experiments.

The astronaut will obtain one photograph of the central station showing the LDDE taken from a distance of approximately 7 feet. A

Success Criteria

FTO 1)
FTO 2)
FTO 3) Experiment data defined as mandatory under Data Requirements shall be provided to the Principal Investigator and shall include telemetry data for a minimum of one lunar day after activation of the ALSEP central station on the lunar surface.

Evaluation

FTO 1)
FTO 2) The reduction of solar cell output due to dust accumulation and radiation damage will be determined. (Premission calibration data as defined under Data Requirements and EED measurements AX-4, AX-5 and AX-6) A

FTO 3) The lunar surface temperature will be determined from an analysis of the reflected IR "brightness" temperature and the LDDE package temperatures. (Premission calibration data as defined under Data Requirements, and EED measurements AX-1, AX-2 and AX-3) A

Data Requirements

1) Premission Data (PD): (M)

Premission experiment calibration data included in the Apollo 15 ALSEP Final Acceptance Data Package provided to NASA/MSC by the integration contractor. A

2) Experiment Evaluation Data (EED):

(a) Telemetry Measurements: A

Computer print-outs of telemetry measurements listed below, stripped out from the ALSEP magnetic tapes.

Measurement Number	Description	TM	Priority PD*	ESD*	EED
AX-1	Inner Temperature	PCM			M
AX-2	Cell Temperature	PCM			M
AX-3	Outer Temperature	PCM			M
AX-4	#1 Cell Output (Bare)	PCM			M
AX-5	#2 Cell Output (Irradiated Filter)	PCM			M
AX-6	#3 Cell Output (Filter)	PCM			M

*There are no requirements for Premission Data (PD) or Experiment Support Data (ESD). A

(b) Photographs: (HD)

One copy of each photograph of the central station showing the LDDE. A

5.7 LUNAR DUST DETECTOR

Background and Justification

The LDDE is designed to provide information on high energy radiation, dust accumulations, and lunar surface temperatures. These data will provide long-term shielding information for use in the design of lunar bases and hardware, and for resolution of ALSEP thermal problems caused by dust.

The high energy radiation will be produced primarily in solar flares. A second source of possible high energy radiation will be in the geomagnetic tail. The Apollo 12 LDDE showed no degradation of the solar cells due to dust accretion throughout a year of operation. In addition, cell voltage output variations provided a direct measurement of the difference in solar radiation intensity at the lunar surface between lunar winter (aphelion) and lunar summer (perihelion). Apollo Mission J-1 will provide information for optimizing design of solar cell radiation shields for use in the lunar environment.

The amount of scattered dust which accumulates on reflecting surfaces can cause adverse ALSEP thermal problems. If the effect of the dust can be measured as it accumulates, ground monitoring and controlling could be altered as required to minimize ALSEP thermal problems caused by dust.

The reflected IR "brightness" temperature together with the internal LDDE package temperatures will be used in computing the lunar surface temperature. Knowledge of the actual lunar surface temperature would be useful in the design of the EVA space suits and the thermal control of lunar hardware.

The photograph described under Test Conditions is to provide a permanent record of the physical condition of the deployed LDDE and its approximate relation to the sun. These photographic data are important in interpreting and compensating for any off-nominal experiment operation or anomalous results. B

Previous Mission Experiments

Experiment Number	Title	Mission
M-515	Lunar Dust Detector Experiment	12
M-515	Lunar Dust Detector Experiment	14

5.8 LUNAR GEOLOGY INVESTIGATION

Collect and document samples and study surface morphology.

Purpose

The purposes are to obtain a better understanding of the nature and development of the Apennine Mountain area and the processes which have modified the highland surface, through the study of documented lunar geologic features and returned lunar samples. [The experiment will be conducted by the Apollo Lunar Geology Experiment Team (Experiment S-059) for J-1, in consultation with the Science Working Panel representing the requirements of PI's for sample analysis.]

The functional test objectives are as follows:

FTO 1) Examine, describe, photograph, and collect lunar geologic samples for return to earth.

FTO 2) Examine, describe, and photograph field relationships (such as shape, size, range, patterns of alignment, or distribution) of all accessible types of lunar features.

FTO 3) Collect special soil samples from the lunar surface and subsurface.

FTO 4) Collect large equidimensional rock samples from the lunar surface.

FTO 5) Collect special container samples from the lunar surface and subsurface.

FTO 6) Return an organic control sample in each SRC.

Test Conditions

FTO 1) Geologic samples which represent different morphologic and petrologic features will be photographically documented and collected. These will include samples from the mare surface in the landing site, from the base of the Apennine Front, from near the edge of Hadley Rille and from the North Complex. At least some of these samples will be taken from crater ejecta. Comprehensive sample collections will be taken from selected areas at the base of the Apennine Front, on the mare surface, and at Hadley Rille. Documented samples will be placed A individually in prenumbered bags and the bags placed in an SRC or a collection bag. Samples too large to fit in the bags will be stored in a collection bag. Samples will be obtained from each of the major geological sites on the traverse. Fifty to 100 grams of soil will be collected from each documented sample site. The soil will be placed either in a separate prenumbered bag or in a prenumbered bag with a rock sample. The following kinds of samples are required: A

- In each sample site the exposed rocks and soil will be examined for variations in color, texture, shape and degree of rounding, and possible mineral composition where obvious differences occur. Samples of the different types will be collected. Where rocks are too large to be collected, it is desirable to remove chips by chipping or prying from the large rocks. The number and location of chips to be taken will be determined by rock texture, mineralogy, and structure.

- Samples which appear to represent local bedrock will be collected from around blocky-rimmed craters of various diameters including the large blocky-rimmed crater at the base of the Apennine Front and the ridge extending from the Apennine Front. A

- Three comprehensive sample areas will be selected, and all rocks larger than approximately 3/8 in. diameter will be collected. The size and nature of the comprehensive sampling areas will be dependent on astronaut assessment of the task; however, it is highly desirable that at least 1 kilogram of rocks in the size range approximately 3/8 in. to approximately 1-1/2 in. diameter be collected from each area and be placed in a separate prenumbered bag. A soil sample of 1 kilogram will be taken from within each sample area and placed in a separate prenumbered bag. One comprehensive sample area will be in an area representative of the mare surface, in the general vicinity of the trench excavated as part of the Soil Mechanics Experiment (S-200) and near a double or triple core tube sample location. A second comprehensive sample area will be in the general area of the Apennine Front and will be near both a small exploratory trench and a double core tube sample location. The third comprehensive sample area will be in the general area of Hadley Rille and will be near both a small exploratory trench and a single or double core tube sample location. A

Each of the above samples, with the exception of the comprehensive samples, if size permits, will be placed in a separate prenumbered sample bag whose identity will be called out at the time the sample is placed in the bag. Additional samples judged by the crew to be of particular interest will be stowed loose in an SRC or in a collection bag. Near the end of the available sampling time on each EVA, additional samples will be placed in any remaining volume of an SRC available for samples and in the collection bags to maximize the amount of material returned. The priority of these additional samples in descending order is as follows:

- Small rocks (similar in size to bagged documented rocks)
- Soil

Radial sampling of a very fresh crater (approximately 5 to 10 meters in diameter) in relatively flat territory will be accomplished to include three soil-plus-rock samples from the following locations: the crater rim; one-half the crater diameter outward from the crater rim; and one crater diameter outward from the crater rim. Each sample will be placed in a separate prenumbered bag. If time and crew assessment of the task permit, it is highly desirable that the crew continue and perform diametric sampling of the crater from the following locations: the crater center; the diametrically opposite crater rim; one-half crater diameter outward from this crater rim; and one crater diameter from the crater rim. Full photographic documentation is not required, but one stereoscopic partial panorama covering the sampling area will be obtained.

Single geologic samples and the comprehensive sample areas will be photographically documented to show their orientation on the lunar surface and to show their relationship to geologic features on the lunar surface such as other rocks, craters, fillets, and lineaments. The Documented Sample Photographs will be taken with the Hasselblad electric data camera (HEDC) using the following procedure:

- The gnomon will be positioned down-sun from the sample. The leg with attached photometric chart will be pointed up-sun.
- Three photographs will be taken before sampling. One photograph will be taken down-sun at a distance of 11 feet. B
  A stereo-pair will be taken cross-sun at a distance of 7 feet.

- A location photograph will be taken approximately cross-sun at a distance of 15 feet and will include both the sample area and some identifiable landmark or object and horizon before or after sampling.

- A photograph will be taken after sampling. A cross-sun photograph of the sampled area will be taken at a distance of 7 feet, from approximately the same place as the stereo pair before sampling. A

If only one crew member collects and photographically documents a single sample, the gnomon will be positioned as described above and only the cross-sun stereo pair prior to sampling and the location photograph are mandatory.

FTO 2) Lunar surface features and field relationships will be examined, described, and photographically documented. Such features and relationships include:

- Hadley Rille walls.

- Surface patterns of linear features or other surface textures. A

- Rock surfaces that show textures and structures (such as layering, fracturing, or color variations) too large to be returned.

- Craters that show the range of size, freshness, and degradation.

- Rock-soil contacts such as fillets that are banked against rocks, especially those that are primarily banked against rocks on one or two sides. A

- Boundary zones between hillsides and relatively level ground at their bases.

- Disturbed (such as footprints, wheel tracks, trenches) and undisturbed surface material.

Examples of the above features will be photographically documented at crew discretion.

Large areas of the landing site will be documented by panoramic photographs. Each set will consist of a minimum of 15 photographs (20 photographs are highly desirable), overlapped to provide 360-degree coverage. The far-field (74-foot) detent will be used for all panoramic photographs. The astronaut will aim the HEDC so that the horizon will appear near the top of each photograph. A

Three sets of panoramic photographs will be taken approximately 20 feet from the LM at positions 120 degrees apart. A set of panoramic photographs will be taken during the stand-up extra-vehicular activity (SEVA). Additional panoramas of areas of interest and prominent distant features will be taken during the traverse. These photographs will be based on the following criteria:

- Geological features of scientific interest along the planned traverse.
- From high elevation points along the traverse from which the unobstructed horizon can be seen.
- Items of geological interest at the discretion of the crew.

The long-focal-length camera (HEDC with 500 mm lens) will be used to photograph distant features on the lunar surface. Surface features to be photographed are listed below:

- Far wall and, if possible, the near wall of Hadley Rille.
- Deposits on or near Hadley Rille floor.
- Outcrops and large boulders on the Apennine Front, both during the SEVA and during the traverses.

The polarimetric photographs can be combined with the documentation for sample areas described in FTO 1). If samples are photographed between the time that near-field and far-field polarimetric measurements are obtained, then it is permissible to photograph the samples with the filter on the camera.

Near-field polarimetric measurement photographs will be obtained with an HEDC to provide local calibration data. The film will provide "in situ" measurements of the photometric properties of the fine-grained material and rock fragments, and will provide stereo-coverage of the sample area. The following procedure will be used:

- An area of several rocks will be located.
- The gnomon will be placed beside the rocks (where it is clearly visible). The leg with attached photometric chart will be pointed up-sun.
- One photograph will be taken of the area down-sun (10 degrees on either side of the down-sun line) at a distance of 11 feet. This is equivalent to the down-sun photograph in the Documented Sample Photographs procedure of FTO 1). B

- Three photographs with the polarizing filter will be obtained at a distance of 7 feet. One photograph through each of the three filter positions at a phase angle of 90 degrees will be obtained. This procedure will be repeated at phase angles of approximately 110 and 130 degrees, for a total of nine photographs.

Following the near-field polarimetric measurements, at least four rock samples will be collected from the rock area which has been photographed. Samples will be placed in prenumbered sample bags. A location photograph and after-sample collection photograph will be taken of the collection site as required in FTO 1).

Far-field polarimetric measurement photographs will be obtained with an HEDC of an area such as a rocky area or an inner crater wall (crater diameter will be greater than 12 meters). If the photographs are of a rocky area, the camera will be at least 12 meters from the scene. If the photographs are of an inner crater wall, the camera will be used from the edge of the crater wall opposite the photographed wall. The following procedures will be used to obtain six photographs.

- The astronaut will select a far-field area of interest and maneuver to about cross-sun so that the central area is observed at a phase angle between 50 and 130 degrees. The polarizing filter will be attached to the camera lens. The camera will be focused at 74 feet.

- Three photographs will be taken of the field of interest through the filter, moving the filter control between photographs. The initial filter position will be reported. The f/stop and shutter speed between photographs will not be changed during a polarization sequence.

- The astronaut will maneuver to about 20 degrees down-sun from the first position such that the same area is viewed at a phase angle 20 degrees different from the phase angle used for the first series of photographs, and will then repeat the preceding steps for an additional three photographs.

Deleted

FTO 3) The following special soil samples will be collected and photographically documented. The HEDC will be used for all photographs.

a) Core tube soil samples will be collected as follows:

- A double (or, at crew discretion, a triple) core tube sample will be obtained from the comprehensive sample area representative of the mare surface. It is desirable that this core be taken in the vicinity of the trench excavated as part of Soil Mechanics Experiment S-200.

A

- A double core tube sample in the Apennine Front comprehensive sample area.

- A single (or, at crew discretion, a double) core tube sample in the Hadley Rille comprehensive sample area.

- Single (or double) core tube samples at targets of opportunity; e.g., North Complex, expected multiple layer areas (such as the ejecta from a fresh crater, or the mare/Apennine Front), Apennine Front talus, a mound, a fillet, and patterned ground. These samples will be based on crew discretion and knowledge gained from the exploratory trenches.

The following procedure will be used for photographic documentation of core tube sample locations:

- It is highly desirable that the gnomon be positioned near the core tube. The leg with attached photometric chart will be pointed up-sun.

- It is highly desirable that a cross-sun stereo-pair of the core tube in contact with the lunar surface be taken from a distance of 7 feet. A

- A location photograph including the core tube and horizon will be taken from a distance of 15 feet after core tube(s) are implaced. A

The number and order of the multiple core tubes will be reported. The multiple core tubes will be separated and stored either in a collection bag or in an SRC. A

b) Separate soil samples (200 to 500 grams each) will be taken from the bottom, side, and top of a trench and/or from all discernible layers at a location at least 300 feet from the LM in a direction away from the LM descent flight path. The samples will be placed in prenumbered bags whose identities will be called out when the bags are filled. The samples should include both soil, and small rocks if encountered. The Soil Mechanics Experiment trench may be used for these samples. Photographs taken in support of the Soil Mechanics Experiment will suffice for documentation.

c) After use of the ALSD in support of the Heat Flow Experiment (S-037), the Apollo lunar surface drill will be used to obtain a 3-meter drill core. It is highly desirable that no apparent geological contacts and no craters greater than 2 meters in diameter lie between the 3-meter drill core hole and the heat probe holes. The drill will be used in the vicinity of the deployed ALSEP during the first EVA. The six drill stems will be stowed in the SRC No. 1. One panorama consisting of a minimum of 15 photographs (20 photographs are highly desirable) will be taken 7 feet from the drill during or after drilling. B

d) Small exploratory trenches will be dug by the crew using hand tools. The trenches will be dug 10 degrees off the sun line and to a depth of 3 to 8 inches depending on crew judgment.

- One trench will be dug in the comprehensive sample area in the general area of the Apennine Front, located preferably on the edge of the comprehensive sample area diametrically opposite the double core tube sample location. Another trench will be dug in the comprehensive sample area in the general area of the Hadley Rille, located preferably on the edge of the comprehensive sample area diametrically opposite the single (or double) core tube location. A 200- to 500-gram soil sample will be taken from the bottom of each trench and will be placed in a prenumbered bag in an SRC.

- Other trenches will be located at the following types of sites based on crew judgment. Soil samples will be taken at the crew's discretion and placed in prenumbered bags in an SRC.

  - Near rim in the ejecta from a small fresh crater in a mare area.

- Near edge of Hadley rille.

- At break of slope near Apennine Front.

- At least two locations on the steeper slope of the Apennine Front.

- On the south side of secondary crater cluster at base of Apennine Front.

- In a mound.

- In an area where there is a change in surface characteristics such as color, surface patterns, or mechanical properties.

- In a distinct crater ray.

At least one buried rock sample will be collected from an exploratory trench, if encountered, and placed in a prenumbered bag. Additional photographs are not required. A

The small trench photographs will be taken with the HEDC using the following procedures if interesting features are observed:

- Deleted

- Deleted

- After the trench is dug, a stereo pair will be taken cross-sun of the interesting features. A

- Deleted

- A location photograph will be taken approximately cross-sun at a distance of 15 feet and will include the trench, some identifiable landmark or object and the horizon.

FTO 4) Large rock samples will be collected and photographically documented using the Documented Sample Photographs procedure in FTO 1) at any point on the traverse. A

- At least one large, roughly equidimensional rock about 6 to 8 inches on a side (preferably showing clear evidence of erosion) will be collected from a relatively flat area and placed in a collection bag. It should be a crystalline rock, if this characteristic can be distinguished. It is highly desirable that this rock be one that is partially buried at the time of collection. This rock should be fully documented using the Documented Sample Photographs procedure in FTO 1). A

- Several smaller roughly equidimensional rocks (approximately five in number, each approximately 3 to 6 inches in diameter) will be collected and placed individually in prenumbered bags. It is desired that these samples include examples of the most angular and the most rounded rocks observed on the surface. If different rock types can be distinguished, it is desirable that representatives of each type be collected. A

- One rock should be selected from a relatively level area and should have an equally well-developed fillet on all sides. Both the rock and a sample of the fillet material will be collected, identified, and placed in separate prenumbered bags. Typical soil near the fillet will be collected and placed in another prenumbered bag. The Documented Sample Photographs procedure listed under FTO 1) will be used. The fillet sample and the typical soil sample near the fillet should be collected in the field-of-view of the before and after photographs. It is highly desirable that this procedure be repeated for a rock collected from within a fresh crater. A

FTO 5) The following samples will be collected and placed in special containers.

- Two lunar environment soil samples will be collected from the bottom of trenches at least 300 feet from the LM in a direction away from the LM descent flight path. The trenches will be a minimum of 3 inches deep. The Soil Mechanics Trench may be used for one of these, provided that the sample is taken prior to the penetrometer and plate load tests performed at the bottom of the Soil Mechanics Trench. The second sample may be taken from one of the small trenches specified under FTO 3)d). It is highly desirable that this small trench be the one in the vicinity of the comprehensive sample area in the Apennine Front comprehensive sample area. The samples will be sealed in special environment containers (SESC's) whose identity will be called out at the time the containers are filled, and placed in SRC's. It is highly desirable that the SESC's be filled as near as possible to capacity. A

- An exhaust-contaminated soil sample will be collected, using the scoop, from the erosion crater caused by DPS exhaust impingement. If the material included in the erosion crater is too hard to be collected with the scoop, the sample will be taken as close to the erosion crater as possible. The sample will be sealed in an SESC whose identity is called out at the time the container is filled, and placed in an SRC. The material in the top layer of surface material is of primary interest. It is highly A desirable that sufficient sample material be collected to fill the SESC and that one photograph be taken before and after sampling. A

FTO 6) The organic control sample will be sealed by the crew at the beginning of an EVA for each SRC. A

FTO 1)
FTO 2)
FTO 3)
FTO 4)
FTO 5)
FTO 6)

The position of the landed LM will be determined in real time. The priority of stowage of returned lunar samples in the SRC's is as follows:

1) Organic Control Sample
2) Deepest drill stem A
3) Remaining five drill stems
4) Lunar Environment Soil Samples (SESC's)
5) Up to four core tubes A
6) Documented samples
7) Exhaust-contaminated sample (SESC)
8) Comprehensive Samples (1 kg of rocks and 1 kg of soil each) A
9) Equidimensional rocks (3 to 6 inches in diameter)

Success Criteria

FTO 1)
FTO 2)
FTO 3)
FTO 4)
FTO 5)
FTO 6)

Verbally and photographically documented samples shall be collected, placed in the proper containers, and returned with the film data to the LRL.

FTO 2) Lunar surface features shall be observed, described and photographed, and the film data shall be returned to the LRL.

Evaluation

FTO 1)
FTO 2)
FTO 3)
FTO 4)
FTO 5)
FTO 6)

Samples will be returned to the LRL for preliminary study by the Lunar Samples Preliminary Examination Team (LSPET). These investigations will be conducted in the LRL at MSC. The LSPET will provide a complete catalog of all returned samples and distinguishing characteristics of these samples to MSC for use in distribution to sample Principal Investigators, who will make further investigations in their own laboratories. (Lunar samples).

The Lunar Geology Experiment Team will locate returned samples and emplaced instruments on photographs and traverse maps. They will integrate geological information obtained from the transcript of voice communication, from debriefing of the crew, from all photographs and from the preliminary examination of the returned samples. (Astronaut records, still and sequence photographs, video tapes, landed LM location, debriefing data, photomaps) A

Data Requirements

1) Experiment Support Data (ESD): A

a) Position of the landed LM as determined by the RTCC. (M)

b) Voice Comments: (M)

(1) Comments and identification of samples and photographs.

(2) Records of where samples were obtained (location and depth).

(3) Geologic observations of lunar surface.

c) Lunar Surface TV. (HD)

d) Location and heading of the LRV at each geological stop. (HD) A

2) Experiment Evaluation Data (EED):

a) Position of the landed LM. (M)

b) Astronaut Logs or Voice Records: (M)

(1) Comments and identification of samples and photographs.

(2) Records of where samples were obtained (location and depth).

(3) Geologic observations of lunar surface.

c) Astronaut Debriefings: (M)

One copy each of astronaut postmission scientific and photographic debriefing transcripts pertaining to both mandatory and highly desirable experiment objectives.

d) Still Photographs:

Photographs of lunar surface sample areas and of the samples as defined in the Photographic and Television Procedures for this mission to include:

(1) Photographs of the samples and individual sample areas: (M)

- At least four photographs of each specific sample. The photographs of the individual sample areas will include two cross-sun (stereo-pair), one down-sun before retrieving the sample, and one cross-sun after retrieving the sample. A

- A fifth photograph to show the location of the general sample area with respect to a landmark or object and horizon.

- Where sampling is done by only one crewman, three photographs to include the cross-sun stereo pair before sampling and the location photograph after sampling. A

(2) Photographs of the small trench samples, the small trench and the small trench area: (HD)

- Deleted

- A stereo pair cross-sun of the interesting features. A

- Deleted

- A photograph to show the location of the small trench area with respect to a landmark or object and horizon.

(3) Near-field and far-field polarimetric surveys. (M)

(4) Deleted A

(5) Three sets of panoramic photographs near the LM during EVA and one set during the SEVA. (M) A

(6) One set of panoramic photographs near drill stem. (M)

(7) Panoramic photographs taken during the traverses.

- At least one panorama per major site as identified in the Lunar Surface Procedures. (M)

- Remainder of panoramas are highly desirable. (HD)

(8) Long focal length photographs of Hadley Rille wall, Hadley Rille floor and Apennine Front during SEVA and during at least two traverses: (M) A

e) Sequence and/or still photographs: (HD)* A

(1) Descent to touchdown.

(2) EVA activities.

(3) Ascent from lunar surface.

(4) All orbital photography of the landing area. A

f) Lunar Samples:

(1) Lunar geologic samples:

- Samples from each major geological site. (M)
- Fifty to 100 grams of soil from each documented sample site. (M) A
- Rocks and soil with variations in color, texture, shape and degree of rounding. (M)
- Samples which appear to represent local bedrock. (M) A
- Rocks larger than 3/8 inch in diameter from each of the three comprehensive sample areas. (M)
- Samples as selected to fill remaining storage volume in each SRC. (M)
- Samples obtained by radial sampling of a crater. (M)
- Samples obtained by diametric sampling of a crater. (HD) A

(2) Four rock samples associated with the near-field polarimetric measurements. (M)

(3) Deleted A

*No specific crew tasks are required. Copies of these photographs are to be provided to the Principal Investigators and Lunar Geology Experiment Team only if they are obtained in support of operational tasks, detailed objectives or other detailed experiments. A

(4) Special soil samples:

- One double or triple core tube sample. (M)
- One double core tube sample. (M)
- One single or double core tube sample. (M) A
- Remaining two to four core tubes in any combination of single or double core tube samples at targets of opportunity. (M)
- A 1 kilogram soil sample from each of three comprehensive sample areas. (M)
- Separate soil samples of 200 to 500 grams each from the bottom, side and top of a trench and/or from all discernible layers. (M) A
- Six drill stems. (M)
- Soil samples of 200 to 500 grams each from two small trenches. (M) A
- Soil samples from other small trenches. (HD)

(5) Large equidimensional rock samples. (M) A

- One large, roughly equidimensional rock.
- Approximately five roughly equidimensional rocks (3 to 6 inches in diameter).
- Rock, associated fillet material and nearby typical soil material.

(6) Special container soil samples. (M) A

- Two lunar environment soil samples.
- An exhaust-contaminated sample.

g) Organic control sample in each SRC. (M)

h) Lunar surface TV video tapes. (HD)

i) Copies of annotated photomaps returned from the moon. (HD) A

Background and Justification

The fundamental objective of the Lunar Geology Investigation Experiment is to provide data in the vicinity of the landing site for use in the interpretation of the geologic history of the moon. Apollo lunar landing missions offer the opportunity to correlate carefully collected samples with a variety of observational data on at least the upper portions of the mare basin filling and the lunar highlands, the two major geologic subdivisions of the moon. The nature and origin of the maria and highlands will bear directly on the history of lunar differentiation and differentiation processes. From the lunar bedrock, structure, land forms and special materials, information will be gained about the internal processes of the moon. The nature and origin of the debris layer, or regolith, and the land forms superimposed on the maria and highland regions are a record of lunar history subsequent to their formation. This later history predominately reflects the history of the extra-lunar environment. Within and on the regolith, there will also be materials that will aid in the understanding of geologic units elsewhere on the moon and the broader aspects of lunar history.

Documented sample collection and geological observation of the lunar surface in mare areas were accomplished on Apollo 11 and 12. The landing site for Apollo 14 was Fra Mauro. This site, in the center of the moon's face as seen from the earth, was of different geologic interest from the Apollo 11 and 12 landing sites. The crewmen were able to inspect, document and collect lunar material which may originally have come from deep inside the moon and may have been thrown out onto the lunar surface during the formation of the very large Imbrium crater. The prime landing site designated for Apollo Mission J-1 is Hadley-Apennine. Sampling of Apenninean material should provide very ancient rocks, the origin of which predates the formation and filling of the major mare basins. A

The development of Mare Imbrium and related features, including the Apennine Mountains, forms one of the focal points of lunar chronology. A mission to Hadley-Apennine is highly desirable to resolve questions concerning the chronology of major events in lunar history, the nature of these events, and the composition of deep-seated materials. A

The primary data for the Lunar Geology Investigation Experiment come from photographs, verbal data, and returned lunar samples. Photographs taken according to specific procedures will supplement and illustrate crew comments, record details not discussed by the crew, provide a framework for debriefing, and record a wealth of lunar surface information that cannot be returned or adequately described by any other means.

In any Hasselblad picture taken from the lunar surface, as much as 90 percent of the total image information may be less than 100 feet from the camera, depending on topography and how far the camera is depressed below horizontal. Images of distant surface detail are so foreshortened that they are difficult to interpret. Therefore, it is important that panoramas be taken at intervals during the traverse and at the farthest excursion of the traverse. This procedure will extend the high resolution photographic coverage to the areas examined and discussed by the astronaut, and will show the regional context of areas of specific interest that have been discussed and photographed in detail.

The polarizing filters will permit the measurement of the degree of polarization and orientation of the plane of polarization contained in light reflected from the lunar surface. Different lunar materials, i.e., fine-grained glass and/or fragments, strongly shocked rocks, slightly shocked rocks and shock-lithified fragmental material, have different polarimetric functions, in other words, different polarimetric "signatures." Comparison of the polarimetric function of known material, such as returned samples and close-up lunar surface measurements, with materials photographed beyond the traverse of the astronaut will allow the classification and correlation of these materials even though their textures are not resolvable. The polarimetric properties of lunar materials and rock types are a useful tool for correlation and geologic mapping of each landing site, and for extrapolation of geologic data from site to site across the lunar surface.

The photometric chart will be used to establish more accurate photometric and colorimetric constants ("signatures") than is possible with the gnomon. The "in situ" photometric properties of both fine-grained materials and coarse rock fragments will serve as a basis for delineating, recognizing, describing, and classifying lunar materials. The photometric chart will be placed in a picture at least once and, if feasible, whenever different-appearing lunar materials are encountered. Thus, the photometric chart will be photographed beside a representative rock and, if practical, beside any rock or fine-grained material with unusual features. The photometric chart measurement may be combined with the documented sample and polarization measurements.

Small exploratory trenches several inches deep are to be dug to determine the character of the regolith down to these depths. The trenches should be dug in the various types of terrain as discerned on the Lunar Orbiter photograph of the site, and in areas where the surface characteristics of the regolith are of significant interest as determined by the astronaut crew. The main purpose of the trenches will be to determine the small scale stratigraphy (or lack of) in the upper few inches of the regolith in terms of petrological characteristics and particle size.

The organic control sample, carried in each SRC, will be analyzed postmission in the Lunar Receiving Laboratory to determine the level of contamination in each SRC. This will then be compared to an organic control sample which was removed from the SRC prior to the SRC being shipped to KSC for loading onto the LM.

It is recognized that there will be an area of minimum contrast and maximum albedo when taking down-sun photographs at high-sun angles (as will exist during the second and third EVA periods). To aid in the assessment of the lunar photometric function, all down-sun photographs should be taken as specified in the Test Conditions, rather than with a relative sun azimuth.

The long focal length (500 mm) lens with the Hasselblad 70-mm film camera will be used to provide high resolution data not available from previous mission. A 5 to 10 centimeter resolution is anticipated at a A

1 to 2 kilometers. Pictures of the cliff exposure on the far wall of the Hadley Rille should show the contact of the regolith layer with the lava flows of the Mare basin fill as well as possible fragmental debris layers between lava flows. This cliff is probably bedrock below the fragmental debris layer, and is also probably the only continuous exposure of lunar bedrock that will be visited during an Apollo mission. The resolution should be sufficient to show layering within the flows and distribution patterns of vesicles (gas bubble holes). The distribution patterns of vesicles in bedrock units may allow an interpretation of the mode of emplacement of the lava flows. In addition, it may be possible to photograph the near side of the rille wall late in the mission when the sun is high enough to provide adequate illumination. If so, the achievable resolution may be 2 to 4 centimeters.

The high degree of resolution will make it possible to analyze the shape and size distribution of material on or near the floor of the rille. This may lead to an understanding of the processes of rille formation. A

Photographs will be obtained of outcrops and large blocks surrounding small impact craters on the slopes of the Apennine Front, in areas not accessible to the crew. These high resolution photographs will allow the texture and structures of these rocks to be recorded.

In order to more fully sample the major geological features of the Hadley-Apennine site, various groupings of sampling tasks are combined and will be accomplished in concentrated areas. This will enable vertical as well as lateral data to be obtained in the three principal geological settings; i.e., the Apennine Front, the mare surface and the Hadley Rille. Thus, the Test Conditions now show that some trench samples, core tube samples and lunar environmental soil samples will be collected in association with the comprehensive samples. Table 1 provides a summary of the samples to be taken in the vicinity of these comprehensive sample areas.

Previous Mission Experiments

Experiment Number	Title	Mission
S-059	Lunar Field Geology	11
S-059	Lunar Field Geology	12
S-059	Lunar Geology Investigation	14 A

Table 1

Samples to be Taken in Vicinity of Comprehensive Sample Areas

Priority	Vicinity of Apennine Front	Mare Surface	Vicinity of Hadley Rille
1	Comprehensive sample: At least 1 kg of rocks 3/8 in. to 1-1/2 in. diameter	Comprehensive sample: At least 1 kg of rocks 3/8 in. to 1-1/2 in. diameter	Comprehensive sample: At least 1 kg of rocks 3/8 in. to 1-1/2 in. diameter
2	Double core tube	Double (or triple) core tube	Single (or double) core tube
3	Comprehensive sample: 1 kg of soil	Comprehensive sample: 1 kg of soil	Comprehensive sample: 1 kg of soil
4	Comprehensive sample: All rocks larger than 1-1/2 in. diameter	Comprehensive sample: All rocks larger than 1-1/2 in. diameter	Comprehensive sample: All rocks larger than 1-1/2 in. diameter
5	Exploratory trench: 200 to 500 grams of soil from bottom	S-200 trench: 200 to 500 grams from each of three locations (i.e., bottom, top and side)	Exploratory trench: 200 to 500 grams of soil from bottom
6	Lunar environmental soil sample	Lunar environmental soil sample	N/A

5.9 LASER RANGING RETRO-REFLECTOR

Deploy the Laser Ranging Retro-Reflector Experiment (S-078).

Purpose

The purpose is to deploy the Laser Ranging Retro-Reflector Experiment package on the lunar surface to provide a corner reflector for laser ranging from earth.

The functional test objective is as follows:

FTO 1) Deploy the Laser Ranging Retro-Reflector (LRRR) Experiment.

Test Conditions

FTO 1) The astronaut will remove the experiment from the descent stage of the LM and transport it to the deployment site. The LRRR Experiment will be emplaced, leveled and oriented with the leveling bubble and shadowgraph.

Deployment Requirements:

a) The LRRR will be deployed a minimum of 300 feet from the LM; a deployment of greater than 500 feet from the LM is highly desirable.

b) The deployment direction will be such that the ascent engine plume does not impinge on the array face.

Two Hasselblad electric data camera photographs will be obtained of the array and the deployment area. Photographic requirements are as follows:

a) One photograph of the top of the array taken from a distance of 3 to 5 feet showing the bubble level and shadowgraph. The astronaut will not shadow the array.

b) One photograph of the array taken at a 45-degree angle between the front and side at a distance of 10 to 15 feet. This photograph will include the LM or other identifiable objects or landmarks.

Success Criteria

FTO 1) Successful ranging data shall be obtained at the earth by use of the passive corner reflector system of the LRRR on the moon.

Evaluation

FTO 1) Ranging data obtained by use of the LRRR Experiment will be studied by the Principal Investigator and by other scientists who obtain ranging data from the LRRR. (Experiment support and experiment evaluation data as defined under Data Requirements) A

Data Requirements

1) Experiment Support Data (ESD): (HD) A

a) Voice Comments:

Comments on location of deployed experiment with respect to the LM and comments on any problems related to deployment.

2) Experiment Evaluation Data (EED): A

a) Astronaut Logs or Voice Records: (HD)

One copy each of astronaut logs or voice records containing comments on location of the deployed experiment with respect to the LM and comments on any problems related to deployment. A

b) Astronaut Debriefing: (HD)

One copy each of astronaut postmission scientific and photographic debriefing transcripts pertaining to the deployment of the Laser Ranging Retro-Reflector. A

c) Photographs: (HD)

One copy each of photographs of the deployment area with the deployed experiment. A

d) Ranging Data: (M)

Provisions for obtaining LRRR ranging data is not an MSC requirement. The ranging data will be obtained from appropriate stations by the experiment Principal Investigator. A

5.9 LASER RANGING RETRO-REFLECTOR

Background and Justification

Apollo 11 included the emplacement of a Laser Ranging Retro-Reflector Experiment package on the lunar surface. Various factors affect laser ranging such as lunar motion, lunar librations and earth rotation. Data on the nature of the irregular variations in the earth's rotation, and hence its cause, are determined from the laser ranging data. Data are also obtained on factors affecting earth rotation such as material imperfections, ocean loading and energy interchanges between atmosphere and crust or the core and the mantle.

Apollo Mission J-1 will provide further knowledge of gravity and relativity, selenophysics, geophysics, and the motion of the moon. These data will supplement the Apollo 11 and 14 data. This should result in a refined definition of lunar motion and libration.

The Laser Ranging Retro-Reflector array will consist of 300 quartz cubes.

The two photographs described under Test Conditions are to provide a permanent record of the deployed LRRR precise level condition, relation to the sun, location within the landing area, and the cleanliness condition of the quartz corner-reflectors. These photographic data are important in interpreting and compensating for any off-nominal experiment operation or anomalous results. B

Previous Mission Experiments

Experiment Number	Title	Mission
S-078	Laser Ranging Retro-Reflector	11
S-078	Laser Ranging Retro-Reflector	14

5.10 SOIL MECHANICS

Conduct the Soil Mechanics Experiment (S-200).

Purpose

The purpose is to obtain data on the physical characteristics and mechanical properties of the lunar soil at the surface and subsurface and their variations in a lateral direction. A

The functional test objectives are as follows:

FTO 1) Obtain data on the lunar surface and subsurface characteristics relative to the origin and nature of the lunar soil and its mechanical properties.

FTO 2) Obtain penetrometer data to maximum depth within crew capability (about 30 inches) and plate load-sinkage data at the surface.

Test Conditions

FTO 1)
FTO 2) Lunar surface activities will include excavating a trench, recording crew observations and obtaining photographs. At the trench excavation site located at least 100 feet from the LM and in the immediate proximity (approximately 10 feet) of an LRV track, a penetrometer test will be performed on a level surface. When using the penetrometer, a smooth, even force will be applied to accomplish the penetrometer test. Immediately adjacent to the penetrometer test location, a narrow trench (a minimum of 8 inches wide) aligned 20 degrees off the sunline will be excavated to a depth of 12 inches or until one of the following conditions occurs: A A

a) A wall failure occurs.

b) An impenetrable stratum is reached. A

c) Timeline limit is reached.

The sunlit long wall should be vertical and smooth. Another penetrometer test and a plate load test will be performed at the bottom of the trench.

If a wall does not fail during excavation, a plate load test using the 1-inch by 5-inch bearing plate will be performed at the top of the wall in an effort to induce a wall failure. The 5-inch side of the plate should be placed parallel to the smooth vertical wall and approximately one-third the trench depth from the smooth vertical wall. A

Trenching activities will be documented according to the following procedure (to insure that the no-contrast region is avoided, a sun relative azimuth is permitted when taking down-sun photographs):

a) The gnomon will be placed near the trench site (down-sun). The leg with the attached photometric chart will be pointed up-sun.

b) Three Hasselblad electric data camera (HEDC) photographs will be obtained of the trench site before excavation. One photograph will be taken down-sun at a distance of 11 feet and a stereo pair will be taken cross-sun from a distance of 7 feet.

c) 16 mm data acquisition camera sequence photographs will be obtained down-sun during excavation.

d) Deleted B

e) One stereo-pair will be taken from a distance of 7 feet, cross-sun, of the sunlit side of the trench, using the HEDC. (Field-of-view to include excavated material.) B

f) A stereo-pair of the trench will be taken down-sun, at a distance of 7 feet, using the HEDC.

g) It is highly desirable that photography listed in e), and f) above, be taken of the LRV track section closest (approximately 10 feet) to the trench. B

h) A photograph will be taken at a distance of 15 feet to show site location with respect to the LM or a prominent terrain feature using the HEDC.

i) A cross-sun stereo pair will be taken from a distance of 7 feet of the material from the collapsed wall, using the HEDC. If the wall did not fail during excavation, the stereo pair will be taken of the bearing plate imprint. B

In addition, photographs of the following will be obtained:

a) HEDC photographs of the lunar surface showing erosive craters caused by DPS exhaust impingement. A photograph will be taken cross-sun at about 11 feet from the center of the landed LM.

FTO 2) Lunar surface activities will include probing the surface with the penetrometer to provide load-penetration and plate load-sinkage data at locations of differing soil consistency, texture or type, and obtaining photographs. The priority, location, type of penetrometer test and the number of tests are listed below:

Priority	Location	Test Type	Number of Tests
1 (M)	Adjacent to trench	0.5 in^2 cone	1
2 (M)	Top of vertical cut (trench)	1 in. x 5 in. plate	1
3 (M)	At one core tube site	0.5 in^2 cone* 1 in. x 5 in. plate	1 1
4 (M)	In and adjacent to LRV track (soft soil)**	0.5 in^2 cone	2
5 (M)	Trench bottom	1 in. x 5 in. plate	1
6 (HD)	In and adjacent to LRV track (firm soil)**	0.5 in^2 cone	2
7 (HD)	At four additional core tube sites	0.5 in^2 cone	4
8 (HD)	Trench bottom	0.5 in^2 cone	1
		TOTAL	14

B

Penetration tests of priorities 1, 3 (cone only) and 4 above will be documented according to the following procedure (photographs of penetration tests of priorities 6 and 7 are HD but no photographs are required of penetration test of priority 8):

HEDC photograph of each test to show site location with respect to LM or a prominent terrain feature, and to show the maximum depth to which the astronaut was able to push the penetrometer. The gnomon will also be in the field-of-view.

*Not required if the core tube site is within 15 feet of the trench. B

**Extreme conditions; e.g., shallow and deep tracks, should be chosen if possible.

Plate load-sinkage test of priority 2 above will be documented with an HEDC as follows: B

- The gnomon will be positioned down-sun near the plate load site.

- A cross-sun stereo-pair of the test surface (after the plate load is removed) will be taken from a distance of 7 feet.

- Deleted B

Plate load-sinkage tests of priorities 3 and 5 above will be documented with an HEDC as follows:

- The gnomon will be positioned down-sun near the plate load site. B

- One photograph of the test surface (after the plate load is removed) will be taken from a distance of 7 feet.

Success Criteria

FTO 1) Data shall be obtained from trenching operations on lunar surface and subsurface characteristics relative to the origin and nature of the lunar soil. Data shall also be obtained on the mechanical properties of lunar surface material including texture, consistency, density, color, compressibility, cohesion, and adhesion. The data shall include the natural slope of the excavated material, the integrity of the sidewalls of the excavation, and the resistance of the soil at the bottom of the trench and in the sidewalls to penetration and plate loads.

FTO 2) Data shall be obtained from penetrometer and plate load tests.

Evaluation

FTO 1) Lunar surface and subsurface characteristics will be evaluated through analysis of the crew comments and photographs of the excavation and material excavated and penetration test results. The excavation and excavated material will provide data of subsurface strata, sidewall crumbling, density and natural slope of the subsurface material. Penetrometer and plate load data (force versus penetration or sinkage) will yield quantitative data on strength, density, and stress-deformation characteristics. Properly calibrated LRV performance and wheel/soil interaction data, obtained along the LRV traverses, will yield information relating to the variability of lunar surface materials with lateral position and to depths of the order of the LRV wheels width (approximately 9 inches). These data will be used for scientific analysis of the origin and nature of lunar surface material.

(Astronaut records, debriefing transcripts, still photographs, sequence photographs and lunar samples data) A

The mechanical behavior of the lunar surface material will be assessed through analyses of the LM footpad-lunar soil interactions, soil accumulation on the LM vertical surfaces, soil mechanics data obtained during EVA, lunar soil-LRV interactions and samples of returned lunar surface material. The interaction of the LRV with the lunar surface soil will be evaluated from: (1) photographs; (2) astronaut observations or returned data from the LRV in terms of terrain, power consumption, wheel-slip and sinkage, and dust trajectories at the wheel/soil interface under various terrain conditions; (3) geometry, mass distribution and dynamic characteristics of vehicle mobility system. The footpad-soil interaction will be determined from photographs and from analysis of the landing gear stroking and touchdown conditions as determined from lunar trajectory data, descent engine thrust and vehicle mass properties. The Soil Mechanics Team will analyze data from the soil samples returned to the LRL and will debrief the astronauts on the basis of the results of examination of the returned data. (Astronaut records, photographs, and LM descent data) A

FTO 2) Lunar soil strength and deformation characteristics and the existence of any hard stratum or subsurface boulders will be evaluated by comparing the effort required to push the penetrometer and bearing plate into lunar soil with that required to probe terrestrial soil analogs. Variability of lunar soil mechanical properties with lateral position and to depths of up to 30-inches will be evaluated from penetrometer and plate load test results, trenching, core tube sampling, astronaut footprints, and interactions between the LM, ALSEP and LRV with the surface. The performance of the LRV on the lunar surface will be compared with LRV full-scale and model tests on terrestrial analogs of lunar soil performed under one g and reduced gravity conditions. (Astronaut records, photographs, penetrometer calibration data, and penetrometer recording drums) A

Data Requirements

1) Premission Data (PD): A

a) Penetrometer Calibration Data: (M)

Calibration data from penetrometer tests will be obtained by S&AD for the Principal Investigator. A

b) Photographs: (HD)

Photographs of the landing gear to show the primary and secondary strut assemblies. One photograph is required for each of the eight secondary strut assemblies and the adjoining primary strut assembly. A total of eight photographs is required. The line-of-sight from the camera should be approximately perpendicular to the plane containing the strut assembly. Each field-of-view should be as small as possible, but should include all of the secondary strut assembly at or below the attachment of the secondary assembly.

c) Geometry, mass distribution and dynamic characteristics of the LRV system. These data will be supplied to the Principal Investigator by S&AD. (HD) A

2) Experiment Support Data (ESD):

a) Voice Comments: (M)

(1) Estimates of depths of any layers (or strata) detected while excavating the trench.

(2) Penetration number as read from self-recording penetrometer indexing system.

(3) Smoothness of application of pressure upon the penetrometers and any abrupt changes in force applied. Abrupt changes in resistance to penetration of the cone penetrometer as would indicate the presence of hard subsurface layers, rock fragments, very soft substrata or cavities. A

3) Experiment Evaluation Data (EED):

a) Astronaut Logs or Voice Records:

One copy of each astronaut log or voice records pertaining to information on the following:

(1) Comments on the depths of any layers (or strata) detected while excavating the trench. (M)

(2) Penetration number as read from self-recording penetrometer indexing system. (M)

(3) Comments on abrupt changes in resistance to penetration of the cone penetrometer as would indicate the presence of hard subsurface layers, rock fragments, soft substrata or cavities. (M) A

(4) Comments on visibility effects due to any lunar dust erosion during the final approach, on the severity of the landing and on the vehicle stability during touchdown. (HD)*

(5) Comments on LM footpad-lunar soil interactions to include estimates of the amount of penetration (depth of 6 inches or greater), soil displacement and footpad skidding (6 inches on a side). (HD)* A

(6) Comments on slope and roughness of the terrain. (HD)* A

(7) Comments on lunar soil erosion caused by the DPS exhaust impingement during landing to include depth, diameter and shape of any erosion crater (visible craters deeper than 3 inches). (HD)*

(8) Comments describing the descent engine skirt ground clearance. (HD)* A

(9) Estimate of walking distance, weight carried, time required, and description of terrain traversed during traverses for ALSEP deployment or lunar geology sampling. (HD)* A

(10) Comments describing the variations in depth of boot prints in the lunar surface. (HD)* A

(11) Comments on the color and texture of both undisturbed areas of the lunar surface and areas disturbed by LM landing and by the astronauts. (HD)* A

(12) Estimate of the depth, description of the excavation, and time required to complete the excavation. (HD)* A

(13) Estimate of the natural slope of the pile of excavated lunar soil. (HD)* A

(14) Comments on the effort required to push the penetrometer and bearing plate into the lunar surface and on the depth and firmness of any subsurface obstructions. (HD)* A

(15) Comments on soil behavior (i.e., texture, consistency and adhesiveness) during collection of samples or other surface activities, including LRV operations. (HD)* A

(16) Estimate of the amount of stroking of each primary and secondary strut assembly if the landing gear strut assembly photographs cannot be obtained. (HD)* A

*No specific crew tasks are required. Copies of these logs and voice records are to be provided to the Principal Investigator and Soil Mechanics Team only if they are obtained in support of operational tasks, detailed objectives or other detailed experiments.

(17) Comments on tendency of surface adjacent to penetrometer and bearing plate test location to bulge, or crack. (HD)*

(18) Comments in regard to LRV performance, in terms of terrain, power consumption, wheel/soil interaction and wheel slippage data. (HD)*

b) Astronaut Debriefings:

One copy each of astronaut postmission scientific and photographic debriefing transcripts pertaining to both mandatory and highly desirable experiment functions. (M)

c) Photographs:

Two copies each of the following photographs:

(1) Set of panoramic photographs taken in the immediate proximity of the LM. (M)

(2) Photographs of the lunar surface showing DPS exhaust impingement erosion crater. (M)

(3) Photographs of the excavation area before and after the excavation, using the Hasselblad electric data camera. (M)

(4) Photographs at penetrometer test sites to show site location and the maximum depth to which the astronaut was able to push the penetrometer. (Mandatory for tests with priorities 1, 3 and 4; HD for tests with priorities 6 and 7) B

(5) Photographs of the plate load test area after each plate load test is conducted. (M)

(6) Photographs of the area where each plate load test was conducted to show the location with respect to the LM or a prominent terrain feature. (M)

(7) Photographs obtained by the 16 mm battery operated camera of the trenching operations. (M)

(8) Photographs of the course traversed before and after traverses for ALSEP deployment, including photographs of an astronaut footprint showing interaction between astronaut boots and lunar surface. (HD)*

*No specific crew tasks are required. Copies of these logs and voice records are to be provided to the Principal Investigator and Soil Mechanics Team only if they are obtained in support of operational tasks, detailed objectives or other detailed experiments.

(9) Photographs of the LM exterior showing any soil accumulation on the vertical surfaces. (HD)*

(10) Photographs of each LM footpad and surrounding lunar soil exhibiting evidence of LM footpad-lunar soil interaction. (HD)*

(11) Photographs of natural slopes, boulders, ridges, rills, crater walls and embankments in the vicinity of the landing site. (HD)*

(12) Photographs of the lunar soil-LRV interactions, using the Hasselblad electric data camera. (HD)*

(13) Photographs obtained by the 16 mm battery operated camera of the LRV in motion. (HD)*

(14) Photographs of LRV track in vicinity of soil mechanics trench which will consist of a stereo pair down-sun, a stereo pair up-sun, and a cross-sun stereo pair of each track wall. (HD) A

d) Lunar Sample Data:

Lunar soil mechanics data derived from the returned lunar samples, as provided by the Lunar Sample Preliminary Examination Team. (M)

e) Penetrometer recording drum. (M)

f) LM Descent Data: (M)

LM mass, position, velocity and accleration with respect to the LM landing point, and descent engine thrust level during final approach. To be provided to the PI by the Apollo Spacecraft Program Office/Test Division. (Note: These data will be used in rocket exhaust soil erosion studies. In previous missions, data for the last 2 minutes prior to touchdown were applicable.)

g) Deleted

A

*No specific crew tasks are required. Copies of these photographs are to be provided to the Principal Investigator and Soil Mechanics Team only if they are obtained in support of operational tasks, detailed objectives or other detailed experiments.

5.10 SOIL MECHANICS

Background and Justification

The Soil Mechanics Experiment will provide data that will enable determination of the compositional, textural, and mechanical properties of lunar soils and their variations with depth, in lateral directions, and between Apollo landing sites. These data are essential to the verification or modification of existing theories or to the formulation of new theories of lunar history and lunar processes. The "in-situ" characteristics of the unconsolidated surface materials can provide an invaluable record of the past influences of time, stress, and environment. Of particular importance are such characteristics as particle size and shape, particle size distribution, density, strength and compressibility, and their variations from point to point.

The Soil Mechanics Experiment and several of the other Apollo experiments (e.g., Lunar Geology Investigation, Passive Seismic Experiment, and Heat Flow Experiment) are mutually interdependent in the sense that data analysis and interpretation in one experiment may depend to a significant extent on the results from another. Any satisfactory new hypothesis for lunar history and processes must be compatible with the findings from all of them.

Data obtained from Apollo 11, 12, and 14, in conjunction with that planned to be obtained from Apollo Mission J-1, will be used to correlate terrain features and properties, and to predict soil mechanical properties and probable behavior during later Apollo missions. These data are essential for improving methods for site selection and the development of design criteria and performance prediction techniques and terrestial validation testing for roving vehicles. The accumulated data will be needed for development of lunar construction techniques and equipment should lunar basing be undertaken in the post-Apollo period. A A

Direct observation and testing (in the LRL) of returned lunar soils are essential to the success of this experiment. Some of the needed properties such as grain size, grain shape, grain size distribution, and specific gravity cannot practicably be determined on the moon. Studies in the LRL of such characteristics as strength, modulus of deformation, compressibility, density, and adhesion serve vital functions: namely, (1) development of a "feel" for the behavior of the real material; (2) direct measurement of some properties that otherwise could only be deduced indirectly, and the dependence of these properties on such factors as stress, disturbance, and densification; (3) determination of the influences of environmental changes on behavior; and (4) evaluation of the suitability of terrestrial, lunar soil simulants that are being used for a variety of baseline studies.

Apollo Mission J-1 will provide additional data on lunar soil mechanical properties and terrain features to include penetrometer and plate load test data. These data are essential for meeting the objectives of the Soil Mechanics Experiment.

Previous Flight Objectives/Experiments

Objective/Experiment Number	Title	Mission
B	Lunar Surface EVA Operations	11
D	Landing Effects on LM	11
E	Lunar Surface Characteristics	11
B	Lunar Surface EVA Operations	12
H	Lunar Surface Characteristics	12
S-200	Soil Mechanics	14 A

5.11 GAMMA-RAY SPECTROMETER

Conduct the Gamma-Ray Spectrometer Experiment (S-160).

Purpose

The purpose is to obtain data relating to the origin and evolution of the moon by determining the degree of chemical differentiation the moon has undergone during its development and to determine the composition of the lunar surface.

The functional test objectives are as follows:

FTO 1) While the CSM is in lunar orbit, measure the gamma-ray flux at the CSM from the direction of the lunar surface to determine the degree of chemical differentiation in different regions of the lunar surface.

FTO 2) While the CSM is in transearth coast, measure the gamma-ray flux of cislunar space to obtain background reference data, a spectrum of the cosmological gamma-ray flux, and the CSM/SIM radioactivity background flux to determine the contribution of this flux to the experiment data.

Test Conditions

FTO 1)
FTO 2) The crew will operate the Gamma-Ray gainstep switch as requested by MCC. (Such requests are expected to be infrequent.) The switch in the GAINSTEP position is a control used to adjust the spectrometer energy range. The switch will be placed in the SHIELD OFF position for 10 continuous minutes within 1 hour after the initial experiment activation. Successive 10-minute periods of operation with the switch in the SHIELD OFF position will be required each nominal 5 hours of experiment operation. This will not be required during crew rest periods. The SHIELD OFF switch position commands a function which certifies proper operation of the veto logic of the gamma-ray spectrometer. The crew will place the Gamma-Ray experiment switch (S9 on panel 230) to the OFF position for all SPS burns. After each SPS burn is completed, the switch will be returned to the pre-SPS burn switch configuration as soon as is practicable. B

FTO 1) The experiment will be operated in lunar orbit with the boom fully extended for 10 hours minimum (not necessarily continuous). It is highly desirable that the experiment be operated during all the remaining time in lunar orbit. For any 50-hour portion of highly desirable period, the boom will be fully extended. For lunar revolution 69 while the 3-Inch Mapping Camera is being used for one photographic sequence, B the experiment will be operated with the boom at an extension of 8 feet. For any remaining period of experiment operation in lunar orbit, the boom will be fully retracted to prevent possible reflection of light into the cameras used in support of the SM Orbital Photographic Tasks objective. Data will be obtained during as much of each orbit as possible throughout the experiment period. Concurrent operation with the X-Ray Spectrometer Experiment and the Alpha Particle Spectrometer Experiment is highly desirable. B

During experiment operation, the CSM will be maneuvered such that the experiment detector points toward the lunar surface within ±11.5 degrees of the lunar local vertical. A CSM attitude deadband no greater than ±5 degrees in both pitch and roll axes will be established to compensate for SIM boom attachment and bending uncertainties. Drift rates in all axes and the attitude about the yaw (Z) axis are not critical. The SIM centerline direction must be known within ±2 degrees to satisfy postmission pointing knowledge requirements.

FTO 2) The boom will be fully deployed and data collection initiated as soon as practicable after TEI. The data collection period may be interrupted for such events as EVA or mid-course corrections but the cumulative data collection period will be at least 30 hours and will include 2 hours of continuous data collection with the 3-Inch Mapping Camera cover open. It will be highly desirable to obtain data during all remaining TEC time following the cumulative 30-hour period. B

It will be highly desirable to collect data for 2 hours when the boom is retracted to about 15 feet, for 2 hours when the boom is retracted to about 8 feet, and for 2 hours when the boom is fully retracted. Collection of data for an additional 2-hour period with the boom in each of these three positions will be useful in the evaluation of the CSM/SIM contribution to the background flux. Data is not required to be collected continuously during the specified data collection periods.

There are no attitude constraints during the transearth coast data collection periods, and the CSM may be in the passive thermal control (PTC) mode.

Success Criteria

FTO 1) Mandatory experiment data defined under Data Requirements
FTO 2) shall be obtained and provided to the Principal Investigator.

Evaluation

FTO 1) FTO 2) The data analysis and evaluation will be conducted postflight by the Principal Investigator. The linearity of the system and the detector response as a function of energy will be determined by inflight calibration of the system using monoenergetic sources. Least squares analysis and statistical correlation techniques will be used to convert the measured pulse height spectra to the photon spectra incident on the detector. To enhance data quality, interfering radiation (such as contributed by the CSM/SIM environment) will be evaluated.

The characteristic lines of these spectra will be related to the abundance of geochemical sources on the lunar surface through laboratory and field tests. (Premission, experiment support and experiment evaluation data listed under Data Requirements) A

Data Requirements

1) Premission Data (PD):

a) Telemetry Measurements:

Telemetry measurements listed under 3)a). (M)

b) Calibration and Checkout Data:

Calibration and checkout data in accordance with KSC procedure TCP-505397. (M)

2) Experiment Support Data (ESD):

a) Telemetry Measurements: A

Telemetry measurements listed under 3)a). Display preference is indicated by (D) for digital. (M)

b) Voice Comments:

(1) Description and GET of changes to experiment control settings during mandatory periods of experiment operation. (M)

(2) Description and GET of changes to experiment control settings during highly desirable periods of experiment operation. (HD)

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority PD	ESD	EED
SL 1085 T	Temp Gamma-Ray Detector	PCM	1	HD	HD(D)	HD
SL 1086 T	Temp Gamma-Ray Electronics Pkg	PCM	1	HD	HD(D)	HD
SL 1087 K	Gamma-Ray Spectr Serial Output	FM	N/A	M	M*(D)	M*
SL 1208 T	Temp Thrm Envir-Gamma-Ray Struct	PCM	1	N/A	N/A	HD

A

b) Telemetry Measurement Tapes:

One copy of tapes** containing EED telemetered measurements listed under 3)a), recorded and correlated with GMT during periods of experiment operation.

c) Astronaut Logs or Voice Records:

One copy each of astronaut logs or voice records containing:

(1) Description and GET of changes to experiment control settings during mandatory periods of experiment operation. (M)

(2) Description and GET of changes to experiment control settings during highly desirable periods of experiment operation. (HD)

d) Astronaut Debriefings: A

One copy of each astronaut postmission scientific and photographic debriefing transcript pertaining to both mandatory and highly desirable periods of experiment operation. (HD)

e) Photographs: A

One copy of each appropriate Mapping and/or Panoramic Camera photograph that has been taken of the lunar surface over which the CSM gamma-ray spectrometer has operated. Photographs are to be identified by GET and selenographic coordinates. (HD)

f) Trajectory: A

One copy of tape** containing:

(1) Best estimated of trajectory (BET) including spacecraft attitude for the CSM during mandatory periods of experiment operation. (M) A

(2) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during highly desirable periods of experiment operation. (HD) A

g) Supporting Data: A

The following scientific data will not be provided by MSC but will be obtained through arrangement between responsible Principal Investigators:

(1) Reduced X-Ray Fluorescence Experiment data obtained during periods of Gamma-Ray Spectrometer Experiment operation. (HD) A

(2) Reduced Alpha Particle Spectrometer Experiment data obtained during periods of Gamma-Ray Spectrometer Experiment operation. (HD) A

*This measurement is M during mandatory experiment operation and HD during highly desirable experiment operation.

**Magnetic tapes produced are to be IBM 360/50 computer-compatible digital 7-track, 800-BPI tapes.

5.11 GAMMA-RAY SPECTROMETER

Background and Justification

The Gamma-Ray Spectrometer Experiment is intended to obtain evidence relating to the origin and evolution of the moon. This will be accomplished by measuring the gamma-ray flux from the surface of the moon while the CSM is in lunar orbit. This flux has two components. The first is the decay of natural radioisotopes in the lunar surface material. The principal contributors will be isotopes of potassium, uranium and thorium, plus radioactive "daughters" of the latter two elements. The intensity of these contributors is a sensitive function of the degree of chemical differentiation of the moon. Chemical differentiation is the result of substantial melting within the moon at any time in the past or present, and will be indicated at the lunar surface by concentrations of various elements which are distinctive from the mean solar abundance and values measured in meteorites. The second is gamma radiation which will be produced by the interaction of cosmic ray particles with the nuclei of chemical elements making up the lunar surface. This experiment will extend our chemical information from a few landing sites to the entire area overflown by the CSM, with spatial resolution limited only by the total time of data collection.

Operation of the gamma-ray spectrometer during transearth coast will provide calibration data on the CSM/SIM background fluxes and will provide data that will permit an evaluation of the change in galactic flux as a function of lunar occultation.

The history of gamma-ray experiments relating to the moon's surface is not extensive. Gamma-ray experiments were flown on Rangers III, IV, and V, but no significant data were obtained from the moon. The USSR included a gamma-ray experiment on Luna 10, and possibly on Luna 11 and 12. The data from Luna 10 are not comprehensive, and no data have been published for Luna 11 and 12. The present Gamma-Ray Spectrometer Experiment was originally developed for the Lunar Orbiter.

The Gamma-Ray Spectrometer Experiment is bit-limited and maximum operating time is therefore essential.

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.12 X-RAY FLUORESCENCE

Conduct the X-Ray Fluorescence Experiment (S-161).

Purpose

The purposes are to measure the instantaneous fluorescent X-ray flux from the lunar surface; to monitor both the direct solar X-ray flux which produces this fluorescence and the background galactic X-ray flux in order to obtain a gross analysis of the elemental composition of the lunar surface materials; and to measure the X-ray flux of selected galactic objects for X-ray astronomy investigations.

The functional test objectives are as follows:

FTO 1) While the CSM is in lunar orbit, measure the lunar fluorescent X-ray flux and monitor the solar X-ray flux incident on the lunar surface.

FTO 2) While the CSM is in transearth coast, measure the X-ray flux of selected galactic objects and monitor the background X-ray flux in deep space.

Test Conditions

FTO 1)
FTO 2) The CSM attitude will be changed as necessary to prevent direct sunlight from entering the 60-degree square field-of-view of the experiment detector. If necessary to prevent damage, the experiment will be switched to OFF.

Firing of RCS jets (A2, A4, B1, and B4) will be inhibited during the experiment operating period. It is highly desirable that urine dumps, waste water dumps, and fuel cell purges be inhibited during the experiment operating period prior to rendezvous. If it becomes necessary to accomplish any of the above dumps during the experiment operating period, the GET of the dump will be recorded. The crew will place the X-Ray Fluorescence experiment switch (S25 on panel 230) to the OFF position for all SPS burns. After each SPS burn is completed, the switch will be returned to the pre-SPS burn switch configuration as soon as is practicable. B

FTO 1) The experiment will be operated in lunar orbit and data collected for 10 hours minimum with at least 8 hours and 10 minutes of continuous operation. Additional operation and data collection during available time periods throughout the SIM experiment period will be highly desirable to improve the statistical quality of experiment data. During experiment operation, the CSM will be maneuvered such that the experiment detector points toward the lunar surface within ±6.5 degrees of the lunar local vertical. A CSM attitude deadband no greater than ±5 degrees in both the pitch and roll axes will be established to compensate for SIM and detector pointing uncertainties. Drift rates in all axes and the attitude about the yaw (Z) axis are not critical. The direction of the experiment detector must be known within ±2 degrees to satisfy post-mission pointing knowledge requirements. Data will be obtained during complete orbits unless interrupted by required operational activities such as tape recorder operation. B

Concurrent operation of this experiment and the Gamma-Ray Spectrometer and the Alpha Particle Spectrometer Experiments (geochemical group) is highly desirable.

Once each activity day during the SIM experiment period, the CSM will be maneuvered so that the fluorescence detector is oriented toward deep space at an angle of 135 degrees to 180 degrees with respect to the nadir. This maneuver will be performed on the dark side of the moon and the deep space background X-ray flux data collected for 15 minutes.

FTO 2) Anytime during transearth coast, the experiment will be operated and data collected for the specified times from the following galactic objects listed in order of priority:

Source	Right Ascension	Declination	Data Collection Time
Sco X-1	$16^{hr}\ 0^{min}$	-10°	60 min.
Cyg X-1	$19^{hr}\ 15^{min}$	+30°	60 min.
Centaurus	$11^{hr}\ 5^{min}$	-60°	60 min.
North Galactic Pole (NGP)	$12^{hr}\ 46^{min}$	12°24'	35 min.
Mid-Galactic Lattitude (MGL)	$16^{hr}\ 50^{min}$	20°39'	35 min.
South Galactic Pole (SGP)	$1^{hr}\ 45^{min}$	-36°45'	35 min.
Galactic Plane Anti-Center (GPA)	$7^{hr}\ 0^{min}$	-15°	35 min.

B

After the above data are collected, it is highly desirable that data from Cyg X-1 again be collected as many times as possible. The required combined pointing accuracy and stability is ±3 degrees. These observations will not be made if in so doing the thermal constraints of the spacecraft are violated.

Success Criteria

FTO 1) FTO 2) Mandatory experiment data defined under Data Requirements shall be obtained and provided to the Principal Investigator.

Evaluation

FTO 1) The geochemical interpretation will be conducted under a consortium utilizing the results from this analysis and, if available, those of the Gamma-Ray and Alpha Particle Experiments. (Premission, experiment support and experiment evaluation data listed under Data Requirements) A

FTO 1) FTO 2) The Principal Investigator and investigation team will study and evaluate the data. Automatic in-flight calibration using internal monoenergetic sources will establish the linearity of the system and detector response as a function of energy input.

Least squares analysis and statistical correlation techniques will be used to convert the measured pulse height spectra to the photon spectra incident on the detectors. This conversion to the photon spectra will allow information to be more readily distinguished. (Premission, experiment support and experiment evaluation data listed under Data Requirements)

FTO 2) The transearth coast data will be evaluated and correlated with existing radio and optical data to identify and categorize galactic X-ray sources. (Experiment support and experiment evaluation data listed under Data Requirements) A

Data Requirements

1) Premission Data (PD):

a) Telemetry Measurements:

Telemetry measurements listed under 3)a). (M)

b) Calibration and Checkout Data:

Calibration and checkout data in accordance with KSC procedure TCP-132143. (M) A

2) Experiment Support Data (ESD):

a) Telemetry Measurements:

Telemetry measurements listed under 3)a). Display preference is indicated by (D) for digital. (M)

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority PD	ESD	EED
CH 3546 X	RCS Solenoid Activate C3/13/+X	PCME	1	N/A	N/A	HD
CH 3547 X	RCS Solenoid Activate A4/14/+X	PCME	1	N/A	N/A	HD
CH 3548 X	RCS Solenoid Activate A3/23/-X	PCME	1	N/A	N/A	HD
CH 3549 X	RCS Solenoid Activate C4/24/-X	PCME	1	N/A	N/A	HD
CH 3550 X	RCS Solenoid Activate D3/25/+X	PCME	1	N/A	N/A	HD
CH 3551 X	RCS Solenoid Activate B4/26/+X	PCME	1	N/A	N/A	HD
CH 3552 X	RCS Solenoid Activate B3/15/-X	PCME	1	N/A	N/A	HD
CH 3553 X	RCS Solenoid Activate D4/16/-X	PCME	1	N/A	N/A	HD
CH 3554 X	RCS Solenoid Activate B1/11/+Z	PCME	1	N/A	N/A	HD
CH 3555 X	RCS Solenoid Activate D2/22/+Z	PCME	1	N/A	N/A	HD
CH 3556 X	RCS Solenoid Activate D1/21/-Z	PCME	1	N/A	N/A	HD
CH 3557 X	RCS Solenoid Activate B2/12/-Z	PCME	1	N/A	N/A	HD
CH 3558 X	RCS Solenoid Activate A1/+Y	PCME	1	N/A	N/A	HD
CH 3559 X	RCS Solenoid Activate C2/+Y	PCME	1	N/A	N/A	HD
CH 3560 X	RCS Solenoid Activate C1/-Y	PCME	1	N/A	N/A	HD
CH 3561 X	RCS Solenoid Activate A2/-Y	PCME	1	N/A	N/A	HD
SL 1050 K	X-Ray PHA Count 8 Bit	PCMD	1	M	M*(D)	M*
SL 1051 V	X-Ray LVPS Summed Monitor	PCM	1	HD	HD(D)	HD
SL 1053 V	X-Ray Discrim Ref Volt Monitor	PCM	1	HD	HD(D)	HD
SL 1054 V	X-Ray +6.75V Analog P/S Monitor	PCM	1	HD	HD(D)	HD
SL 1055 V	X-Ray +5.0V Digital P/S Mon	PCM	1	HD	HD(D)	HD
SL 1056 V	X-Ray Processor Temp Monitor	PCM	1	HD	HD(D)	HD
SL 1057 T	X-Ray Detector Temp Monitor	PCM	1	HD	HD(D)	HD
SL 1059 T	X-Ray LVPS Temp Monitor	PCM	1	HD	HD(D)	HD
SL 1060 T	X-Ray Lunar Detect Temp Monitor	PCM	1	HD	HD(D)	HD
SL 1061 T	X-Ray Solar Detect Temp Monitor	PCM	1	HD	HD(D)	HD
SL 1202 T	Temp Thrm Envir-BM1 XS221, R62	PCM	1	N/A	N/A	HD
SL 1205 T	Temp Thrm Envir-BM6 XS221, R62	PCM	1	N/A	N/A	HD

A

b) Telemetry Measurement Tapes:

One copy of tapes** containing EED telemetered measurements listed under 3)a), recorded and correlated with GMT during periods of experiment operation. (M)

c) Astronaut Logs or Voice Records:

One copy each of astronaut logs or voice records containing:

(1) Description and GET of changes to experiment control setting during mandatory periods of experiment operation. (M)

(2) Description and GET of changes to experiment control settings during highly desirable periods of experiment operation. (HD)

(3) Description and GET of waste water and urine dumps, and fuel cell purges during SIM orbital and A

transearth experiment periods. (HD)

d) Astronaut Debriefings: A

One copy each of astronaut postmission scientific and photographic debriefing transcripts pertaining to both mandatory and highly desirable periods of experiment operation. (HD)

e) Photographs: A

One copy each of appropriate Mapping and/or Panoramic Camera photographs that have been taken of the lunar surface over which the X-ray fluorescence spectrometer has operated. Photographs are to be identified by GET and selenographic coordinates. (HD) A

f) Trajectory: A

One copy of tape** containing:

(1) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during mandatory periods of experiment operation. (M) A

(2) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during highly desirable periods of experiment operation. (HD) A

g) Supporting Data: A

The following scientific data will not be provided by MSC but will be obtained through arrangement between the responsible Principal Investigators.

(1) Reduced Gamma-Ray Spectrometer Experiment data obtained during periods of X-Ray Fluorescence Experiment operation. (HD)

(2) Reduced Alpha Particle Spectrometer Experiment data obtained during periods of X-Ray Fluorescence Experiment operation. (HD)

*This measurement is M during mandatory experiment operation and HD during highly desirable experiment operation.

**Magnetic tapes produced are to be IBM 360/91 computer-compatible digital 7-track, 800-BPI tapes.

Background and Justification

The X-Ray Fluorescence Experiment is one of a group of experiments designed to perform a remote compositional survey of the lunar surface from lunar orbit. The other experiments in this group involve gamma-ray and alpha particle measurements made from lunar orbit. Similar X-ray spectrometer experiments either have been flown on or have been planned for the OGO, OSO, AIMP, and Orbiter spacecraft. The Russians have also attempted such an experiment in their Luna series of spacecraft.

The solar X-rays will interact with the lunar surface material to produce characteristic fluorescence X-rays. The measurement of these X-rays would then be expected to yield the following information about the lunar surface:

a. Nature of surface material.

b. A measure of the homogeneity of the upper few millimeters of the lunar surface as the spacecraft orbits the moon.

c. By comparison with the Gamma-Ray Spectrometer and Alpha Particle Experiment results, some idea of the extent of "gardening"* and whether the composition of the surface is like that of the subsurface.

In particular, the solar X-ray flux incident on the lunar surface will produce a substantial X-ray albedo that will consist primarily of "K" and "L" lines from the more abundant elements. This will enable the detection of the relative abundance of the elements sodium, magnesium, aluminum, silicon, potassium, calcium, and iron as determined from the measured fluorescence yield of the lunar surface obtained during the quiet, active, and flare periods of the sun that may occur during the experiment period. The simultaneous measurement of the solar X-ray spectrum for background information will determine the excitation conditions for the radiation yield measured. The experiment results should provide the capability to discriminate among regions that are granitic, basaltic, or meteoritic in nature.

*The outer layer of the lunar surface - regolith - is sometimes called the "gardened layer."

X-ray astronomy as conducted from sounding rockets, balloons, and the satellite Uhuru has detected numerous important galactic objects such as supernova, radio galaxies, and energetic galaxies which represent a fundamental stage in the evolution of the universe. However, there are many X-ray objects which have been detected but as yet not identified or categorized. Several of these objects exhibit unusual variations in their intensity on time scales of seconds, minutes, and hours. These variations are of fundamental importance and require detailed observation. The X-ray spectrometer's energy range is coincident with that of the X-ray emissions of these objects and has the capability of essentially continuous observation during transearth coast. This capability is unique compared to previous and scheduled experiments which provide limited observation duration capability. The observations of the selected galactic objects will provide data on the integrity and spectral variations of isolated X-ray sources for longer continuous time periods than previous experiments. The X-ray data will be correlated with observations in the radio and optical spectra. The X-ray data will also be used to determine locations of X-ray sources. A

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.13 ALPHA PARTICLE SPECTROMETER

Conduct the Alpha Particle Spectrometer Experiment (S-162).

Purpose

The purpose is to obtain data on the gross rate of lunar surface radon evolution and on localized sources of enhanced radon emission for use in constructing a radiation map showing lunar surface inhomogeneities.

The functional test objective is as follows:

FTO 1) While the CSM is in lunar orbit, obtain data on lunar surface alpha particle emission from Rn^{222}, Rn^{220}, and their daughter products.

Test Conditions

FTO 1) During experiment operation, the CSM will be maneuvered such that the experiment detector points toward the lunar surface within ±6.5 degrees of the lunar local vertical. A CSM attitude deadband no greater than ±5 degrees in both the pitch and roll axes will be established to compensate for SIM and detector pointing uncertainties. Drift rates in all axes and the attitude about the yaw (Z) axis are not critical. The experiment detector direction must be known within ±2 degrees to satisfy postmission pointing knowledge requirements. The CSM attitude will be changed as necessary to prevent direct sunlight from entering the ±45 degree field-of-view of the sensor for more than 5 minutes at any one time or for more than 30 minutes total during experiment operation. The crew will place the Alpha Particle α RAY/X DR Switch (S13 on panel 230) to the OFF position for all SPS burns. After each SPS burn is completed, the switch will be returned to the pre-SPS burn switch configuration as soon as is practicable. B

Firing of RCS jets (A2, A4, B1, and B4) will be inhibited during the experiment operating period. It is highly desirable that urine dumps, waste water dumps and fuel cell purges be inhibited during the experiment operating period. If it becomes necessary to accomplish any of the above dumps during the experiment operating period, the GET of the dump will be recorded.

The experiment will be operated in lunar orbit and data collected for 10 hours minimum. Additional operation and data collection during available time periods throughout the SIM experiment period will be highly desirable to improve the statistical quality of experiment data. Continuous experiment operation and data collection during complete orbits are desired. Concurrent operation of this experiment and the

Gamma-Ray Spectrometer and X-Ray Fluorescence Experiments is highly desirable. Once each activity day during the SIM experiment period, the CSM will be maneuvered so that the experiment sensor is oriented toward deep space at an angle of 135 to 180 degrees with respect to the local vertical. This maneuver will be performed on the dark side of the moon and the background alpha particle emission data collected for 15 minutes.

While in transearth coast, it will be highly desirable to collect data concurrent with X-Ray Fluorescence Experiment operation. There are no alpha particle attitude, contamination, or sun avoidance constraints during this data collection period. A

Success Criteria

FTO 1) Mandatory data defined under Data Requirements shall be acquired and provided to the Principal Investigator.

Evaluation

FTO 1) The Principal Investigator (PI) will study and evaluate the data obtained from the MSFN receiving stations. Inflight calibrations using internal monoenergetic sources will establish the energy scale and resolution of the detectors. Statistically significant peaks in the energy spectrum will be identified. From these numbers it will be possible to determine the strength of the alpha lines from Rn^{222}, Rn^{220} and their daughter products, and the extent to which radon has evolved. If an important radon effect is found, the results of this measurement become strongly coupled with the gamma-ray measurements and the two must be analyzed and interpreted together in terms of uranium content and the radon diffusion properties of the lunar surface. A

Examination of spatial inhomogeneities will be made in the alpha particle data and the results will be correlated with the X-ray and gamma-ray measurements plus topographic maps of the lunar surface. The final result will be an attempt by the entire geochemistry study group to incorporate all measurements obtained to arrive at a consistent picture of the chemical condition of the lunar surface plus the demarcation of the following possible lunar regions: unusual radon transparency such as from crevices or fissures, sites of escaping volatiles, and areas with unusually large thorium and uranium concentrations. (Premission, experiment support, and experiment evaluation data listed under Data Requirements) A

Data Requirements

1) Premission Data (PD):

a) Telemetry Measurements:

Telemetry measurements listed under 3)a). (M)

b) Calibration and Checkout Data:

Calibration and checkout data in accordance with KSC procedure TCP-132143. (M)

2) Experiment Support Data (ESD):

a) Telemetry Measurements:

Telemetry measurements listed under 3)a). Display preference is indicated by (D) for digital. (M)

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority PD	ESD	EED
CH 3546 X	RCS Solenoid Activate C3/13/+X	PCME	1	N/A	N/A	HD
CH 3547 X	RCS Solenoid Activate A4/14/+X	PCME	1	N/A	N/A	HD
CH 3548 X	RCS Solenoid Activate A3/23/-X	PCME	1	N/A	N/A	HD
CH 3549 X	RCS Solenoid Activate C4/24/-X	PCME	1	N/A	N/A	HD
CH 3550 X	RCS Solenoid Activate D3/25/+X	PCME	1	N/A	N/A	HD
CH 3551 X	RCS Solenoid Activate B4/26/+X	PCME	1	N/A	N/A	HD
CH 3552 X	RCS Solenoid Activate B3/15/-X	PCME	1	N/A	N/A	HD
CH 3553 X	RCS Solenoid Activate D4/16/-X	PCME	1	N/A	N/A	HD
CH 3554 X	RCS Solenoid Activate B1/11/+Z	PCME	1	N/A	N/A	HD
CH 3555 X	RCS Solenoid Activate D2/22/+Z	PCME	1	N/A	N/A	HD
CH 3556 X	RCS Solenoid Activate D1/21/-Z	PCME	1	N/A	N/A	HD
CH 3557 X	RCS Solenoid Activate D2/12/-Z	PCME	1	N/A	N/A	HD
CH 3558 X	RCS Solenoid Activate A1/+Y	PCME	1	N/A	N/A	HD
CH 3559 X	RCS Solenoid Activate C2/+Y	PCME	1	N/A	N/A	HD
CH 3560 X	RCS Solenoid Activate C1/-Y	PCME	1	N/A	N/A	HD
CH 3561 X	RCS Solenoid Activate A2/-Y	PCME	1	N/A	N/A	HD
SL 1065 K	Alpha Particle Count 8 Bit	PCMD	1	M	M*(D)	M*
SL 1066 K	Alpha Part Detector Indent	PCM	1	M	M*(D)	M*
SL 1067 K	Alpha Part Count Rate Meter	PCM	1	M	M*(D)	M*
SL 1068 T	Alpha Part Detect Temp Mon No 1	PCM	1	HD	HD(D)	HD
SL 1069 V	Alpha Part +6.75V Anal P/S Mon	PCM	1	HD	HD(D)	HD
SL 1070 T	Alpha Part Detect Temp Mon No 2	PCM	1	HD	HD(D)	HD
SL 1071 T	Alpha Part LVPS Temp Mon	PCM	1	HD	HD(D)	HD
SL 1072 V	Alpha Part Detect Bias Voltage	PCM	1	HD	HD(D)	HD

A

Measurement Number	Description	TM	Mode	Priority PD	ESD	EED
SL 1073 V	Alpha Part Discrim Ref -12V Mon	PCM	1	HD	HD(D)	HD
SL 1074 V	Alpha Part +6.75V ADC P/S Mon	PCM	1	HD	HD(D)	HD
SL 1075 V	Alpha Part +5V Dis P/S Mon	PCM	1	HD	HD(D)	HD
SL 1076 V	Alpha Part Summed LVPS Mon	PCM	1	HD	HD(D)	HD
SL 1202 T	Temp Thrm Envir-BM 1 XS221, R62	PCM	1	N/A	N/A	HD
SL 1205 T	Temp Thrm Envir-BM 6 XS221, R62	PCM	1	N/A	N/A	HD

A

b) Telemetry Measurement Tapes:

One copy of tapes** containing EED telemetered measurements listed under 3)a), recorded and correlated with GMT during periods of experiment operation. (M)

c) Astronaut Logs or Voice Records:

One copy each of astronaut logs or voice records containing:

(1) Deleted A

(2) Description and GET of changes to experiment control setting during mandatory periods of experiment operation. (M)

(3) Description and GET of changes to experiment control settings during highly desirable periods of experiment operation. (HD)

(4) Description and GET of waste water and urine dumps, and fuel cell purges during SIM orbital and trans-earth experiment periods. (HD) A

d) Astronaut Debriefing:

One copy of each astronaut postmission scientific and photographic debriefing transcript pertaining to both mandatory and highly desirable periods of experiment operation. (HD)

e) Photographs: A

One copy of each appropriate Mapping and/or Panoramic Camera photograph that has been taken of the lunar surface over which the CSM alpha particle spectrometer has operated. Photographs are to be identified by GET and selenographic coordinates. (HD)

f) Trajectory: A

One copy of tape** containing:

(1) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during mandatory periods of experiment operation. (M) A

(2) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during highly desirable periods of experiment operation. (HD) A

g) Supporting Data: A

The following scientific data will not be provided by MSC but will be obtained through arrangement between the responsible Principal Investigators.

(1) Reduced Gamma-Ray Spectrometer Experiment data obtained during periods of Alpha Particle Spectrometer Experiment operation. (HD) A

(2) Raw X-Ray Fluorescence Experiment data obtained during periods of Alpha Particle Spectrometer Experiment operation. (HD) A

*These measurements are M during mandatory experiment operation and HD during highly desirable experiment operation.

**Magnetic tapes produced are to be IBM 360/40 computer-compatible digital 9-track, 800-BPI tapes. A

Background and Justification

Terrestrial radon evolution is a well-known phenomenon. Observations of this effect on the earth, carried out mostly by collecting the radon, have indeed shown enhanced local emission from the surface fissures and regions having substantial uranium and thorium concentrations. The terrestrial radon transparency exhibits variations with rock type and the concentration of water. Because of the short range of alpha particles in the earth's atmosphere, it is not possible to detect this radon by the method described for use in this experiment.

A recent analysis of lunar surface data obtained during background measurements of the Surveyor alpha backscattering instruments has revealed a surface deposit of alpha particle activity at the Surveyor V landing site. The surface deposit indicated the presence of radon daughter products of the type that would occur as a result of radon diffusion. These recent Surveyor results provide the following favorable indications for the Apollo Alpha Particle Spectrometer Experiment:

1) The existence of a fairly intense radioactive deposit on the lunar surface.

2) The surface deposit is inhomogeneous; it is different for the Surveyor V, VI, and VII landing sites.

3) The background alpha particle emission for the experiment is lower than previously thought.

Instrumentation required in this experiment has already been used successfully in space. Similar alpha particle detectors were used in the alpha-scattering measurements at the Surveyor lunar landing sites. There are many other instances in which these detectors have been used successfully in space.

There are several reasons for a study of radon evolution from the moon. Perhaps the most important is that the concentrations of uranium and thorium in different lunar regions can be directly compared when the alpha particle and gamma-ray results are correlated. With information from a gamma sensor, the concentration of uranium can be determined so that it is possible to determine the diffusion characteristics of the soil. In turn, the diffusion properties are related to the porosity and quantity of absorbed gases in the lunar soil. If there is significant diffusion of radon to the surface, then the active deposit from the radon decay will increase the gamma activity of the surface (for terrestrial rates of radon evolution, the gamma emission would be increased by a factor of three, thus making the surface appear considerably more granitic). Hence, the alpha measurement is needed in order to subtract the effect of surface deposits and give a clearer interpretation to the gamma measurements in terms of uranium concentrations. The location of regions with enhanced radon emission is an indication of one or more of the following interesting features: the occurrence of crevices or fissures on the lunar surface; areas which release volatiles generally; or possibly regions with unusual concentrations of thorium.

The alpha particle data will be considered along with the X-ray and gamma-ray data to determine a map of the lunar chemical composition.

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.14 SUBSATELLITE

Conduct the Subsatellite Experiment while it is in lunar orbit (S-164, S-173, S-174).

Purpose

The purposes are to obtain data to study the lunar gravitational field, the formation and dynamics of the earth's magnetosphere, the physical and electrical properties of the moon, the interaction of plasmas with the moon, and the physics of solar flares. The Subsatellite includes the S-band Transponder Experiment (S-164), the Particle Shadows/Boundary Layer Experiment (S-173), and the Magnetometer Experiment (S-174). A

The functional test objectives are as follows:

FTO 1) Obtain S-band Doppler tracking measurements of the Subsatellite in lunar orbit. (S-164)

FTO 2) Obtain charged particle measurements from the Subsatellite in lunar orbit. (S-173)

FTO 3) Obtain magnetic field measurements from the Subsatellite in lunar orbit. (S-174)

Test Conditions

FTO 1)
FTO 2)
FTO 3)

Effluent dumps will be avoided and RCS jets (A2, A4, B1 and B4) will be inhibited between Subsatellite cover removal and Subsatellite launch. A A

In preparation for Subsatellite launch, the CSM will be maneuvered to an inertial attitude which will permit launch with the Subsatellite/SIM interface plane oriented to within ± 2 degrees of the parallel to the ecliptic plane, and which will also prevent sunlight from entering the field-of-view of the SIM sun-sensitive experiment instruments. The CSM will be placed in attitude hold with a deadband of ± 0.5 degrees or less in all axes and a rate no greater than 0.05 degrees per second. The ± 0.5 degree deadband takes into account predicted SIM, launch platform, and launch pointing uncertainties, and satisfies postmission pointing knowledge requirements.

The CSM will be stabilized to a drift rate of 0.05 degrees per second or less prior to Subsatellite launch. The Subsatellite will be launched northward normal to the ecliptic plane. The Subsatellite lunar orbit will have an expected lifetime of 1 year.

After Subsatellite launch while the CSM is still in launch attitude, photographs of the Subsatellite will be obtained to check its external physical condition, to confirm boom deployment, and to determine relative motion with respect to the CSM. A hand-held 16 mm DAC with 75 mm lens and installed ring sight will be used. For a nominal launch, photographs will be taken through the hatch window looking toward the SIM at an angle of approximately 50 degrees from the normal to the window. The DAC will be operated at 12 frames per second for a 30-second time period. A

The Subsatellite launch platform will be retracted after launch to permit an unobstructed field-of-view for the other experiments.

Deleted A

MSFN tracking of the Subsatellite is not required until after CM return to earth.

FTO 1) Subsatellite S-band Doppler tracking data will be collected by the MSFN in accordance with the following guidelines:

a) All tracking stations collecting data will use resolvers to improve data accuracy.

b) A tracking data collection period will ideally consist of two consecutive lunar frontside (AOS to LOS) passes. The minimum data collection period will be one frontside (AOS to LOS) pass if the Subsatellite altitude is never less than 16 NM. If the altitude is less than 16 NM for any portion of a frontside pass, the minimum data collection period will be the time the Subsatellite is below 16 NM provided the time period is at least 10 minutes duration. A

c) The minimum tracking data sample rate required to obtain the desired spatial resolution of gravitational variations is dependent on the vehicle altitude above the lunar surface. The following table lists the minimum data sample rates for various lunar altitudes.

Lunar Altitude (NM)	Tracking Data Sample Rate
≥30	1 per minute
20 to 30	6 per minute
≤20	1 per second

d) Deleted A

The scientific data collection activities are listed below in order of priority.

a) It is highly desirable to collect tracking data for all frontside periods when the Subsatellite altitude is 30 NM or less. However, as a minimum, data will be collected for all periods when the altitude is below 16 NM.

b) If new gravitational anomalies are discovered during the course of the mission, sufficient data will be collected to define the anomalistic region.

c) Data will be collected from a minimum of two different altitudes over gravitationally equivalent groundtracks. These altitudes will be separated by at least 10 NM. One groundtrack is gravitationally equivalent to another if it lies within a specific altitude-dependent band about that groundtrack. For J-1, the size of such a band may be defined as:

$$BW = \frac{\text{Altitude}}{40 \sin i} = \frac{\text{Altitude}}{17.5^*}$$

Where:

BW = width of band in terms of degrees of longitude at the lunar equator. A

Altitude = altitude of spacecraft above the lunar surface in nautical miles.

i = the angle of inclination of the orbital plane to the lunar equatorial plane.

*For the planned inclination of approximately 26 degrees.

Data collection at more than two different altitudes is highly desirable.

d) Two-station tracking data will be collected at least four times per month to support the generation of a spherical harmonic coefficient set to describe the total lunar gravitational field. If only four such passes are made, they will be separated by at least 5 days. No two consecutive two-station passes will be separated by more than 9 days. More frequent two-station tracking, up to intervals of 3 days, is highly desirable. The stations collecting these data can be any combination (excluding prime/wing combinations) of Goldstone, Honeysuckle, Madrid, Guam, Hawaii, Carnarvon or Ascension stations. A A

e) In order to permit correlation with Lunar Orbiter data, it is highly desirable to obtain at least one, and preferably two, sets of data during collection periods covering the complete frontside overflown while the Subsatellite is within the altitude band between 60 NM and 45 NM. The second set should be complimentary to the first. To obtain complete coverage, tracking passes will be separated by not greater than 4.3 degrees longitude. A

f) It will be highly desirable to obtain complete tracking coverage over preselected lunar features of special interest as specified in Table 1.

FTO 2) Telemetry data at the maximum data rate will be required for the approximately 5-day period each month when the Subsatellite is in the earth's magnetotail.

Data will be collected for the entire period each month when the Subsatellite is outside the magnetotail.

Outside the magnetotail, real-time mode data will be collected at least once per day until the end of four complete lunations after the initial Subsatellite turn-on.

After four lunations are completed, the long-term support schedule will provide for real-time mode data at least twice a week. Additional collection of real-time mode data is highly desirable.

Support requirements will be reviewed after 4 months of operation and periodically thereafter to determine if the support level will be changed. Any request for a change in support level will be based on an analysis of previously collected data. A

Approximately 50 percent of the analyses planned for the Particle Shadow/Boundary Layer Experiment data depends on knowing the Subsatellite altitude to within ± 2.5 NM and latitude and longitude to within ± 0.5 degrees. Current calculations, based on 6-revolution propagations, indicate that position errors will fall within these limits for a large part of the Subsatellite mission if two-station tracking is performed during the real-time support periods described above. If this conclusion is verified by analysis of Subsatellite tracking data, the ephemeris accuracy provided by twice-a-week tracking is considered adequate for the long-term support of the Particle Shadows/Boundary Layer Experiment. The ephemeris accuracy capability and requirement will be evaluated at the 4-month support requirements review, and any change in support level will be requested at that time based on analysis of previously collected data.

Scheduled real-time mode data collection periods will be separated by approximately equal time intervals.

A polar cap sounding rocket program is planned to be conducted in conjunction with this Subsatellite mission but is not mandatory to support the Subsatellite experiments. Three rockets will be launched near Resolute Bay, Cornwallis Island, Canada when the Subsatellite is in the magnetotail. One rocket will be launched when the Subsatellite is outside of the magnetotail. This effort will require real-time monitoring of S-173 experiment data to determine when solar event particles are detected at the Subsatellite. The presence of event particles at the Subsatellite must be confirmed before each rocket launch. Controlled operation of the Subsatellite will be required concurrent with the rocket experiments.

FTO 3) Data will be collected for the entire Subsatellite mission. Real-time mode data will be collected to satisfy the following requirements:

a) During the approximately five-day period each month that the Subsatellite is in the earth's magnetotail, magnetometer data will be collected whenever valid data are being collected by any of the particles experiment sensors. A

b) Outside the magnetotail, real-time mode data will be collected at least once per day until the end of four complete lunations after the initial turn-on of the Subsatellite.

c) After four lunations are completed, the long-term support schedule will provide for real-time mode data at least twice a week.

Support requirements will be reviewed after four months of operation and periodically thereafter to determine if the support level is to be changed. Any request for a change in support level will be based on an analysis of previously collected data.

d) Additional real-time mode data collection is highly desirable.

e) Scheduled real-time mode data collection periods will be separated by approximately equal time intervals.

For noncontinuous real-time support of the magnetometer experiment, the following guidelines will be followed:

a) Data will be collected in the real-time data mode for at least two frontside passes during each support period. These passes will be separated by no more than four hours.

b) Where possible, the real-time data collection period during a pass will be selected to maximize coverage while the Subsatellite is in the following regions which are listed in the order of their priority:

   (1) Within 15° of arc, on the lunar surface, of any operating ALSEP magnetometer.

   (2) Along a 30° arc centered on each terminator.

   (3) Along a 30° arc centered on the perilune.

c) Telemetry data will be stored on the farside with the Subsatellite in the telemetry store fast (TSF) mode.

d) Memory readout (MRO) will be scheduled for minimum interference with real-time mode data collection in the regions specified in b) above. A

If the perilune drops below 30 NM, it is highly desirable to obtain data around perilune in the TSF mode if perilune is on the farside of the moon, and in the real-time mode if perilune is on the nearside.

It is highly desirable to obtain real-time data whenever the moon is in the magnetosheath and the Subsatellite groundtrack lies within 30 degrees of arc of any operating ALSEP magnetometer.

For magnetometer experiment real-time mode data collection, the knowledge of the Subsatellite position along its orbital arc is required to be less than the arc the Subsatellite passes through during one spin period. For a nominal spin rate of 12 rpm, this would be 0.25 degrees of arc. When the Subsatellite is in the telemetry store normal (TSN) or TSF mode, the resolution of the Subsatellite position will be less than the arc the Subsatellite passes through in one sample interval. This is 1.2 degrees and 0.6 degrees for TSN and TSF respectively, assuming a 60-NM circular orbit.

Success Criteria

FTO 1) MSFN and trajectory data shall be obtained, reduced, and provided to the Principal Investigator.

FTO 2) FTO 3) Mandatory premission, experiment support, and experiment evaluation telemetry and trajectory data defined under Data Requirements shall be obtained and provided to the Principal Investigator. A

Evaluation

FTC 1) The Principal Investigator will study and evaluate the S-band Doppler tracking data. Subsatellite data will be combined with CSM, LM, and Lunar Orbiter data to generate an improved lunar frontside surface mass distribution model. Long-term Subsatellite gravitational data will be combined with Lunar Orbiter long-term data to yield an improved spherical harmonic coefficient set to describe the total lunar gravity field. This information will be incorporated into future lunar navigational models for more precise trajectory calculations and orbit prediction capability. In addition, the presence of mascons, their properties, and association with lunar features will be investigated. (Experiment evaluation, MSFN and trajectory data listed under Data Requirements) A

FTO 2) The Principal Investigator and Investigation Team will study and evaluate the data to determine the spatial distribution of low energy electrons and protons near the charged particle terminator. The derived distributions will then yield the desired information on plasma flow and electric fields associated with the solar wind and magnetotail. (Premission, experiment support, and experiment evaluation telemetry and trajectory data listed under Data Requirements) A

FTO 3) The Principal Investigator and Investigation Team will study and evaluate the data to determine the magnetic fields at nominal Apollo lunar orbital altitudes. The behavior of the field in this region will, in turn, provide information on physical processes in the solar wind plasma, the macroscopic and microscopic properties of the interaction of the plasma with the moon, and the physical properties of the moon. This lunar magnetic field determination will also be utilized in the analysis supporting FTO 2). (Premission, experiment support, and experiment evaluation telemetry and trajectory data listed under Data Requirements) A

Data Requirements

1) Premission Data (PD):

a) Telemetry Measurements: A

Telemetry measurements listed under 3)a). (M)

b) Calibration and Checkout Data:

Calibration and checkout data in accordance with TRW procedure HC-21S-02. (M)

2) Experiment Support Data (ESD):

a) Telemetry Measurements:

Telemetry measurements listed under 3)a).

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Priority PD	ESD	EED
D04B	Subsatellite I.D.	PCMD	M	HD	M
D05B	Data Format (R/T or Dump)	PCMD	M	HD	M
D06B	Auto or Manual Mode	PCMD	M	HD	M
D07B	Calibration (ON or OFF)	PCMD	M	HD	M
D08B	Elapsed Time, Coarse	PCMD	M	HD	M
D09B	Elapsed Time, Fine	PCMD	M	HD	M
D10B	Frame Count	PCMD	M	HD	M
D11B	Bit Rate	PCMD	M	HD	M
D12B	2.56V Calibration Voltage	PCM	HD	HD	HD
C01B	Command Validity	PCMD	HD	HD	HD
C02B	Receiver Signal Present	PCMD	HD	N/A	HD
C03B	Receiver Loop Stress	PCM	HD	N/A	HD
S01D	Magnetometer Traverse Mag. (B_{TM})	PCM	M	M	M
S02D	Magnetometer Time Delay (T_M)	PCMD	M	M	M
S03R	Magnetometer Traverse Out (B_T)	PCM	M	M	M
S04B	Magnetometer Parallel Out (B_p)	PCM	M	M	M
S05B	Magnetometer Range I.D. (R_t)	PCMD	M	M	M
S06B	C1 Detector Count	PCMD	M	M	M
S07B	C2 Detector Count	PCMD	M	M	M
S08B	C3 Detector Count	PCMD	M	M	M
S09B	C4 Detector Count	PCMD	M	M	M
S10B	C5 Detector Sector I Count	PCMD	M	M	M
S11B	C5 Detector Sector II Count	PCMD	M	M	M
S12B	C5 Detector Sector III Count	PCMD	M	M	M
S13B	C5 Detector Sector IV Count	PCMD	M	M	M
S14B	Curved Plate Voltage Monitor	PCM	M	HD	M
S15B	Zero Gamma Reference	PCM	HD	HD	HD
S16B	Open Telescope, Channel 1-4 Count	PCMD	M	M	M
S17B	Shielded Telescope, Channel 1-4 Count	PCMD	M	M	M
S18B	Open Telescope, Channel 2 Count	PCMD	M	M	M
S19B	Shielded Telescope, Channel 2 Count	PCMD	M	M	M
S20B	Open Telescope, Channel 3 Count	PCMD	M	M	M
S21B	Shielded Telescope, Channel 3 Count	PCMD	M	M	M

A

Measurement Number	Description	TM	Priority PD	ESD	EED
S22B	Open Telescope, Channel 4 Count	PCMD	M	M	M
S23B	Shielded Telescope, Channel 4 Count	PCMD	M	M	M
S24B	Open Telescope, Channel 5 Count	PCMD	M	M	M
S25B	Shielded Telescope, Channel 5 Count	PCMD	M	M	M
S26B	Open Telescope, Channel 6 Count	PCMD	M	M	M
S27B	Shielded Telescope, Channel 6 Count	PCMD	M	M	M
S28B	Telescope I.D. (Open or Shielded)	PCMD	M	M	M
S29B	Open Telescope Det. Temp	PCM	M	HD	M
S30B	Shielded Telescope Det. Temp	PCM	M	HD	M
S31B	Magnetometer Range (Rp)	PCMD	M	M	M
S32B	PHA Threshold	PCMD	M	M	M
S34B	Magnetometer Temperature	PCM	M	HD	M
T01B	Sun Pulse Delay	PCMD	M	HD	M
T02B	Spin Count	PCMD	M	HD	M
T03B	Sun Elevation Angle	PCMD	M	HD	M
T04B	Sector Period	PCMD	M	HD	M
T05B	Sun Sensor Polarity	PCMD	M	HD	M
E02B	Solar Array Current	PCM	HD	HD	HD
E03B	Battery Voltage	PCM	HD	HD	HD
E04B	Battery Current	PCM	HD	HD	HD
E05B	Battery Temperature	PCM	HD	HD	HD
E06B	Low Voltage Monitor	PCM	HD	HD	HD
E08B	Undervolt. Protection IN/OUT	PCMD	HD	HD	HD

A

b) Telemetry Measurement Tapes: (M)

Two sets of tapes* containing EED telemetered measurements listed under 3)a) and recorded during periods of experiment operations.

c) Astronaut Debriefings: (HD)

Three copies of each astronaut postmission scientific and photographic debriefing transcripts pertaining to Subsatellite launching.

d) Photographs: (HD)

(1) Photographs of launched subsatellite specified under Test Conditions for FTO 1), FTO 2), and FTO 3).

(2) Three copies of each appropriate Mapping and/or Panoramic Camera photograph that has been taken of the lunar surface over which the Subsatellite has operated.

A

e) MSFN Data: (M) A

(1) S-band Doppler tracking data for Subsatellite in lunar orbit.

(2) Transmitting frequency of each MSFN station which supplies data.

(3) Identity of transmitting ground stations and GET of their transmissions at acquisition of signal and loss of signal.

(4) Identity of ground stations which are in 3-way mode and GET of their transmissions at acquisition of signal and loss of signal.

(5) Geocentric coordinates for all MSFN stations which supply data.

f) Trajectory Data: (M) A

Three sets of tapes** containing Subsatellite ephemeris data.

g) Supporting Data: (HD)

The following scientific data will not be provided by MSC but will be obtained through arrangement between the responsible Principal Investigators.

(1) Charged Particle Lunar Environment Experiment data from Apollo 14. A

(2) Suprathermal Ion Detector Experiment data from Apollo 12 and 14 and from Apollo Mission J-1.

(3) Lunar Surface Magnetometer Experiment data from Apollo 12 and from Apollo Mission J-1.

*One set of the magnetic tapes is to be CDC 6400 computer compatible 7-track, 800-BPI for S-173 and the second set is to be IBM 360/91 computer compatible 9-track, 800-BPI for S-174. Each tape will include all of the telemetry measurements listed in paragraph 3)a) above. A

**One set of the magnetic tapes is to be CDC 6400 computer compatible 7-track, 800-BPI for S-173; second set is to be IBM 360/91 computer compatible 9-track, 800-BPI for S-174; and the third set is to be UNIVAC 1108 computer compatible, 7-track, 800-BPI for S-164.

5.14 SUBSATELLITE

Background and Justification

S-Band Transponder Experiment (S-164)

S-band Doppler tracking data have been analyzed from the Lunar Orbiter missions. Definite gravity variations were detected. These results showed the existence of mass concentrations (mascons) in the ringed maria. Confirmation of these results has been obtained with Apollo tracking data.

The Subsatellite affords the means to obtain lunar gravitational data with a greater spatial resolution than on any pre-Apollo experiment. The Subsatellite data will be combined with CSM and LM S-band tracking data from Apollo 14 and Apollo Mission J-1, and with Lunar Orbiter data to yield an improved lunar frontside surface mass distribution. Long-term Subsatellite gravitational data will be combined with Lunar Orbiter long-term data to yield an improved spherical harmonic coefficient set to describe the total lunar gravity field. Low altitude gravitational data can be used in conjunction with high altitude data to provide a description of the size and shape of the perturbing masses. Correlation of gravity data with photographic and other scientific records will give a more complete picture of the lunar environment and support future lunar activities. Inclusion of these gravitational field description results is pertinent to any theory of the origin of the moon and the study of the lunar subsurface structure. There is also the additional benefit of obtaining better navigational capabilities for future lunar missions in that an improved lunar gravity model will be known.

Particle Shadows/Boundary Layer (S-173) and Magnetometer (S-174) Experiments

Vector magnetometer surveys have been the primary means of determining magnetic fields in space. Many basic properties of the interplanetary medium, bow shock, and magnetosphere have been determined by this method. Although generally highly successful, the method does have limited ability to detect weak, directed components due to considerable variability of the fields. Thus, it has not been possible to find or to rule out the existence of a field component normal to the magnetopause. Such a component bears directly on the question of openness of the magnetosphere. Also, it has not been possible to identify which field lines surrounding the neutral sheet in the tail connect on both ends to the earth and which go behind the earth and perhaps extend into interplanetary space.

a. Particle Shadows

Recently a new method complementary to vector magnetometers has been described. This method is used to determine the large scale topology of field lines under certain conditions. It is essentially a particle tracing technique which determines where particles have been and where they go on the particular field lines under study. The tracer particles are supplied by the sun. The method also requires the presence of a large absorber such as the moon. As a spacecraft orbits the moon, a pattern of varying solar electron intensity is produced. The characteristics of the field lines are then deduced from the symmetry properties of these patterns. Much has already been learned on the lunar orbiting Explorer XXXV, but the method should now be applied in full measure in order to deal with the most basic problems of magnetospheric structure and dynamics. The improvements that must be incorporated in any new experiment to exploit the method of large absorbers are as follows:

1. The shadow patterns which reveal the field line topology will be obtained much more frequently. This will permit better spatial determinations in a moving spacecraft, and allow better temporal resolution for study of magnetospheric dynamics.
2. Data coverage is needed over the entire lunar orbit. This requires a simple data storage system in the spacecraft. Full data coverage will allow all details of the shadow pattern to be studied.
3. Better time resolution is needed to examine the penumbral regions of the shadows. This is important for setting improved limits on electric fields and diffusion in certain regions of the magnetotail.

b. The Boundary Layer

The empirical study of the boundary layers and discontinuities in naturally occurring plasmas is, in most cases, greatly complicated by the motion of the layers. This problem has arisen, for example, in the studies of the bow shock and magnetopause at the earth.

On the basis of present evidence, the interaction of the solar wind with the moon occurs very close to the lunar surface. The boundary layer for this interaction extends from the lunar surface outward to some distance which is as yet unknown, but which is estimated to be of the order of 100 km. Thus, there is a boundary layer that is fixed, since the inner boundary is the lunar surface, and is variable in thickness. In this particular boundary layer, complications due to the motion do not exist.

The goal of this part of the experiment is to obtain data on the physics of this interaction region or boundary layer. The characteristics of the boundary layer are determined by the properties of the plasma as well as those of the moon. Thus, the study of the interaction region will yield information of the external plasma, the interior of the moon, the surface and the lunar ionosphere.

Measurements from a 60 NM lunar orbit should provide information on both microscopic processes in the interaction region and macroscopic features of the flow. This low altitude should also provide a more sensitive mapping of the lunar magnetic field than was accomplished during Lunar Orbiter flights from altitudes greater than 400 NM.

At present, very little work has been done on the theory of the microscopic behavior of the plasma in the boundary layer immediately above the lunar surface. On the daylight side, the solar wind particles probably reach the surface in their steady state condition but photoelectric fields and ionized particles from the moon may complicate the situation.

c. <u>Magnetometer</u>

Measurements of magnetic fields in the transient and steady state boundary layers should provide indirect information on the lunar ionosphere and transient lunar atmosphere. It is estimated that the altitude of the top of the boundary layer at the surface, or the skin depth of the lunar perturbation in the solar wind plasma, will vary from 5 to 500 km. The dynamical processes, e.g., wave-particle and field-particle interactions, are probably very important in this region. Magnetic field measurements at the high data rate should provide exploratory data on such phenomena.

In the cavity directly behind the moon, the properties of the plasma and magnetic field are very different from those of the solar wind flowing in the adjacent regions. At the boundary between this downstream cavity and the solar wind, there are strong gradients in the density and velocity of the plasma. The 60 NM lunar orbit will traverse this layer in two places. Thus, one of the main purposes of this experiment would be to obtain data on the microscopic behavior in this region.

Previous Mission Experiments

Experiment Number	Title	Mission	
S-164	CSM/LM S-band Transponder	14	A

Table 1. Lunar Features of Special Interest for S-band Transponder Experiment

	Feature	Latitude	Longitude
1.	Grimaldi	- 5	-68
2.	Sinus Aestuum	12	- 8
3.	Orientale	-20	-95
4.	Sinus Medii	0	0
5.	Copernicus	+10	-20
6.	Apennines	20	0
7.	Carpathians	-15	-20
8.	Marius Hill	12	-52
9.	Mare Crisium	17	57
10.	Serenitatis	25	20
11.	Humorum	-25	40
12.	Nubium	-25	15
13.	Smythii	0	85
14.	Gassendi	-18	-40
15.	N.W. of Humorium	-15	-43
16.	Petavius	-25	60
17.	Riccioli	- 2	-75
18.	Langrenus	- 8	62
19.	Fracastorius	-20	34
20.	Nectaris	-16	34
21.	Ptolemaeus	- 9	- 3

A

5.15 MASS SPECTROMETER

Conduct the Mass Spectrometer Experiment (S-165).

Purpose

The purpose is to obtain data on the composition of the lunar ambient atmosphere, to determine areas of lunar volcanism, and to determine levels of contamination in the vicinity of the CSM.

The functional test objectives are as follows:

FTO 1) While the CSM is in lunar orbit, obtain data to determine the natural distribution of gases in the lunar atmosphere.

FTO 2) While the CSM is in lunar orbit, obtain data to locate areas of lunar volcanism.

FTO 3) While the CSM is in lunar orbit, obtain data to determine the amount of lunar atmospheric contamination due to rocket firing near the lunar surface.

FTO 4) While the CSM is in transearth coast, obtain data to determine the amount of contamination due to the spacecraft.

Test Conditions

FTO 1)
FTO 2)
FTO 3)
FTO 4)
The crew will perform necessary control functions to extend and retract the experiment boom, to energize the ion source heaters, to place the experiment in STANDBY, ON, and OFF modes, and to control experiment electronics. The experiment will be placed in the OFF mode for all SPS burns. After each SPS burn is completed, the experiment will be returned to the pre-SPS burn mode as soon as is practicable. B

FTO 1)
FTO 2)
FTO 3)
The boom will be fully extended for all mass spectrometer data collection and ion source heater operations. The boom will be fully extended with the experiment OFF or fully retracted and the experiment cover in place for all fuel cell purges, waste water and urine dumps. If the first data collection period is in the 60 x 8 NM orbit, the ion source heater will be operated continuously, immediately prior to data collection, for a minimum of one hour with additional ion heater source operation being highly desirable. Before initial data collection in the 60 NM circular orbit, the ion source heaters will be operated for a cumulative period of 6 hours of which the last hour will be continuous. One-half hour of heater operation will be added to the 6-hour total each time heater operation is interrupted. Waste water and urine dumps will be inhibited 1 hour before ion source heater operation (i.e., heater OFF for 1 hour after

dump). Before a dump is initiated, the heater will be set to OFF for at least 15 minutes but it is highly desirable that the heater be OFF for 1 hour. RCS jets A2, A4, B1, B4, C1, and C3 which could contaminate the experiment will be inhibited during heater operation. There are no requirements for a specific CSM attitude or for telemetry data during ion source heater operation.

Before each data collection period following the 60 x 8 NM period and the initial 60 NM circular orbit period, the ion source heaters will be operated continuously for 30 minutes. Fuel cell purges, waste water and urine dumps will be inhibited 2 hours before and during data collection, and a minimum of 5 minutes following data collection. RCS jets A2, A4, B1, B4, C1, and C3 will also be inhibited during data collection.

During data collection, the CSM -X axis will be oriented to within ±5 degrees of the velocity vector and the centerline of the SIM pointed toward the nadir ±5 degrees to insure that the boom is pointed in the proper direction within the required tolerances of ±10 degrees pitch, ±15 degrees yaw, and ±60 degrees roll with respect to the velocity vector. Drift rates in all axes are not critical. The SIM centerline direction must be known to within ±2 degrees to satisfy post-mission pointing knowledge requirements.

When the CSM is in a 60 x 8 NM orbit, the experiment will be operated and data collected for a minimum of two complete revolutions, not necessarily consecutive or continuous. Data collection for three additional orbits will be highly desirable.

When the CSM is in a 60 NM circular orbit, the experiment will be operated and data collected for a minimum of two complete revolutions, not necessarily consecutive nor continuous, during each of three separate periods. Mass spectrometer data collection for three additional revolutions during the above separate periods in 60 NM circular orbit will be highly desirable. While the mass spectrometer is operating, it will be photographed in the fully-extended position with the DAC using the 18 mm lens at a minimum of one frame per second during two complete sunlit passes, terminator to terminator, preferably near the end of one spectrometer operating period as early as possible in lunar orbit, and near the end of another spectrometer operating period as late as possible in lunar orbit. The DAC will be bracket-mounted in the CM right-hand side window. It is highly desirable to obtain DAC photographs of the mass spectrometer in the fully-extended position during one additional sunlit pass, preferably near the beginning of one spectrometer operating period midway during lunar orbit activities. During the photography, the CSM will be oriented with the -X axis pointed in the direction of the velocity vector and the SIM will be pointed toward the nadir as defined in the above paragraph. Telemetry data are highly desirable relative to the time of shutter opening for the DAC; however, these data do not take precedence over the use of this telemetry channel for the HEC in support of the CM Photographic Tasks detailed objective. B

It will also be highly desirable during each revolution to collect data from a lunar surface area extending ±15 degrees longitude on each side of the sunset and sunrise terminators.

Background contamination data will be collected for one complete revolution with the CSM +X axis pointed in the direction of the velocity vector. It is desirable that those data be obtained toward the end of the experiment period to maximize the possibility of a contaminated environment. Drift rates and attitudes are not critical during this revolution. However, the CSM orientation will be such that the experiment scoop is pointed in a direction opposite that of the spacecraft travel and that the scoop is oriented with respect to the velocity vector to within ±30 degrees in pitch, ±60 degrees in yaw, and ±60 degrees in roll. During this single revolution, it is highly desirable that the Panoramic Camera be operated for at least one frame in order to provide a known contamination source of nitrogen which will be dumped from around the camera film rollers. Collection of background contamination data will not be allowed to compromise the obtainment of data when the CSM -X axis is pointed forward.

FTO 4) The experiment will be operated during transearth coast no sooner than 6 hours after TEI. Before data collection, the ion heaters will be operated for a cumulative period of 3 hours of which the last hour will be continuous. During this ion source heater activity, the boom may be in the one-half extension position, if required by operational constraints. Effluent dumps will be inhibited 1 hour before and during ion source heater operation and data collection. RCS jets A2, A4, B1, B4, C1, and C3 will be inhibited; the heater will be set to OFF 15 minutes before a dump is initiated, and for 1 hour after the dump. Data will be collected for 1 hour minimum with the boom fully extended. The boom will then be retracted in five equal steps with data being collected for 7 minutes after each retraction step, for a total of 35 minutes. The last 7-minute data collection period will occur with the boom in a fully-retracted position. CSM attitude is not critical during this transearth coast activity. B

Success Criteria

FTO 1) Mandatory experiment data defined under Data Requirements
FTO 2) shall be acquired and provided to the Principal Investigator.
FTO 3)
FTO 4)

Evaluation

FTO 1) FTO 2) FTO 3) FTO 4) Data obtained will be studied and evaluated postflight by the Principal Investigator and Investigation Team. The data obtained from this experiment are in the form of a counting rate for each channel as a function of the step number of the ion accelerating voltage. A direct plot of these parameters will produce an analog representation of the mass spectrum for each channel. Further data reduction will produce the amplitude and position of each peak in the mass spectrum, and a plot of this information as a function of time.

The position of the peak in the spectrum determines the mass number of gas species in the ion source being measured. The amplitude of the peak is a function of the concentration of that species in the source. The data will then be plotted as a function of lunar coordinates and local lunar time in order to be applicable to the flight objectives of this experiment. (Premission, experiment support, and experiment evaluation data listed under Data Requirements)

Data Requirements

1) Premission Data (PD):

a) Telemetry Measurements:

Telemetry measurements listed under 3)a). (M)

b) Calibration and Checkout Data:

Calibration and checkout data in accordance with KSC procedure TCP-151-005, Revision A. (M)

2) Experiment Support Data (ESD):

a) Telemetry Measurements:

Telemetry measurements listed under 3)a). Display preference is indicated by (D) for digital. (M)

b) Voice Comments:

(1) Description and GET of changes to experiment control settings during mandatory periods of experiment operation. (M)

(2) Description and GET of changes to experiment control settings during highly desirable periods of experiment operation. (HD)

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority PD	ESD	EED	
CH 3546 X	RCS Solenoid Activate C3/13/+X	PCME	1	N/A	N/A	HD	
CH 3547 X	RCS Solenoid Activate A4/14/+X	PCME	1	N/A	N/A	HD	
CH 3548 X	RCS Solenoid Activate A3/23/-X	PCME	1	N/A	N/A	HD	
CH 3549 X	RCS Solenoid Activate C4/24/-X	PCME	1	N/A	N/A	HD	
CH 3550 X	RCS Solenoid Activate D3/24/+X	PCME	1	N/A	N/A	HD	
CH 3551 X	RCS Solenoid Activate B4/26/+X	PCME	1	N/A	N/A	HD	
CH 3552 X	RCS Solenoid Activate B3/15/-X	PCME	1	N/A	N/A	HD	
CH 3553 X	RCS Solenoid Activate D4/16/-X	PCME	1	N/A	N/A	HD	
CH 3554 X	RCS Solenoid Activate B1/11/+Z	PCME	1	N/A	N/A	HD	
CH 3555 X	RCS Solenoid Activate D2/22/+Z	PCME	1	N/A	N/A	HD	
CH 3556 X	RCS Solenoid Activate D1/21/-Z	PCME	1	N/A	N/A	HD	
CH 3557 X	RCS Solenoid Activate B2/12/-Z	PCME	1	N/A	N/A	HD	
CH 3558 X	RCS Solenoid Activate A1/+Y	PCME	1	N/A	N/A	HD	
CH 3559 X	RCS Solenoid Activate C2/+Y	PCME	1	N/A	N/A	HD	
CH 3560 X	RCS Solenoid Activate C1/-Y	PCME	1	N/A	N/A	HD	
CH 3561 X	RCS Solenoid Activate A2/-Y	PCME	1	N/A	N/A	HD	
CK 0026 A	CM Acceleration X-Axis	PCM	1	N/A	N/A	HD	
CK 0027 A	CM Acceleration Y-Axis	PCM	1	N/A	N/A	HD	
CK 0028 A	CM Acceleration -Z Axis	PCM	1	N/A	N/A	HD	
CK 1040 X	16 mm Event Sequence Camera	PCM	1	N/A	N/A	HD	B
SL 1082 K	Mass Spectr Output 10 Bit Data A	PCMD	1	M	M*(D)	M*	
SL 1083 K	Mass Spectr Output 10 Bit Data B	PCMD	1	M	M*(D)	M*	
SL 1084 X	Mass Spec Sweep Start Flag Data C	PCME	1	M	M*(D)	M*	B
SL 1124 V	Mass Spectr Comb Data	PCM	1	M	M*(D)	M*	
SL 1201 T	Temp Thrm Envir Shelf XS236.5	PCM	1	N/A	N/A	HD	
SL 1202 T	Temp Thrm Envir - BM 1 XS221, R62	PCM	1	N/A	N/A	HD	

b) Telemetry Measurement Tapes:

One copy of tapes** containing EED telemetered measurements listed under 3)a), recorded and correlated with GMT during periods of experiment operation. (M)

c) Astronaut Logs or Voice Records:

One copy each of astronaut logs or voice records containing:

(1) Description and GET of changes to experiment control setting during mandatory periods of experiment operation. (M)

(2) Description and GET of changes to experiment control settings during highly desirable periods of experiment operation. (HD)

(3) Description and GET of waste water and urine dumps, and fuel cell purges during SIM orbital and trans-earth experiment periods. (HD)

(4) GET, magazine number, frame rate and frame number of first and last DAC photograph in each set of photographs of the mass spectrometer. (M for two revolutions; HD for third revolution)

d) Astronaut Debriefings:

One copy of each astronaut postmission scientific and photographic debriefing transcript pertaining to both mandatory and highly desirable periods of experiment operation. (HD)

e) Photographs:

(1) One copy of each appropriate Mapping and/or Panoramic Camera photograph that has been taken of the lunar surface over which the CSM mass spectrometer has operated. Photographs are to be identified by BET and selenographic coordinates. (HD)

(2) DAC photographs of mass spectrometer as specified under Test Conditions for FTO 1), FTO 2) and FTO 3) and obtained with CSM -X axis pointed forward. (M for two revolutions; HD for third revolution)

(3) Deleted

(4) Deleted

f) Trajectory:

One copy of tape** containing:

(1) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during mandatory periods of experiment operation. (M)

(2) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during highly desirable periods of experiment operation. (HD)

g) Supporting Data:

The following scientific data will be provided by MSC but will be obtained through arrangements between responsible Principal Investigators:

(1) Laser Altimeter altitude data obtained during periods of Mass Spectrometer Experiment operation. (HD)

(2) Reduced Alpha Particle Spectrometer Experiment data obtained during periods of Mass Spectrometer Experiment operation. (HD).

*These measurements are M during mandatory experiment operation and HD during highly desirable experiment operation.

**Magnetic tapes produced are to be IBM 360/50 computer-compatible digital 7-track, 800-BPI (620 bytes blocking with 16 bit words) tapes.

Background and Justification

It has recently been shown that light gases with negligible production and loss rates tend to be distributed at the lunar surface as the inverse 5/2 power of temperature, while heavier gases are influenced by rotation of the moon. Neon is a light gas, and its concentration on the dark side should be about 32 times that on the sunlit side and thus, at an assumed satellite altitude of 100 km, the diurnal fluctuation of neon concentration should be about 1.5. Argon is heavier than neon, has less diurnal variation, and is expected to be noticeably influenced by the rotation of the moon. As a result, there will be a longitudinal shift of argon's maximum toward sunrise and thus a sunrise concentration about twice that which exists at sunset.

Water vapor and carbon monoxide probably exist in the lunar atmosphere, but not on the dark side nor near the poles where the surface temperature is below 100 degrees K and absorption must remove particles that come in contact with the surface. Gases absorbed in continuously shadowed regions near the poles are unlikely to reenter the atmosphere, but at lower latitudes the rotation of the moon transports absorbed gases into sunlight where they are released into the atmosphere. Since surface heating occurs rapidly, this release probably occurs entirely within a few degrees longitude from the sunrise terminator, creating a pocket of gas. Whether this dawn enhancement can be detected at satellite altitudes is speculative, depending mainly on the abundance of these gases in the lunar atmosphere.

Study of the composition and distribution of gases in the lunar atmosphere is important to two current problems. The first problem is the understanding of the origin of the lunar atmosphere. Light gases, such as hydrogen, helium, and neon, probably originate from neutralization of solar wind ions at the surface of the moon, whereas Ar^{40} is most likely due to radioactive decay of K^{40}; Ar^{36} and Ar^{38} may be expected as spallation products of cosmic ray interactions with surface materials. Molecular gases, such as carbon dioxide, carbon monoxide, hydrogen sulfide, ammonia, sulphur dioxide, and water vapor may be produced by lunar volcanism.

The second problem is related to transport processes in planetary exospheres. The exosphere of the earth, and that of almost any other planet, is bounded by a dense atmosphere in which hydrodynamic wind systems complicate the problem of specifying appropriate boundary conditions for exospheric transport. This contrasts sharply with the situation in the lunar atmosphere, which is entirely a classical exosphere, with its base the surface of the moon. The lunar exosphere should be amenable to accurate, analytical study. Experimental determination of the global distribution of lunar gases can provide a reasonable check on theory, giving confidence to the application of theoretical techniques to transport problems in the terrestrial exosphere.

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.16 DOWN-LINK BISTATIC RADAR OBSERVATIONS OF THE MOON

Conduct the Down-Link Bistatic Radar Observations of the Moon Experiment (S-170).

Purpose

The purpose is to obtain S-band and VHF down-link bistatic radar data reflected from the lunar crust.

The functional test objectives are as follows: A

FTO 1) Obtain data in the S-band to allow determination of geological structure and electrical characteristics of the lunar crust.

FTO 2) Obtain data in the VHF band to allow determination of geological structure and electrical characteristics of the lunar crust.

FTO 3) Obtain data in the S-band and in the VHF band over the same lunar surface track to allow determination of geological structure and electrical characteristics of the lunar crust.

Test Conditions

FTO 1)
FTO 2) Test data will be collected during a minimum of approximately one-half of a frontside pass for S-band and for another one-half pass for VHF, either beginning at nominal AOS and ending at the earth moon line of centers, or beginning at the earth/moon line of centers and ending at LOS. It is highly desirable to obtain additional data listed in order of priority as follows:

a) The remaining lunar frontside half (S-band).

b) The remaining lunar frontside half (VHF).

c) Additional passes of either frontside half over different surface tracks from previous tests (S-band).

d) Additional passes of either frontside half over different surface tracks from previous tests (VHF).

For all VHF data collection, the lunar surface above 5 degrees north and below 5 degrees south latitudes is of greatest scientific interest. During data acquisition, the

CSM will be maneuvered so that the antenna axis* remains pointed near the specular point.** For a nominal 60-NM circular orbit, the CSM maneuver rate is approximately 5 degrees per minute. It is highly desirable that the maneuver rate be computed for the actual CSM orbit. The pointing accuracy requirement is that the specular point will be within a 5-degree half-angle cone, symmetric about the antenna axis. A

A

An alternate, less desirable, procedure is to maneuver the CSM at the orbital rate. Starting with no pointing error, this procedure will accumulate pointing error at the rate of approximately 2 degrees per minute. Degraded data will result; however, it is acceptable if operational considerations preclude the desired procedures.

An additional alternate, least desirable, procedure is to collect data while the CSM is in an inertial hold attitude. This alternate is only available for collection of the highly desirable data prioritized in items a) through d) above and is not applicable for obtaining the minimum requirements.

FTO 1)
FTO 3) While the CSM is in lunar orbit, the S-band PM transmitter (2287.5 MHz) will be used at high power to provide a signal for reflection from the lunar surface. A

Transmission during the experiment period will be in down-link mode 4 (i.e., carrier, 1.024 MHz low bit rate telemetry and 1.25 MHz voice). The uplink transmission from the MSFN will be turned off for the experiment period, and the spacecraft voice and telemetry data will be recorded for subsequent playback to the MSFN. The S-band high gain antenna is the preferred radiator; however, an omnidirectional S-band antenna is acceptable. Reflected signals will be recorded by the 210-foot MARS dish antenna and related dual polarization facility. Tuning of receivers will be based on calculations performed by the Principal Investigator using operational trajectory data. The necessary oscillators, mixers, and filters will be provided by the Principal Investigator/Stanford University. The MARS antenna will be oriented by computer-generated data rather than by autotrack data.

*The antenna axis is defined to be along the axis of symmetry of the radiation pattern.

**The specular point is the instantaneous point on the lunar surface from which maximum power will be reflected toward the earth.

FTO 2) FTO 3) With the CSM in lunar orbit, a VHF scimitar antenna will transmit a 259.7 MHz signal, which will be reflected from the lunar surface and received at the 150-foot antenna at Stanford University, Palo Alto, California. It is highly desirable for FTO 2) that the VHF scimitar antenna be oriented so that the blade of the antenna lies along the track of the specular point. Reflected signals will be recorded by the predetection method. The VHF AM configuration for the VHF test will be as follows:

a) VHF AM B to DUPLEX

b) VHF RANGING to RANGING

c) VHF AM T/R to OFF or RECEIVE (3 Audio Panels)

Voice transmissions over VHF will be inhibited during the VHF test.

It is highly desirable that additional VHF data on the geological structure of the lunar crust be obtained whenever the SIM bay is pointed towards the lunar surface. To obtain the best data, the VHF scimitar antenna nearest the lunar surface will transmit a 259.7-MHz signal (as described above) to the 150-foot antenna. A

FTO 3) S-band and VHF data will be collected over the same ground track during a minimum of one-half of a frontside pass either beginning at AOS or the earth/moon line of centers. It is highly desirable that the data be obtained during simultaneous operation of the S-band and VHF transmitters. The CSM look angles will be dependent upon the combinations of selected antennas as shown below. The test may be conducted using any of the four combinations of antennas with the vector, as defined by the look angles, being pointed at the specular point and the VHF antenna blade being parallel to the specular point track.

S-band Antenna	VHF Antenna	θ (Degrees)	ϕ (Degrees)
High Gain	Right (A)	145^{+0}_{-15}	129.5
High Gain	Left (B)	145^{+0}_{-15}	309.5
Omni A	Right (A)	106	132.25
Omni C	Left (B)	106	312.25

A

The maneuver rate will be the same as FTO 1) and FTO 2). The pointing accuracy requirement is that the specular point will be within a 5-degree half-angle cone, symetric about the selected vector.

It is highly desirable to obtain additional data listed in order of priority as follows:

a) The remaining lunar frontside half.

b) Additional passes of both frontside halves over different surface tracks from previous tests.

These highly desirable tests may be conducted using any of four combinations of antennas specified above. A

Success Criteria

FTO 1)
FTO 3) The S-band predetection recordings shall be obtained at the 210-foot MARS tracking station and provided to the Principal Investigator.

Spacecraft attitude and trajectory data, and astronaut logs or voice records shall be provided to the Principal Investigator.

FTO 2)
FTO 3) The VHF predetection recording shall be obtained by the Principal Investigator at the Stanford University ground station.

Spacecraft attitude and trajectory data, and astronaut logs and voice records shall be provided to the Principal Investigator.

Evaluation

FTO 1)
FTO 2)
FTO 3)
FTO 4) The Principal Investigator will conduct a spectral analysis of the S-band and VHF analog data signals. The analog data will be digitized and Fourier coefficients will be produced. The data will be utilized to compute the power spectrum and to effect detection in a 4-cycle bandwidth for VHF and a 40-cycle bandwidth for S-band. The appropriate corrections for experiment geometry will be applied to the data. The data in this format will be analyzed to obtain information on the geological structure and electrical characteristics of the lunar crust. (Experiment evaluation data listed under Data Requirements) A

Data Requirements

1) Experiment Evaluation Data (EED): A

Measurement Number	Description	TM	Mode	Priority PD*	ESD*	EED
ST 0152 H	High Gain Ant Pos Pitch	PCM+	2			M**
ST 0153 H	High Gain Ant Pos Yaw	PCM+	2			M**

*There are no requirements for Premission Data (PD) and Experiment Support Data (ESD). A

b) Telemetry Measurement Listing:

One copy of listing containing EED telemetered measurements listed under 1)a), recorded and correlated with GMT during periods of experiment operation. (M)

c) Astronaut Logs or Voice Records:

One copy each of astronaut logs or voice records containing:

(1) Record of SM high-gain antenna pitch and yaw attitude angles for S-band tests (if used). (Mandatory only if telemetry measurements ST 0152 H and ST 0153 H are not available) A

(2) Record of CM omni antenna selected at the start of S-band tests (if used). (M) A

(3) Record of VHF antenna selected at start of VHF tests and record of any change to the other VHF antenna. (M)

d) Astronaut Debriefings:

One copy of each astronaut postmission scientific and photographic debriefing transcript pertaining to both mandatory and highly desirable periods of experiment operation. (HD) A

e) Dual polarization predetection recording of the reflected S-band signals. (M)

f) Dual polarization predetection recording of the reflected VHF signal. (M) A

g) Photographs: A

One copy of appropriate Mapping and/or Panoramic Camera photographs taken of the lunar surface over which the down-link bistatic radar observations of the moon have been conducted. Photographs are to be identified by GET and selenographic coordinates. (HD)

h) Trajectory Data:

One copy of tape*** containing:

(1) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during all mandatory S-band and VHF test periods. (Note: PRN data will not be available during the S-band test period and are not required for this BET data.) (M) A

(2) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during all highly desirable S-band and VHF test periods. (HD) A

**These measurements are M during mandatory experiment operation and HD during highly desirable experiment operation.

***Magnetic tapes produced are to be XDS Sigma 5 computer-compatible digital 9-track, 800-BPI tapes. A

5.16 DOWN-LINK BISTATIC RADAR OBSERVATIONS OF THE MOON

Background and Justification

This experiment will provide fundamental new scientific information on the upper few meters of the lunar crust by determining the surface roughness and the dielectic constant (by the Brewster angle method) at wavelengths of approximately 13 centimeters and 1 meter. The experiment will also provide information on subsurface layering to the depth of approximately 20 meters and will provide engineering data necessary for optimizing the design of future bistatic experiments from low lunar orbits (≈ 60 NM altitude). In addition, the results will provide lunar S-band bistatic radar calibrations which will have considerable utility in the interpretation of similar experiments conducted in the future on the planets.

Experiments have been conducted in a down-link mode of operation using the telemetry carriers from Lunar Orbiters I and III and Explorer XXXV as lunar orbiting radar beacons.

The Lunar Orbiter observations were conducted at S-band, with reception at the Goldstone Tracking Station of the Deep Space Network. To date, the principal result of these observations has been the development of experimental techniques, demonstration of a spectral analysis process for the detection of the bistatic echo, and the location of discrete scattering centers on the lunar surface.

Much more extensive observations have been carried out with Explorer XXXV at a 2-meter wavelength and several results important to lunar exploration have been achieved. Among these are: verification of the separability of roughness and reflectivity (as predicted by earlier analyses), detection of radar echoes from lunar bedrock in the vicinity of the Flamsteed ring, demonstration of correlation between lunar surface reflectivity and depth of the regolith layer as determined by independent means (Orbiter and Surveyor photography), direct measurement of lunar dielectric properties through polarization effects on the carom signal (detection of Brewster angle of the lunar crust) and a first-order measurement of lunar surface roughness on the scale of several wavelengths. It seems clear from the Explorer XXXV observations that penetration of the lunar crust to depths comparable with those predicted by recent laboratory measurements of various terrestrial materials (10 to 50 wavelengths) is being achieved.

However, ambiguities remain in the Explorer XXXV data because a single frequency experiment is incapable of resolving variations in surface structure with depth from those which are due to lateral changes in lunar material. The progress which has been made so far is due primarily to the existence of the structural models inferred from surface photography.

Transmissions from the CSM will be A
received on the ground after they have caromed from the lunar surface. In the case of a perfectly smooth moon the received signal would come from a small region of Fresnel zone size about the point of specular reflection. Roughening of the lunar surface will convert the single Fresnel zone spot into a glistening region centered on the point of specular reflection of the average surface. The size of this region will depend entirely upon the experimental geometry and the exact degree of roughness encountered. As the spacecraft moves, the glistening region will follow, creating a scanning action.

In general, the total power received at the receiving station will be the product of two independent factors, one of which depends entirely upon experimental geometry, and to a very good approximation, one which depends only upon the intrinsic surface reflectivity. The effect of surface roughness will be the modulation of the spectrum (frequency domain) of the received signal. Thus, the effects of surface roughness (shape) and reflectivity (material and vertical structure) will be easily separated. RF polarimetry data may provide an important internal experimental check on the validity of this theory. Quasi-specular reflections are deterministically polarized, while diffuse scattering randomizes polarization. Thus, by separating the received signals into a polarized and depolarized part, the quasi-specular and diffuse components of the scattered signal may be separated. Furthermore, it should be possible to distinguish depolarization resulting from volumetric distributions of small scale structure from the products of surface roughness by its wavelength dependence.

Polarization also provides the means for distinguishing between variations in depth and the material composition of subsurface interfaces. Depth variations will affect two orthogonal polarizations equally, while changes in material will produce differential changes between two orthogonal polarizations.

Since the carom signal will follow a path whose total length changes at a different rate than does the length of the direct path, separation of the comparatively weak reflected signal from the directly propagating wave will be based upon a differential Doppler effect. Thus, for the periods that direct transmission data are available, data reduction will be accomplished in the frequency domain with spectral analysis techniques. A

Common geophysical materials exhibit a constant loss tangent property in the radio-radar frequency range so that penetration depth is proportional to frequency. Thus, raising the frequency of the probing wave by a factor of two effectively halves the depth. Similar effects observed in two distinct frequency ranges may be due to variations in material, with little or no change in vertical profile of the reflecting structure. Variations in reflectivity with frequency are interpreted as resulting from changes in vertical profile. Thus, the electromagnetic structure of the lunar surface will be determined to a considerable depth by these means. The test is expected to effectively isolate the properties of the top several decimeters of lunar surface (using S-band data) and depths further below the surface (using the VHF data).

Bistatic radar data also provide information on surface shape through the spectrum of the reflected signal. The great majority of the energy reflected from the glistening region arises from those portions of the surface whose radii of curvature are large compared with a wavelength of the probing wave. The scale of the structure which contributes to the reflection process is limited on one end by the small scale roughness of the surface, and on the other by the large scale modulation. In either case, the surface is ineffective as a reflector when it introduces phase modulations which are large compared with unity, regardless of their source. The scattered wave may be interpreted as coming from a bandpass-filtered version of the real surface, where the filter characteristics are primarily dependent on the wavelength of the exploring signal.

This experiment will be carried out utilizing the S-band PM and VHF AM transmitters of the CSM as lunar orbiting radar beacons. The down-link S-band carom signal will be received by the MARS tracking station along with the directly propagating wave. The VHF carom signal will be received by the Stanford Tracking Station. Predetection recordings (of appropriate bandwidths) of the tracking station receiver outputs will provide the necessary data for this experiment. The recorded data will be subsequently converted to digital samples and analyzed.

For the S-band test, the Brewster angle measurement will be based on the reversal of the polarization ellipse and will require the use of two orthogonally polarized antennas at the receiving site. This method is predicated on sufficient signal-to-noise ratio in the vicinity of the Brewster null to allow detection of the above effect. For this reason, the 210-foot MARS dish antenna is the selected receiving station. The MARS site is instrumented for simultaneous reception on right and left circularizations with phase coherence.

For the VHF test, the Brewster angle measurement will be based upon changes of signal strength and polarization as a function of time. The 150-foot Stanford antenna system is capable of receiving the Apollo VHF signal which will exhibit both circular and linear polarization characteristics as a function of VHF antenna and moon and earth geometry. As with the S-band signal, the method is predicated upon sufficient signal-to-noise ratio. The experiment, as performed on Apollo 14, showed that a sufficient signal-to-noise ratio was present on both S-band and VHF to achieve the experiment objective. A

The data obtained from Apollo Mission J-1 will supplement that obtained from Apollo 14.

Previous Mission Experiments

Experiment Number	Title	Mission	
S-170	Down-Link Bistatic Radar Observations of the Moon	14	A

5.17 UV PHOTOGRAPHY-EARTH AND MOON

Conduct the UV Photography-Earth and Moon Experiment (S-177).

Purpose

The purpose is to obtain ultraviolet (UV) photographs of the earth and moon for use in the study of planetary atmospheres, and for the investigation of short wavelength fluorescence from the lunar surface.

The functional test objective is as follows:

FTO 1) Obtain photographs of the earth and of the lunar surface in three UV and one visual region of the spectrum.

Test Conditions

FTO 1) Photographs will be obtained from the CM while in earth parking orbit, translunar coast, lunar orbit, and transearth coast, using a Hasselblad camera with a 105 mm UV transmitting lens. The photographs will be taken through the RH side window. This window will be supplied with quartz panes that pass a large fraction of the incident UV radiation. It should be noted that the UV radiation hazard from this window will therefore be higher than from a standard CM window. The camera will be mounted on a special bracket and will be provided with a ring slide for filters. The following four band-pass filters will be provided:

a) UV filter centered at 3750 Angstrom units (Å)

b) UV filter centered at 2600 Å

c) UV filter centered at 3250 Å

d) Visible band-pass filter in the range of 4000-6000 Å.

The band-pass ranges for the three UV filters will be at most 400 Å (central wavelength ±200 Å).

The film to be used is Eastman Kodak spectroscopic film type IIa-O. Sensitometric calibration of the film is required for this experiment. The minimum sequence of photographs consists of 11 sets of four photographs each, for a total of 44. Each set will contain one photograph with each of the four filters. The sequence is as follows: B

a)	Earth Parking Orbit:	Earth Limb	4	(1 set)
b)	Translunar Coast (TLC) (photographs of the earth disc from these approximate distances):	60,000 NM	4	(1 set)
		120,000 NM	4	(1 set)
		180,000 NM	4	(1 set)
c)	Lunar Orbit:	Earth	4	(1 set)
		Earth and Lunar Horizon	4	(1 set)
		Lunar Terra	4	(1 set)
		Lunar Maria	4	(1 set)
d)	Transearth Coast (TEC) (photographs of the earth disc from these approximate distances):	180,000 NM	4	(1 set)
		120,000 NM	4	(1 set)
		60,000 NM	4	(1 set)
		TOTAL	44*	

B

(* If time is available, it is highly desirable to obtain two photographs at each location with each filter, i.e., to double the number of photographs.)

B

It is highly desirable that one color photograph be obtained with each set of four above, using the 70 mm Hasselblad electric camera and showing approximately the same scene that is taken in the set of four photographs. It is also highly desirable that two sets of calibration photographs of the moon be obtained: one set as soon as is practical after translunar injection; and one set as late as is practical during TEC. Crew comments on the condition of the RH side window are desired at the times calibration photographs are obtained and at several other times spaced throughout the duration of the mission.

Tolerance on the times of TLC and TEC photography is ±30 minutes from the time of passage through the indicated distances, except that photography is not to interfere with scheduled crew sleep periods or other necessary crew tasks. During earth orbit and lunar orbit, photographs may be taken at any time the indicated subject areas are available*. The CSM will be maintained in attitude hold such that the photographic subject is in the field of view of the camera, which is mounted with its optical axis normal to the RH side window. The CSM attitude rates will be no more than 0.05 degrees per second during periods of photography. It is highly desirable that no forward firing thrusters be activated during film exposures. Exposure parameters for the photographs will be given in the Photographic and Television Procedures for Apollo Mission J-1. B

*Note: Solar illumination is required since the experiment is searching for UV fluorescence.

Success Criteria

FTO 1) The mandatory data defined under Data Requirements shall be acquired and provided to the Principal Investigator.

Evaluation

FTO 1) The Principal Investigator will examine the photographs for correlation with known earth conditions, and to discover evidence of lunar surface UV fluorescence. (Premission and experiment evaluation data as defined under Data Requirements)

Data Requirements

1) Premission Data (PD):

Premission sensitometry data for the IIa-0 spectroscopic film in accordance with the standard procedures of the Photographic Technology Laboratory. (M)

2) Experiment Evaluation Data (EED):

a) Deleted

b) Astronaut Logs or Voice Records: (M)

One copy of astronaut logs or voice records containing the GET of initiation and completion of each set of four photographs.

c) Astronaut Debriefings: (HD)

One copy of astronaut postmission scientific and photographic debriefing transcripts pertaining to periods of UV photography.

d) Photographs:

(1) Forty-four photographs as described under Test Conditions. (M) B

(2) Additional 44 photographs. (HD)

(3) Color photographs of scenes corresponding to sets of UV photographs. (HD)

(4) One set of calibration photographs of the moon taken soon after translunar injection. (HD)

(5) One set of calibration photographs of the moon taken late in TEC. (HD)

e) Trajectory: (M)

One copy of tape* containing the best estimate of trajectory (BET) including spacecraft attitude data during periods of UV photography.

*Magnetic tapes produced are to be UNIVAC 1108 computer-compatible digital 7-track, 800-BPI tapes.

Background and Justification

This experiment is an investigation of the terrestrial atmosphere by means of photographs of the earth obtained in ultraviolet light at planetary distances in order to aid in the interpretation of similar photographs of Mars and Venus. By photographing the earth in the same manner that is employed for planetary studies, one can use the detailed knowledge about the properties of the terrestrial atmosphere to interpret such planetary observations.

It has been known for many years that photographs of both Mars and Venus obtained in ultraviolet light ($\lambda < 4500$ Å) reveal features not present on visible light photographs. In each case, the anomalous appearance of the planet is attributed to atmospheric effects, but the precise nature of these effects remains unknown.

The appearance of Venus in the ultraviolet is characterized by the presence of dusky markings that are not evident on the customarily featureless visible light photographs of the planet. It has been suggested that the markings may be the result of photochemically-produced species, but no convincing identifications of such absorbers have yet been made.

Ultraviolet photographs of Mars appear nearly featureless, with only a few bright clouds on a generally neutral background. The apparent absence of surface detail has led to the hypothesis of a so-called blue haze, which prevents the observer from seeing the planet's surface at the shorter wavelengths. The nature of this haze has remained obscure, although it has been suggested that it might be the result of very fine ice crystals. Several investigators have proposed that the blue haze as such does not exist, and that the absence of apparent surface detail is simply the result of a lack of contrast in the ultraviolet.

It is probable that photographs of the earth taken at the shorter wavelengths will also be dominated by atmospheric features, since it is well known that atmospheric scattering (both molecular and particulate) becomes much more intense as the effective wavelength of observation diminishes.

It is of special interest to be able to identify the various features that are revealed by earth photographs. Do high altitude clouds appear? Do dark areas correspond to clear or cloudy regions of the atmosphere (both hypotheses have been proposed for Venus and Mars)? How much surface detail is visible? How different is its appearance? These questions of interest will have straightforward answers from the data. One can anticipate that such records of the appearance of our own planet will remove much of the mysticism associated with the observations of Mars and Venus, and may also lead to some concrete suggestions for the interpretation of these observations.

Two additional investigations will be carried out with the photographic data. One of these is a study of the terrestrial atmosphere at 2600 Å; the other is a search for lunar color differences and possible fluorescence, also at this effective wavelength. At 2600 Å the lower atmosphere of the earth will be shielded by the ozone layer and one will in effect be observing Rayleigh and Mie scattering from molecules and aerosols in the upper atmosphere. It will be of considerable interest to see whether characteristic global patterns appear on such photographs, particularly in view of the well-known latitudinal variation in ozone concentration. Of special interest is the opportunity to observe simultaneously the global distribution of high-altitude aerosols. The most familiar manifestation of these to the ground-based observer is the phenomenon of noctilucent clouds. These clouds are observed most commonly in the latitude range of 45-60 degrees, but there is the possibility that this restriction is imposed by conditions of observation rather than by the process of formation of the clouds. At average heights of 82 km, the noctilucent clouds lie well above the maximum ozone concentration ($\sim$23 km) and should appear in the UV photographs. By photographing only that portion of the atmosphere above the ozone layer, it will be possible to determine which of the features appearing at slightly longer wavelengths are caused by the upper atmosphere.

Photographs of the moon at 2600 Å will be used to extend the wavelength coverage of ground-based colorimetric work and to search for possible fluorescence. Color differences on the moon that can be correlated with topographic features have been known for some time. By extending the wavelength range, it should be possible to improve the definition of features already recorded as well as to detect new colorimetric boundaries.

Lunar fluorescence in this spectral region has been reported by Soviet investigators, but has not been confirmed or properly interpreted. By comparing calibrated photographs obtained at several wavelengths, it will be possible to obtain new data regarding this phenomenon.

In summary, UV photographs of the earth obtained in this experiment will be correlated with known conditions of the terrestrial atmosphere. These correlations will be of significant value in the interpretation of previous UV data on planetary atmospheres, e.g., data obtained from the Mariner flyby missions to Mars.

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.18 GEGENSCHEIN FROM LUNAR ORBIT

Conduct the Gegenschein from Lunar Orbit Experiment (S-178).

Purpose

The purpose is to make photographic observations to determine if, and to what extent, reflection from dust particles at the Moulton point contributes to the gegenschein.

The functional test objective is as follows:

FTO 1) Obtain data on the spatial distribution of the gegenschein in the vicinity of the Moulton point.

Test Conditions

FTO 1) During lunar orbit, photographs of the gegenschein and Moulton point regions will be obtained from the CSM while in an undocked configuration. The 35 mm camera will be used with Kodak type 2485 film. The aperture will be set to f/1.2 and the focus will be set to infinity. In order to minimize interference of spacecraft lighting on the photographs, all exterior lights will be turned OFF and window shades deployed. It is desirable that interior lighting be minimized. The camera will be mounted in the CSM window and pointed through an opening in a window shade or shielded such that stray spacecraft light will not enter the camera lens. The RTCC will compute the CSM attitude maneuver required to point the camera in each of the three desired directions. Following acquisition of each photographic target, CSM attitude rates will be allowed to damp automatically until they are less than .03°/sec. about all axes. Forward firing RCS jets will be disabled during film exposure for each target. B

Six photographs will be taken in three different directions as follows: B

a) Two photographs with camera pointed in the anti-solar direction. B

b) Two photographs with camera pointed toward the Moulton point. B

c) Two photographs with the camera pointed midway between the anti-solar and the Moulton point directions. B

The photographs must be taken while the CSM is in total darkness in lunar orbit. For each of the three directions, the exposure times will be 1 minute and 3 minutes.

It is highly desirable to repeat the sequence of six photographs. It is also highly desirable to obtain two window calibration photographs through the right hand side window. The calibration photographs are to be taken in the direction midway between the anti-solar direction and the Moulton point direction, with exposure times of 1 minute and 3 minutes. B

Success Criteria

FTO 1) The mandatory data defined under Data Requirements shall be acquired and returned to earth for processing.

Evaluation

FTO 1) The data will be evaluated by the Principal Investigator to determine if there is any light associated with the Moulton point. (Premission and experiment evaluation data as defined under Data Requirements)

Data Requirements

1) Premission Data (PD): (M)

Premission sensitometry of the flight film in accordance with the standard procedures of the Photographic Technology Division. B

2) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Deleted

b) Astronaut Logs or Voice Records:

(1) One copy of astronaut logs or voice records containing the record of GET at start and stop of each of the six mandatory photographic exposures. (M)

(2) One copy of astronaut logs or voice records containing the record of GET at start and stop of each of the eight highly desirable photographic exposures. (HD) B

c) Photographs:

(1) Two 35mm camera photographs taken in the direction of the anti-solar vector. (M)

(2) Two additional 35 mm camera photographs taken in the direction of the anti-solar vector. (HD)

(3) Two 35 mm camera photographs taken in the direction of the Moulton point. (M)

(4) Two additional 35 mm camera photographs taken in the direction of the Moulton point. (HD)

(5) Two 35 mm camera photographs taken midway between the anti-solar and Moulton point directions. (M) B

(6) Two additional 35 mm camera photographs taken midway between the anti-solar and Moulton point directions. (HD)

(7) Two calibration photographs through the right hand side window. (HD)

d) Trajectory: (M)

One copy of tape* containing the best estimate of trajectory (BET) including spacecraft attitude data for the periods when photographs were obtained.

*Magnetic tapes produced are to be UNIVAC 1108 computer-compatible digital 7-track, 800-BPI tapes.

5.18 GEGENSCHEIN FROM LUNAR ORBIT

Background and Justification

This experiment will provide data for use in determining the relationship (if any) between the Moulton point and the gegenschein. The data will supplement similar data obtained during Apollo 14, thus significantly increasing the confidence in the conclusions of the experiment. A

The following definitions apply:

Gegenschein: A faint light covering a 20 degree field-of-view projected on the celestial sphere about the sun-earth vector (as viewed from the dark side of the earth).

Zodiacal light: A faint glow extending around the entire zodiac but showing most prominently in the neighborhood of the sun. (It may be seen in the West after twilight and in the East before dawn as a diffuse glow. The glow may be sunlight reflected from a great number of particles of meteoritic size in or near the ecliptic in the planetoid belt.)

Moulton point: The L1 libration point of the rotating sun-earth system, located approximately 940,000 statue miles behind the earth, at which the sum of all gravitational forces is zero. A

One of the theories associated with the gegenschein source is that particles of matter are trapped or captured at the Moulton point and produce a brightness as a result of reflected sunlight.

From the earth it is not possible to tell whether the observed light of the gegenschein comes from the vicinity of the Moulton point, or from cosmic dust of the zodiacal light.

From the vantage point of approximately a quarter moon, the Moulton point can be observed and photographed from 15 degrees off the sun-earth line.

During the same time period that photographs of the gegenschein and the Moulton point are taken from lunar orbit, photographs of the same regions will be obtained from the earth under the cognizance of the Principal Investigator.

In order to prevent severe degradation of data caused by light from the Milky Way, this experiment will have to be accomplished anytime other than the periods from 1 June through 3 July or from 5 December through 1 January. The above two periods are applicable for 1971 and 1972.

Photographs of the gegenschein area, as obtained during Apollo 14, demonstrated the engineering feasibility of obtaining such photographs from the CM in lunar orbit, and indicated that longer exposure times are possible without significant image smear. Photographs to be obtained on Apollo Mission J-1 will utilize an improved light-gathering system (i.e., the 35 mm Nikon camera with 55 mm lens) and significantly longer exposure times than were used on Apollo 14. B

Previous Mission Experiments

Experiment Number	Title	Mission
5.13	Gegenschein from Lunar Orbit	14

5.19 S-BAND TRANSPONDER (CSM/LM)

Conduct the S-Band Transponder Experiment (S-164).

Purpose

The purpose is to obtain S-band Doppler resolver tracking data to determine the distribution of mass along the lunar surface ground track.

The functional test objectives listed in order of priority are as follows:

FTO 1) Obtain S-band Doppler tracking measurements of the CSM/LM during non-powered flight while in the low altitude portions of the 60 x 8 NM lunar orbit.

FTO 2) Obtain S-band Doppler tracking measurements of the undocked LM during non-powered portions of the lunar descent.

FTO 3) Obtain S-band Doppler tracking measurements of the ascent stage of the LM during non-powered portions of the descent for lunar surface impact.

FTO 4) Obtain S-band Doppler tracking measurements of the docked CSM/LM and the undocked CSM during non-powered flight while in the 60 x 60 NM lunar orbit.

FTO 5) Obtain S-band Doppler tracking measurements of the docked CSM/LM during non-powered flight while in the 170 x 60 NM lunar orbit.

Test Conditions

FTO 1)
FTO 2)
FTO 3)
FTO 4)
FTO 5)

MSFN will obtain and record S-band Doppler tracking measurements during frontside passes of the docked CSM/LM and undocked CSM in lunar orbit, of the LM during descent, and of the LM ascent stage during descent for impact on the lunar surface.

It is highly desirable to obtain quiescent conditions by minimizing all translational activities (i.e., effluent dumps, fuel cell purges, and unbalanced RCS thruster firing) during data collection. It is also highly desirable to schedule effluent dumps and fuel cell purges for accomplishment during the backside portion of the lunar orbit. This experiment will not include those periods when the SPS, DPS or APS burns occur.

The minimum tracking data sample rate required to obtain the desired spatial resolution of gravitational variations is dependent on the vehicle altitude above the lunar surface.

The following table lists the minimum tracking data sample rates for various lunar altitudes.

Lunar Altitude (NM)	Tracking Data Sample Rate
≥30	1 per minute
20 to 30	6 per minute
≤20	1 per second

S-band Doppler tracking data are required from one ground station operating in the 2-way mode. All ground stations supplying data will use Doppler resolvers. It is highly desirable to obtain tracking data from at least one additional ground station operating in a 3-way mode.

A

FTO 1) MSFN will obtain tracking data for all frontside passes for
FTO 2) FTO 1), FTO 2) and FTO 3).
FTO 3) The data of primary scientific value are those obtained during frontside passes at altitudes of 16 NM or less. The following table presents the impact to the scientific data for six operational modes in which translational activities may take place.

Mode	Science Impact
1. Translational activities on backside only.	None
2. Translational activities above 16 NM only.	Slight degradation.
3. Translational activities below 16 NM on alternate revolutions. (FTO 1 only)	Slight degradation.
4. Translational activities between 13 and 16 NM only.	Loss of good quality gravitational data.
5. Translational activities below 13 NM on alternate revolutions. (FTO 1 only)	Loss of good quality gravitational data.
6. Minimal translational activities below 16 NM on each revolution. For all revolutions after the initial, translational activities scheduled so that they occur at least 10 degrees from the lunar longitudes at which translations had occurred during the previous revolution. (FTO 1 only)	This is the minimum acceptable technique to obtain usable gravity data.

A

It is highly desirable to collect tracking data from the spacecraft at a minimum of two different altitudes, differing by at least 10 NM, over gravitationally equivalent groundtracks. One groundtrack is gravitationally equivalent to another if it lies within a specific altitude-dependent band about that groundtrack. The size of such a band may be defined as follows:

$$BW = \frac{\text{Altitude}}{40 \sin i} = \frac{\text{Altitude}}{17.5^*}$$

where A

BW = width of band in terms of degrees of longitude at the lunar equator.

Altitude = altitude of spacecraft above the lunar surface in nautical miltes.

i = the angle of inclination of the orbital plane to the lunar equatorial plane.

*For the planned inclination of approximately 26°.

FTO 1) FTO 4) FTO 5) The CSM S-band transponder system will be operated during experiment periods while the CSM is in nominal 60 NM circular, 60 x 8 NM elliptical, and 170 x 60 elliptical lunar orbits.

FTO 2) FTO 3) The LM S-band transponder system will be operated during the experiment period.

FTO 4) During the 60 NM circular orbit, the MSFN will track the CSM during a number of quiescent experiment data collection periods. It is highly desirable that each data collection period consist of two consecutive frontside passes. As a A minimum, each data collection period will consist of one complete quiescent frontside pass. The total number of collection periods will be a function of the inclination of the CSM orbit. For an inclination of 26 degrees, three revolutions A must elapse between data collection periods before new unique gravitational data will be obtained.

FTO 5) MSFN will obtain tracking data for all frontside passes while the CSM/LM is in the 170 x 60 NM lunar orbit.

Success Criteria

FTO 1) FTO 4) FTO 5) The mandatory experiment data defined under Data Requirements shall be obtained during the CSM and CSM/LM lunar orbit and delivered to the Principal Investigator.

FTO 2) The mandatory experiment data defined under Data Requirements shall be obtained during the LM descent and delivered to the Principal Investigator.

FTO 3) The mandatory experiment data defined under Data Requirements shall be obtained during the period between LM deorbit burn and lunar impact and delivered to the Principal Investigator.

Evaluation

FTO 1)
FTO 2)
FTO 3)
FTO 4)
FTO 5)

S-band Doppler tracking data will be reduced postflight to produce Doppler residual plots. These plots will be visually inspected to identify time increments containing non-gravitational disturbances. Depending on the results of this inspection, supplemental tracking data may be processed. The unperturbed raw tracking data will then be reprocessed to compute the gravitational acceleration in a continuous form. Line-of-sight acceleration contour maps will be correlated with lunar surface features to define the locations of gravitational anomalies. In addition, the valid raw data will be processed by a Surface Mass Determination Program to generate an enhanced lunar surface mass distribution. (Experiment evaluation data listed under Data Requirements) A

Data Requirements

1) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority PD*	ESD*	EED
CH 3546 X	RCS Solenoid Activate C3/13/+X	PCME	1			HD
CH 3547 X	RCS Solenoid Activate A4/14/+X	PCME	1			HD
CH 3548 X	RCS Solenoid Activate A3/23/-X	PCME	1			HD
CH 3549 X	RCS Solenoid Activate C4/24/-X	PCME	1			HD
CH 3550 X	RCS Solenoid Activate D3/25/+X	PCME	1			HD
CH 3551 X	RCS Solenoid Activate B4/26/+X	PCME	1			HD
CH 3552 X	RCS Solenoid Activate B3/15/-X	PCME	1			HD
CH 3553 X	RCS Solenoid Activate D4/16/-X	PCME	1			HD
CH 3554 X	RCS Solenoid Activate B1/11/+Z	PCME	1			HD
CH 3555 X	RCS Solenoid Activate D1/22/+Z	PCME	1			HD
CH 3556 X	RCS Solenoid Activate D1/21/-Z	PCME	1			HD
CH 3557 X	RCS Solenoid Activate B2/12/-Z	PCME	1			HD
CH 3558 X	RCS Solenoid Activate A1/+Y	PCME	1			HD
CH 3559 X	RCS Solenoid Activate C2/+Y	PCME	1			HD
CH 3560 X	RCS Solenoid Activate C1/-Y	PCME	1			HD
CH 3561 X	RCS Solenoid Activate A2/-Y	PCME	1			HD
GR 5031 X	Press, Thrust Chamber No 4U	PCME	1			HD
GR 5032 X	Press, Thrust Chamber No 4D	PCME	1			HD

A

Measurement Number	Description	TM	Mode	Priority PD*	ESD*	EED
GR 5033 X	Press, Thrust Chamber No 4F	PCME	1			HD
GR 5034 X	Press, Thrust Chamber No 4S	PCME	1			HD
GR 5035 X	Press, Thrust Chamber No 3U	PCME	1			HD
GR 5036 X	Press, Thrust Chamber No 3D	PCME	1			HD
GR 5037 X	Press, Thrust Chamber No 3F	PCME	1			HD
GR 5038 X	Press, Thrust Chamber No 3S	PCME	1			HD
GR 5039 X	Press, Thrust Chamber No 2U	PCME	1			HD
GR 5040 X	Press, Thrust Chamber No 2D	PCME	1			HD
GR 5041 X	Press, Thrust Chamber No 2F	PCME	1			HD
GR 5042 X	Press, Thrust Chamber No 2S	PCME	1			HD
GR 5043 X	Press, Thrust Chamber No 1U	PCME	1			HD
GR 5044 X	Press, Thrust Chamber No 1D	PCME	1			HD
GR 5045 X	Press, Thrust Chamber No 1F	PCME	1			HD
GR 5046 X	Press, Thrust Chamber No 1S	PCME	1			HD

A

*There are no requirements for Premission Data (PD) and Experiment Support Data (ESD).

b) Telemetry Tapes:

One copy of tapes** containing EED telemetered measurements listed under 1)a), recorded and correlated with GMT during periods of experiment operation. (M)

(1) The period between AOS and LOS of the CSM/LM 170 x 60 NM and 60 x 8 NM lunar orbits.

(2) The periods between AOS and LOS of the LM during descent. A

(3) The period between AOS and LOS of the LM ascent stage during its descent to lunar surface impact.

(4) The periods between AOS and LOS of the CSM (or CSM/LM) during the frontside passes of each quiescent data collection period plus the two passes preceding and the two passes following each quiescent period.

c) Astronaut Logs or Voice Records: (HD)

GET of non-gravitational activities for the time periods described in b) above to include effluent dumps and fuel cell purges. A

**Magnetic tapes produced are to be UNIVAC 1108 computer-compatible, 7-track, 800-BPI. A

d) MSFN Data: A

(1) S-band Doppler tracking data for docked CSM/LM and CSM alone. (M)

(2) S-band Doppler tracking data for LM during unpowered lunar descent. (M)

(3) S-band Doppler tracking data for LM ascent stage during unpowered portion of flight after deorbit burn. (M) A

(4) Transmitting frequency of each MSFN station. (M)

(5) Identity of transmitting ground stations and GET of their transmissions at acquisition of signal and loss of signal. (M)

(6) Identity of ground stations which are in 3-way mode and GET of their receptions at acquisition of signal and loss of signal. (M)

(7) Geocentric coordinates (radius, latitude, and longitude) for all MSFN stations. (M)

(8) Station delay time for each ranging pass. (HD)

e) Trajectory Data: (M) A

Best estimate of trajectory (BET) on microfilm with only spacecraft state vector (time, position, and velocity) required during experiment data collection periods.

f) Supporting Data: (HD) A

Reduced Laser Altimeter data for same time periods of S-band Transponder Experiment operation.

5.19 S-BAND TRANSPONDER (CSM/LM)

Background and Justification

S-band Doppler tracking data have been analyzed from the Lunar Orbiter missions. Definite gravity variations were detected. These results showed the existence of mass concentrations (mascons) in the ringed maria. Confirmation of these results has been obtained with Apollo tracking data.

The CSM and/or LM in low altitude orbits will provide detailed information on lunar gravity anomalies to supplement the data obtained during Apollo 14. These data will provide a factor of 10 improvement in spatial resolution over pre-Apollo experiments. The CSM/LM S-band Doppler tracking measurements are the only gravity measurements during the Apollo program that may be made on a spacecraft that is planned to be flown at relatively low altitudes (i.e., below 16 NM). It is uncertain that the Subsatellites will get to low altitudes during their design lives.
These data can also be used in conjunction with high altitude data to provide a description of the size and shape of the perturbing masses.

Data collected during the 60-NM orbits will be combined with Lunar Orbiter and Apollo Subsatellite data collected at similar altitudes to form a more comprehensive data set from which improved lunar mass distribution data can be generated.

Correlation of gravity data with photographic and other scientific records will give a more complete picture of the lunar environment and support future lunar activities. Inclusion of this improved gravitational field description is pertinent to any theory of the origin of the moon and the study of the lunar subsurface structure. There is also the additional benefit of better navigational capabilities in future lunar missions with an improved lunar gravity model.

Previous Mission Experiments

Experiment Number	Title	Mission
S-164	S-band Transponder (CSM/LM)	14

5.20 SOLAR WIND COMPOSITION

Conduct the Solar Wind Composition Experiment (S-080).

Purpose

The purpose is to determine the elemental and isotopic composition of the noble gases and other selected elements in the solar wind by measurement of particle entrapment on an exposed aluminum foil sheet.

The functional test objective is as follows:

FTO 1) Conduct the Solar Wind Composition Experiment (S-080).

Test Conditions

FTO 1) The crewman will remove the Solar Wind Composition Experiment from the LM MESA and deploy it on the lunar surface during the first EVA period.

The experiment will remain deployed for as long as possible within the constraints of the EVA timeline. It will be disassembled during the last EVA period. The reel and foil will be placed in a teflon bag and stored in the ascent stage for return.

Although small rips in the foil or dust on the foil will not seriously degrade the data, an attempt will be made to minimize these conditions.

It is highly desirable that the following photographs of the deployed experiment be taken:

a) One HEDC stereo pair of the deployed SWC showing the staff in the lunar surface and the entire foil and staff filling the field-of-view and taken in the cross-sun direction.

b) Two HEDC photographs of the upper part of the deployed SWC taken from approximately 7 feet to show the red marking on the reel and the upper part of the foil and staff. One photograph is to be taken immediately after deployment. One photograph is to be taken just prior to retrieval of the foil and reel at the end of the foil exposure period. B

Success Criteria

FTO 1) Experiment evaluation data defined as mandatory under Data Requirements shall be delivered to the Principal Investigator.

Evaluation

FTO 1) Postflight data evaluation will include tests to analyze the particle content in the foil by means of mass spectrometers and low level counting devices. These tests will be performed at the Principal Investigator's laboratory facility. (Astronaut records, photographs and reel and foil from the experiment)

Data Requirements

1) Experiment Evaluation Data (EED):

a) Astronaut Logs or Voice Records: (M)

One copy of each astronaut's log or voice record containing location of deployed experiment with respect to the LM, attitude of deployed foil with respect to the sun, and total time the foil was deployed.

b) Photographs: (HD)

One copy of each photograph of the deployed experiment as defined under the Test Conditions.

c) Reel and foil from the Solar Wind Composition experiment. (M)

5.20 SOLAR WIND COMPOSITION

Background and Justification

Both the particle density and energy distribution of the solar wind have been investigated in considerable detail. The Solar Wind Spectrometer used for experiment S-025 on Apollo 12 measured energies, densities, incidence angles and temporal variations of the electron and proton components of the solar wind on the lunar surface. Little is known, however, about the elemental and isotopic composition of the solar wind.

Experiment S-080 is designed to provide information on the elemental and isotopic composition of the noble gases and other elements in the solar wind. Results of the investigation of the solar wind composition are expected to contribute in deciding between competitive theories in the field of elemental synthesis, origin of the solar system, history of planetary atmospheres and solar wind dynamics. The reel and foil will remain at the LRL until its release to the Principal Investigator's laboratory facility is authorized.

This experiment was deployed during Apollo 11, 12, and 14. Apollo Mission J-1 will provide the opportunity to supplement the data from prior missions.

The longer stay time of this mission will provide a substantial increase in the exposure time of the SWC foil to solar wind particles. The longer exposure time will enable the detection of the heavy noble gases krypton and xenon as well as improved data collection of argon. In addition, the variation of the longitude and latitude of sites will enable a check on interference on the solar wind abundance from hydromagnetic effects near the moon.

The stereo pair of photographs described under Test Conditions is to provide a permanent record of the physical condition of the deployed experiment showing any dust coverage, rips, or wrinkles in the foil and the gross relationship of the foil to the sun. The two photographs of the upper part of the deployed experiment at the beginning and end of the foil exposure period, as described under Test Conditions, are to provide a permanent record for determining the attitude of the foil with respect to B the sun throughout the foil exposure period and the amount of dust coverage that may have accumulated during the exposure period from LRV motion or other activities. This will be accomplished by comparing the illumination and shadowing of the red marking on the reel (at the top of the deployed experiment) at the beginning and end of the exposure period. Differences in illumination and shadowing will be due to the predictable change in sun elevation angle accrued during the exposure period and any unpredicted slumping or falling over of the staff due to lunar gravity, loose soil around the staff, or inadvertent bumping of the experiment by a crewman. Any significant dust coverage will be visible on the upper part of the foil as well as the lower part and a comparison of the photographs taken at the beginning and end of the exposure period will indicate whether the dust coverage occurred before or during the exposure period. These photographic data are important in interpreting and compensating for any off-nominal experiment conditions or anomalous results. B

Previous Mission Experiments

Experiment Number	Title	Mission
S-080	Solar Wind Composition	11
S-080	Solar Wind Composition	12
S-080	Solar Wind Composition	14

6.0 ALTERNATE MISSION AND ABORT GUIDELINES

An alternate mission is defined as any deviation from the nominal mission where further mission objectives are considered before mission termination. An abort is defined as any situation where crew safety requires immediate mission termination. No further mission objectives will be considered in that case.

6.1 Alternate mission plans will be based on the following guidelines.

1) Alternate missions will be consistent with spacecraft, crew and operational constraints.

2) No additional RTCC (real time computation center) processors will be necessary.

3) Entry velocities greater than 37,500 fps should not be planned.

4) There will be no additional crew training.

5) The Apollo Mission J-1 timeline will be adhered to whenever possible.

6) Deorbit will be planned so that recovery lighting constraints are met whenever possible.

7) Water landings will be planned.

8) All large SPS maneuvers in earth orbit will be positioned so that MSFN coverage is available.

9) An RCS deorbit capability will be maintained at all times when in earth orbit.

6.2 Contingency plans will be available for the following modes as directed by Reference 1.

1) One S-IC engine out.

2) One S-II engine out.

3) S-II early shutdown.

4) SPS burn for earth orbit insertion.

5) Deleted. B

6) Launch vehicle backup guidance.

7) Launch vehicle target update.

8) Alternate orbit injection. B

9) Alternate transearth injection using LM DPS.

10) Alternate lunar stay times.

11) Alternate transearth return times.

12) LM ascent.

13) LM rescue.

14) Alternate crew transfer.

15) Changed recovery area.

16) LM entry targeting.

17) Circumlunar return.

6.3 Launch aborts will be planned in accordance with MSC Internal Note No. 71-FM-180, "Operational Abort Plan for Apollo 15, Volume I, Launch Aborts" of 25 May 1971. Aborts after TLI will be planned in accordance with MSC Internal Note No. 71-FM-184, "Operational Abort Plan for Apollo 15, Volume II, Translunar, Lunar Orbit and Transearth Aborts" of 26 May 1971.

6.4 The following alternate mission guidelines apply:

1) In case there is no TLI burn, an earth orbit alternate mission will be accomplished with a mission duration of approximately 6-1/3 days. The subsatellite will be jettisoned in the highest apogee, longest lifetime available. A photography orbit of 240 by 114 NM will be established with apogee over the United States to ensure optimum operation of the SIM cameras. The Mass Spectrometer, the Alpha Particle Spectrometer and the Laser Altimeter will be operated to verify the operability of the hardware. The X-Ray Fluorescence equipment will be used to map the universe from pole to pole and to gather data on Sco X-1. The Gamma Ray Spectrometer will be operated in a 702 by 115 NM orbit to obtain limited data on the earth's magnetosphere. The camera cassettes will be retrieved during EVA on the last day. Additional details are provided in MSC Internal Note No. 71-FM-109, " Apollo 15 No-TLI Earth Orbit Alternate Mission", June 2, 1971. B

2) In case the LM cannot be taken into lunar orbit, there will be an alternate lunar orbit mission with the CSM alone. The SIM door will be jettisoned prior to LOI. The duration of the lunar orbit will be approximately 6 days. The lunar orbit will be circularized

at approximately 60 NM and the SIM experiments will be operated. The SIM cameras will be used to photograph targets of prime scientific interest at an inclination of 35 degrees. The subsatellite will be launched in the normal manner during the last revolution prior to TEI. An EVA will be planned for cassette retrieval during TEC.

3) In case the LM is taken into lunar orbit with an operable DPS but a decision not to land, the mission will have a duration of 4 days in lunar orbit. The lunar orbit will be circularized at approximately 60 NM. The SIM cameras and experiments will be operated as long as possible in lunar orbit although the Gamma Ray Spectrometer data are expected to be degraded. The subsatellite will be launched in the normal manner during the last revolution prior to TEI. The DPS will be used for TEI. The LM will be jettisoned soon after TEI. An EVA will be planned for cassette retrieval during TEC. B

4) In case the LM is taken into lunar orbit with an inoperable DPS or the DPS propellant has been expended due to LM abort during attempted landing, a 6 day lunar orbit mission will be conducted and the SIM cameras and experiments will be operated. There will be no lunar orbit plane change (as normally occurs on lunar orbit revolution 45). The subsatellite will be launched in the normal manner during the last revolution prior to TEI. The SIM camera cassettes will be retrieved during an EVA in TEC.

5) Additional details for the above 3 lunar orbit alternate missions will be provided in a MSC/MPAD document, "Apollo 15 Lunar Orbit Alternate Missions", (to be published).

APPENDIX A

ACRONYMS AND ABBREVIATIONS

Å	Angstrom Unit
AIMP	Advanced Interplanetary Monitoring Platform
	Deleted B
ALSD	Apollo Lunar Surface Drill
ALSEP	Apollo Lunar Surface Experiments Package
AM	Amplitude Modulation
AOS	Acquisition of Signal
APE	Apollo Photographic Evaluation B
APS	Ascent Propulsion System
Ar^{36}	Isotope of Argon
Ar^{38}	Isotope of Argon
Ar^{40}	Isotope of Argon
AS	Apollo Saturn
BET	Best Estimate of Trajectory
BPI	Bits per Inch
CCIG	Cold Cathode Ion Gauge
CDR	Commander
CM	Command Module
CMP	Command Module Pilot
CSM	Command and Service Module
DAC	Data Acquisition Camera
db	Decibel
DPS	Descent Propulsion System
EED	Experiment Evaluation Data
EMU	Extravehicular Mobility Unit
ESD	Experiment Support Data
EVA	Extravehicular Activity
EVC-1	Extravehicular Crewman No. 1 (Commander) B
F	Fahrenheit
FM	Frequency Modulation
FOV	Field of View
fps	Feet per Second
FTO	Functional Test Objective

g	Gravity
GAC	Grumman Aerospace Corporation
GCTA	Ground Commanded Television Assembly
GET	Ground Elapsed Time
GMT	Greenwich Mean Time
GOX	Gaseous Oxygen
HD	Highly Desirable
HEC	Hasselblad Electric Camera
HEDC	Hasselblad Electric Data Camera
HOPE	Houston Operations Predictor-Estimator ▌B
HFE	Heat Flow Experiment
hr	Hour
HTRS	Heaters
H_2O	Water
Hz	Hertz
HZE	High-Z, High Energy
IMU	Inertial Measurement Unit
in	Inch
IR	Infrared
JPL	Jet Propulsion Laboratory
K	Kelvin
K^{40}	Isotope of Potassium
KC	Kilocycle
kg	Kilogram
km	Kilometer
KSC	Kennedy Spacecraft Center
λ	Lambda (Wavelength)
LCRU	Lunar Communications Relay Unit
LiOH	Lithium Hydroxide
LLDE	Lunar Dust Detector Experiment
LM	Lunar Module
LO	Lunar Orbit
LOI	Lunar Orbit Insertion
LOS	Loss of Signal
LRL	Lunar Receiving Laboratory
LRRR	Laser Ranging Retro-Reflector

LRV	Lunar Rover Vehicle
LSM	Lunar Surface Magnetometer
LSPET	Lunar Samples Preliminary Examination Team
M	Mandatory
MHz	Megahertz
min	Minute
mm	Millimeter
MCC	Mission Control Center
MESA	Modularized Equipment Storage Assembly
	Deleted B
MSC	Manned Spacecraft Center
MSFN	Manned Space Flight Network
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NM	Nautical Mile
NR	North American Rockwell
$NiSO_4$	Nickel Sulfate
O_2	Oxygen
OGO	Orbiting Geophysical Observatory
OMSF	Office of Manned Space Flight
OSO	Orbiting Solar Observatory
PCM	Pulse Code Modulation
PCMD	Pulse Code Modulation Digital
PCME	Pulse Code Modulation Event
PD	Premission Data
PGA	Pressurized Garment Assembly
PGNS	Primary Guidance and Navigation Subsystem
PI	Principal Investigator
PLSS	Portable Life Support System
PM	Phase Modulation
PM1/WB	Phase Modulation No. 1/Wide Band
PM1/NB	Phase Modulation No. 1/Narrow Band
PRN	Pseudo-Random Noise
PSE	Passive Seismic Experiment
psia	Pounds per Square Inch Absolute
PTC	Passive Thermal Control

Quad	Quadrant
RCS	Reaction Control Subsystem
RF	Radio Frequency
RH	Right Hand
RMT/TV	Remote Television
Rn^{220}	Isotope of Radon
Rn^{222}	Isotope of Radon
RTCC	Real Time Computation Center
SA	Saturn Apollo
SEA	Sun Elevation Angle
Sec	Second
SESC	Special Environmental Sample Container
SEVA	Stand-up Extravehicular Activity A
SIDE	Suprathermal Ion Detector Experiment
SIM	Scientific Instrument Module
SLA	Spacecraft/LM Adapter
SM	Service Module
SPS	Service Propulsion System
SRA	Sun Relative Azimuth
SRC	Sample Return Container
S/S	Samples per Second
STBY	Standby
SWC	Solar Wind Composition A
SWS	Solar Wind Spectrometer
SXT	Sextant
S-IC	Saturn IC
S-II	Saturn II
S-IVB	Saturn IVB
T	Time (of lift-off)
TBD	To Be Determined
TEC	Transearth Coast
TEI	Transearth Injection
TLC	Translunar Coast
TM	Telemetry
TPI	Terminal Phase Initiation
T/R	Transmit/Receive

TSF	Telemetry Store Fast
TSN	Telemetry Store Normal
TV	Television
U	Unclassified
USSR	Union of Soviet Socialist Republics
UV	Ultraviolet
ΔV	Delta Velocity
VHF	Very High Frequency
Z	Atomic Number of an Element

A

AEROSOL	A suspension of fine solid or liquid particles such as smoke or fog in the earth's atmosphere.
ALBEDO	The amount of electromagnetic radiation reflected by a body expressed as a percentage of the radiation incident on the body as sunlight albedo, x-ray albedo, etc.
ALPHA PARTICLE	A nuclear particle of atomic mass 4 made up of 2 protons and 2 neutrons.
ANGSTROM UNIT	A unit of length equal to 10^{-10} meters or 10^{-4} microns commonly used in specifying wavelengths of electromagnetic radiation.
ANISOTROPIC	Exhibiting different properties when tested along axes in different directions. A
BASALTIC	A type of dark grey rock formed by solidification of molten material (previously found on the lunar surface).
BOUNDARY LAYER	Interaction layer between the surface of the moon and the undisturbed portion of the solar wind as the solar wind flows around the moon.
BOW SHOCK	The shock wave produced by the interaction of the solar wind with the earth's magnetosphere.
BRECCIA	A rock consisting of sharp fragments embedded in a fine-grained matrix.
COLORIMETRIC	Pertaining to the measurement of the intensities of different colors as of lunar surface materials.
COSMIC RAYS	Very high energy nuclear particles, commonly protons, that bombard the earth from all directions.
COSMOLOGICAL	Concerned with the investigation of the character and origin of the universe.
EPICENTER	The lunar surface point directly above the source of a seismic disturbance.
EXOSPHERE	The outermost portion of the earth's or moon's atmosphere from which gases can escape into outer space.
FLUORESCENCE	Emission of radiant energy in response to the absorption of radiant energy at a different wavelength.

GALACTIC	Pertaining to a galaxy in the universe such as the Milky Way.
GAMMA	Unit of magnetic field strength equal to 1×10^{-5} oersteds.
GAMMA-RAY	A quantum of electromagnetic radiation emitted by an atomic nucleus as a result of quantum transition between two energy levels of the nucleus.
GNOMON	A rod pivoted about a free bearing used on the lunar surface to indicate the local vertical, to give sun position, and to serve as a distance scale.
GRANITIC	Pertaining to very hard igneous rock.
IGNEOUS ROCK	Rock formed by solidification of molten material.
IN SITU	"In its original position." For example, taking photographs of a lunar surface rock sample "in situ" (as it lays on the surface).
K LINES	Band spectra lines characteristic of the innermost atom electron shell containing 2 electrons; this shell is called the K-shell.
L LINES	Band spectra lines characteristic of the next to innermost atom electron shell containing electrons; this shell is called the L-shell.
LITHIFIED	Evidence of having been changed into stone.
MAGNETOPAUSE	The transition region between the earth's magnetosphere and the solar wind bow shock.
MAGNETOSPHERE	The region of the earth's atmosphere where ionized gases contribute to the determination of the dynamics of the atmosphere and where the forces of the earth's magnetic field are predominant.
MAGNETOTAIL	The tube-like, elongated region of the magnetosphere of undetermined length in the anti-solar direction.
MANTLE	An intermediate layer of the moon between the lithosphere (outer layer) and the central core.
MARE	A large, dark, flat area on the lunar surface (Lunar Sea).
MARIA	Plural form of mare.

MASCONS	Large mass concentrations beneath the surface of the moon. They are believed to contain large bodies or masses that have impacted the lunar surface from outer space.
MASS SPECTROMETER	An instrument which differentiates chemical species in terms of their different isotopic masses.
MIE	Name associated with the theory of scattering of electromagnetic radiation from spherical particles without regard to comparative size of radiation wavelength and particle diameter.
MONOENERGETIC SOURCE	A source of electromagnetic radiation, confined to a very narrow frequency range used, for example, as a calibration source for spectrometers.
NOCTILUCENT	Shining at night. For example, noctilucent clouds or collections of high-altitude aerosols which scatter light.
PENUMBRAL	Referring to the part of a shadow in which the light (or other ray-type material such as the solar wind) is only partially masked in contrast to the umbra in which light is completely masked by the intervening object.
PLASMA	An electrically conductive gas comprised of neutral particles, ionized particles and free electrons but which, when taken as a whole, is electrically neutral.
POLARIMETRIC	Referring to the measurement of the intensity of polarized light in a partially polarized light beam or the measurement of the extent of polarization.
PROTON	The positively-charged constituent of atomic nuclei. For example, the entire nucleus of a hydrogen atom having a mass of 1.67252×10^{-27} kilograms.
RADON	A radioactive gaseous element with atomic number 86 and atomic mass 222 formed by the radioactive decay of radium.
RAYLEIGH	Name associated with atmospheric scattering of electromagnetic radiation from spherical particles of radii smaller than about one-tenth the wavelength of the radiation.
REGOLITH	The unconsolidated residual material that resides on the solid surface of the moon (or earth).

Deleted

A

SEISMIC	Related to mechanical vibrations within the surface of the earth or moon resulting from, for example, impact of projectiles on the surface.
SENSITOMETRIC	Pertaining to the measurement of the light response characteristics of photographic film under controlled conditions of exposure and development.
SIDELAP	Overlap of one aerial or orbital photographic strip with another in a direction perpendicular to the length of the strips.
SOLAR WIND	Streams of plasma emanating from and flowing approximately radially outward from the sun.
SPECTROMETER	An instrument which disperses radiation into energy bands (or, in a mass spectrometer, particles into mass groups) and indicates the flux in each band or group.
SUBSATELLITE	A small unmanned satellite, deployed from the spacecraft while it is in orbit, designed to obtain various types of solar wind and lunar magnetic data over an extended period of time.
THORIUM	A heavy metallic element with an atomic number 90 and an atomic mass of 232.
THREE-WAY MODE	A Doppler radar method involving a primary station which both sends and receives signals, a transponder on the spacecraft, and a secondary station which receives signals only.

TIDAL	Referring to the seismic movement of layers forming the outer portion of the lunar surface or within the lunar mantle as a result of the earth's gravitational attraction. Similar in nature to the tidal movements of the earth's oceans.
TOPOGRAPHIC	Pertaining to the accurate graphical description, usually on maps or charts, of the physical features of an area on the earth or moon.
TWO-WAY MODE	The Doppler radar tracking method which employs a single sending and receiving station and the spacecraft transponder.
URANIUM	A heavy metallic element of atomic number 92 and principal atomic weight 238.

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