BARNES

MSC-05180

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

MISSION REQUIREMENTS
SA-512/CSM-114/LM-12
J-3 TYPE MISSION

LUNAR LANDING

MARCH 16, 1972

(Reprinted September 18, 1972)

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

REV A JULY 5, 1972
REV B SEPT 18, 1972
REV C NOV 15, 1972
REV D DEC 1, 1972

MSC-05180

NASA

National Aeronautics and Space Administration

MISSION REQUIREMENTS

J-3 TYPE MISSION

March 16, 1972

(Reprinted September 18, 1972)

Contract NAS 9-12330

MSC-05180

MISSION REQUIREMENTS

J-3 TYPE MISSION

Contract NAS 9-12330

Prepared by TRW Systems

for

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CCBD NUMBERS	ECP NUMBERS	MANNED SPACECRAFT CENTER	DATE
PCN		PROGRAM OFFICE	December 1, 1972
MSC 2C0141C		CONFIGURATION CONTROL BOARD DIRECTIVE	PAGE 1 OF 1
		CHANGE PRIORITY	
		IMPACT ON ☐ CSM ☐ LM ☐ GFE ☐ LV ☐ LF ☐ EXP ☐ GSE ☐ OTHER	

MSFC

KSC

CHANGE TITLE

Change D to MSC-05180

NOMENCLATURE AND PART NO. OF AFFECTED END ITEM

Mission Requirements, J-3 Type Mission, Lunar Landing

PRODUCTION EFFECTIVITY	MODIFICATION EFFECTIVITY

ESTIMATED COST

FY71	FY72	FY73	TOTAL
		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: No contractor direction is required.

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

- The Test Conditions are modified for objectives Visual Light Flash Phenomenon and Skylab Contamination Study.
- The Test Conditions are modified for experiments Lunar Sounder and Lunar Neutron Probe.
- Additions to the data requirements are identified for passive experiment Soil Mechanics and for experiment Lunar Seismic Profiling.
- Miscellaneous minor changes are provided throughout the remainder of the document.
- All changes in this directive are consistent with the Final Flight Plan (to include Revision A and Changes A and B), the CSM EXP/EVA Checklist (to include Change A), and the Final Lunar Surface Procedures document.

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

SIGNATURE — DATE

CPCB Chairman

SIGNATURE — DATE

SIGNATURE — DATE

12/1/72

SIGNATURE — DATE

CHAIRMAN CONFIGURATION CONTROL BOARD

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MISSION REQUIREMENTS

J-3 TYPE MISSION

CHANGE D

REVISION INSTRUCTION SHEET

Update this document in accordance with the following instructions:

1) Insert page iiia.5 behind page iiia.3.

2) Insert page iiic.5 behind page iiic.3. D

3) Replace the following pages from the basic document (as reprinted on September 18, 1972, to include Change B) and as amended by Change C on November 15, 1972, with the corresponding Change D pages:

2-5	4-13	5-2	5-36A	5-65
3-3	4-14	5-2A	5-48	5-92
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4) Add the following page:

5-22

BARNES

CCBD NUMBERS	ECP NUMBERS	MANNED SPACECRAFT CENTER	DATE
PCN		PROGRAM OFFICE	November 15, 1972
MSC 2C0141B		CONFIGURATION CONTROL BOARD DIRECTIVE	PAGE 1 OF 1
MSFC		CHANGE PRIORITY	
KSC		IMPACT ON ☐ CSM ☐ LM ☐ GFE ☐ LV ☐ LF ☐ EXP ☐ GSE ☐ OTHER	

CHANGE TITLE

Change C to MSC-05180

NOMENCLATURE AND PART NO. OF AFFECTED END ITEM
Mission Requirements, J-3 Type Mission, Lunar Landing

PRODUCTION EFFECTIVITY | **MODIFICATION EFFECTIVITY**

ESTIMATED COST

FY71	FY72	FY73	TOTAL
		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: No contractor direction is required.
CHANGE TO BE IMPLEMENTED ONLY WHEN ALL INTERFACE ACTIONS HAVE BEEN AUTHORIZED

- Detailed objective Food Compatibility Assessment is added.
- Detailed objective Protective Pressure Garment is added.
- Passive objective Long Term Lunar Surface Exposure is added.
- The Test Conditions are modified for objectives SM Orbital Photographic Tasks, Visual Light Flash Phenomenon, CM Photographic Tasks, Visual Observations From Lunar Orbit and Skylab Contamination Study.
- The Test Conditions are modified for experiments Lunar Geology Investigation, Surface Electrical Properties, Traverse Gravimeter, Lunar Sounder, Far UV Spectrometer and IR Scanning Radiometer.
- Miscellaneous changes are provided throughout the remainder of the document.

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

SIGNATURE	DATE
[signature]	NOV 15 1972
CPCB Chairman	

[signature] 11/17/72
SIGNATURE DATE
CHAIRMAN CONFIGURATION CONTROL BOARD

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MISSION REQUIREMENTS

J-3 TYPE MISSION

CHANGE C

REVISION INSTRUCTION SHEET

Update this document in accordance with the following instructions:

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 (as reprinted on September 18, 1972, to include Change B) with the corresponding Change C pages:

v	3-6	4-28	5-39	5-42A	5-44I	5-60	5-81	7-2
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C

4) Add the following pages:

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4-45	4-51	

CCBD NUMBERS	ECP NUMBERS	MANNED SPACECRAFT CENTER	DATE
PCN		PROGRAM OFFICE	September 18, 1972
MSC		CONFIGURATION CONTROL BOARD DIRECTIVE	PAGE 1 OF 1
2C0141A		CHANGE PRIORITY	
		IMPACT ON ☐ CSM ☐ LM ☐ GFE ☐ LV ☐ LF ☐ EXP ☐ GSE ☐ OTHER	
MSFC		CHANGE TITLE: Change B to MSC-05180	
KSC			

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

NOMENCLATURE AND PART NO. OF AFFECTED END ITEM
Mission Requirements, J-3 Type Mission, Lunar Landing

PRODUCTION EFFECTIVITY	MODIFICATION EFFECTIVITY

ESTIMATED COST

FY71	FY72	FY73	TOTAL
		None	None

SCHEDULE IMPACT
None

DISPOSITION AND DIRECTED ACTION: No contractor direction is required.
CHANGE TO BE IMPLEMENTED ONLY WHEN ALL INTERFACE ACTIONS HAVE BEEN AUTHORIZED

- Experiment Cosmic Ray Detector (Sheets) is added.
- Passive experiments Biostack IIA, Gamma-Ray Spectrometer, and Biocore are added.
- Passive objective Apollo Time and Motion Study is deleted.
- Passive experiment Bone Mineral Measurement is deleted.
- The Test Conditions are modified for objectives SM Orbital Photographic Tasks, Visual Light Flash Phenomenon, CM Photographic Tasks and Skylab Contamination Study.
- The sun elevation angles and related data are modified for the launch opportunities in the second and third months.
- The Test Conditions are modified for experiments Heat Flow, Lunar Surface Gravimeter, Lunar Seismic Profiling, Lunar Geology Investigation, Surface Electrical Properties, Lunar Sounder and Far UV Spectrometer.
- Guidelines are provided for three alternate missions.
- Miscellaneous minor corrections are provided throughout the remainder of the document.

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

SIGNATURE [signature] DATE
CPCB Chairman
SIGNATURE [signature] DATE
SIGNATURE DATE

[signature] 9/18/72
SIGNATURE DATE
CHAIRMAN CONFIGURATION CONTROL BOARD

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NASA — MSC

MISSION REQUIREMENTS

J-3 TYPE MISSION

CHANGE B

REVISION INSTRUCTION SHEET

NOTE!

1) FOR THE CONVENIENCE OF THE READER, THE LATEST VERSION OF EACH PAGE TO INCLUDE CHANGES A AND B, HAS BEEN PROVIDED IN THIS REPRINT. THE TABS IN THE BASIC DOCUMENT WERE NOT CHANGED AND WERE NOT REPRINTED BUT MAY BE REUSED IF DESIRED.

2) The following pages from the basic document or Change A were modified by Change B: B

vii	4-6	4-40	5-40A	5-50	5-81	A-5
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3) The following pages in Change B are new pages not in the basic document or Change A.

iiia.1	5-2A	5-48A	5-106	5-109	7-3
iiic.1	5-30A	5-105	5-107	5-110	

CCBD NUMBERS	ECP NUMBERS
PCN	
MSC 2C0141	

MANNED SPACECRAFT CENTER

PROGRAM OFFICE

CONFIGURATION CONTROL BOARD DIRECTIVE

CHANGE PRIORITY

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

DATE: July 5, 1972

PAGE 1 OF 1

MSFC

KSC

CHANGE TITLE

Change A to MSC-05180

NOMENCLATURE AND PART NO. OF AFFECTED END ITEM

Mission Requirements, J-3 Type Mission, Lunar Landing

PRODUCTION EFFECTIVITY	MODIFICATION EFFECTIVITY

ESTIMATED COST

FY71	FY72	FY73	TOTAL
		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: No contractor direction is required.

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

- Experiment Lunar Neutron Probe is added.
- In-flight demonstration Heat Flow and Convection is added.
- DOI 2 is added.
- The sun elevation angles and related data are modified for all launch dates.
- The T+24 hour launch opportunity on the third month is cancelled.
- The landing site coordinates are identified.
- The nominal lunar stay time is extended.
- The order of priority is changed for ten of the detailed objectives and experiments.
- The Test Conditions are modified for objectives Visual Light Flash Phenomenon and CM Photographic Tasks.
- The Test Conditions are modified for experiments Lunar Surface Gravimeter, Lunar Seismic Profiling, Lunar Atmospheric Composition, Lunar Ejecta and Meteorites, Surface Electrical Properties, Lunar Sounder, S-Band Transponder (CSM/LM), Far UV Spectrometer, and IR Scanning Radiometer.
- The Test Conditions, Success Criteria, Evaluation and Data Requirements sections are provided for experiment Lunar Geology Investigation.
- Miscellaneous minor changes are provided throughout the remainder of the document.

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

SIGNATURE — DATE: JUL 5 1972

CPCB Chairman

SIGNATURE — DATE

SIGNATURE — DATE

SIGNATURE — DATE: 7/5/72

CHAIRMAN CONFIGURATION CONTROL BOARD

MSC Form 1156A (Rev Jul 70)

NASA — MSC

MISSION REQUIREMENTS

J-3 TYPE MISSION

CHANGE A

REVISION INSTRUCTION SHEET

Update this document in accordance with the following instructions:

1) Insert page iiia behind existing signature page iii.

2) Insert page iiic behind page iiia.

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

vii	4-8	4-26	5-21	5-41	5-77	A-1
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2-6	4-15	5-10	5-28	5-59	5-82	R-1
2-7	4-16	5-11	5-29	5-60	5-83	D-1
2-8	4-17	5-12	5-31	5-61	5-84	D-2
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A

4) Add the following pages:

2-9	5-40C	5-44A	5-44H	5-100	6-8
4-8A	5-40D	5-44B	5-44I	5-101	A-6
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1.0 PURPOSE

This document defines the mission objectives and experiments for Apollo Mission J-3. The detailed objectives and experiment are derived from the Mission Implementation Plan (Reference 1).

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 and its environment, to emplace Apollo 17 ALSEP, to perform traverse experiments, to obtain lunar material samples, to perform experiments in lunar orbit, to obtain orbital photographs and make observations, and to enhance the capability for future 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 72 to 100 degrees (except that the T-0 launch opportunity in January 1973 will use limits of 84 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. B

Translunar Injection:

The launch vehicle S-IVB 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 with 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 7.0° S and longitude 8.0° W as shown by Lunar Planning Chart, LOC 2 Series, 1:2,250,000, First edition, May 1971.

A second mid-course correction will be performed by the S-IVB at a GET of approximately 10 hours to reduce the error uncertainty.

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 51 by 171 NM.

Lunar Module Descent:

The CSM will be used for DOI1 to transport the LM into an orbit of approximately 15 x 59 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 RCS will then be used (4 jet -X thrusters for maximum of 30 seconds) for DOI2 to put the LM into an orbit of approximately 7 by 60 NM. 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 circularization burn will occur shortly after CSM/LM separation and before DOI2. This burn will establish a 70 NM by 54 NM orbit which will result in approximately a 62 NM circular orbit with respect to the landing site at time of LM liftoff. Since the landing site is approximately 2 NM below the mean lunar surface, there will be a 60 NM circular orbit with respect to the mean lunar surface at time of LM liftoff.

Lunar Landing Site:

Mission planning will allow launch attempts during each of three consecutive months in accordance with the data shown below.

Launch Opportunity	Approximate Sun Elevation Angles (referenced to local horizontal at the landing site) and Sun Relative Azimuths for launch dates and EST window open times as indicated in parenthesis.							
	T-24 Hours		T-0		T+24 Hours		T+48 Hours	
	SEA	SRA	SEA	SRA	SEA	SRA	SEA	SRA
First Month	N/A	N/A	13.3° (12/6/72 21:53 hrs)	+5.8°	16.9° (12/7/72 21:53 hrs)	+7.3°	N/A	N/A
Second Month	N/A	N/A	6.8° (1/4/73 21:51 hrs)	+2.5°	10.2° (1/5/73 20:21 hrs)	+3.7°	20.3° (1/6/73 20:29 hrs)	+7.7°
Third Month	13.3° (2/3/73 18:47 hrs)	+4.1°	13.3° (2/4/73 18:58 hrs)	+4.1°	N/A	N/A	N/A	N/A

B

The approach azimuth will be -90 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
Taurus-Littrow	Latitude 20°09'50.5" N (20.16403°N) Longitude 30°44'58.3" E (30.74953°E) Radius Vector 1,734,484 meters (936.546 NM)	Analytical Triangulation of Apollo 15 photography

Lunar Surface Operations:

The nominal stay time on the lunar surface is planned for, and will not exceed, approximately 75 hours. After checkout of the LM to assess its launch capability, the LM will be depressurized to allow egress of astronauts to the surface. The nominal plan will provide for three periods of simultaneous EVA by both astronauts. If the first EVA comes prior to the first sleep period on the lunar surface, then an effort will be made to limit the time from crew wake up on landing day through cabin repressurization after the first EVA to not exceed 18 hours. The EVA periods will be approximately 7 hours each in duration. Rest periods will be scheduled prior to the second and third EVA's and prior to liftoff.

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 during the first EVA C
as defined in the CSM/LM Spacecraft Operational Data Book,
SNA-8-D-027, Vol. V, ALSEP Data Book, as revised by Appendix F C
for Apollo 17 ALSEP. Requirements for photographs in support of specific ALSEP experiments are shown in Section 5.0 of this Mission Requirements document. In addition, the following photographs will be obtained:

- One photograph of the Central Station from 7 feet behind the station looking south to show the position of the switches.
- One photograph of the Central Station from 7 feet looking north.
- Panoramic photograph from vicinity of Central Station to show entire ALSEP deployed.
- One photograph of the RTG from 7 feet to show leveling of RTG on its pallet and a view of the surrounding area.

Television transmission will be provided as early as practicable during the EVA period. Television coverage will include 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 each science stop when using the LRV.

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

The LRV will be positioned at the end of the third EVA period to enable GCTA-monitored ascent and other TV observations of scientific interest.

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 other science data. 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 19.93°N and longitude 30.54°E as determined by analytical triangulation of Apollo 15 photography. LM ascent stage separation from the CSM is to be accomplished approximately two revolutions after CSM/LM docking. D

Lunar Orbital Operations:

The SIM equipment will be placed in operation. The SIM cameras and antennae will be retracted into the SIM bay prior to TEI. If any HF antenna fails to retract, it will be jettisoned prior to SPS thrusting. After CSM/LM docking, the CSM will remain in lunar orbit for approximately two days.

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.

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 1190 NM.

Earth touchdown will be in the Pacific within ±35 degrees latitude and will occur slightly less than 13 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. An attempt will be made to recover the earth landing system main parachutes. The crew will be returned to MSC for debriefing and will participate in sample unpacking. The sample return containers, film, tapes and astronaut logs will be transported to the LRL.

2.3 DEFINITIONS

1) Detailed Objective - A scientific, engineering, medical, or operational investigation that provides important data and experience for use in development of hardware and/or procedures for application to Apollo missions. Orbital photographic tasks, though reviewed by the Manned Space Flight Experiments Board, are not assigned as formal Experiments and are shown as CM and SM detailed objectives.

2) Experiment - A technical investigation that supports science in general or provides engineering, technological, medical, or other data and experience for application to Apollo lunar exploration or other programs and is recommended by the Manned Space Flight

Experiments Board and assigned by the Associate Administrator for Manned Space Flight to the Apollo Program for flight.

3) Operational Test - A technical investigation that provides for the acquisition of technical data or evaluates operational techniques, equipment, or facilities but is not required by the objectives of the mission. An operational test does not affect the nominal mission timeline, adds no payload weight, and does not jeopardize the accomplishment of primary objectives, experiments, or detailed objectives. Their success or failure is in no way related to mission success.

4) Inflight Demonstration - A technical demonstration of the capability of an apparatus and/or process to illustrate or utilize the unique conditions of space flight environment. Inflight demonstrations will be performed only on a non-interference basis at the crew's discretion. Utilization, performance, or completion of these demonstrations will in no way relate to mission success.

5) Passive Experiments/Objectives - An experiment or an objective that does not require any activity by the crew during the mission and does not in any way affect the mission timeline. These are listed in Section 3 and summarized in Section(s) 4.0 or 5.0 but detailed planning information is not included.

6) Test Conditions - 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.

7) Priorities - 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.

8) 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.

9) 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:

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

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.

10) 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 by Reference 7.

2.4 CONFIGURATION CONTROL

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

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-3, CSM 114/LM-12, Apollo 17 (Reference 4).

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):

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

2) Emplace and activate surface experiments.

3) Conduct in-flight experiments and photographic tasks.

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 Long Term Lunar Surface Exposure, will be listed in Section 4.0, but will not be detailed or assigned a priority. C

Experiments as listed in Reference 1 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-211 (Biostack IIA), M-212 (Biocore), S-160 (Gamma-Ray Spectrometer), S-176 (Apollo Window Meteoroid) and S-200 (Soil Mechanics) are listed in Section 5.0, but are not detailed or assigned a priority. All of the detailed experiments are in support of the primary mission objectives and were assigned by OMSF as numbered experiments.

Two of the detailed objectives include the collection of photographs and related data that will be used by 16 data analysis tasks defined in Reference 8 as lunar orbital photo/laser data analysis program experiments. These 16 experiments are referenced only at the end of the appropriate detailed objective (i.e., SM Orbital Photographic Tasks and CM Photographic Tasks) and are not detailed or assigned a priority.

3.2 PRIORITIES

The detailed objectives and experiments are listed below in their order of priority. Accomplishment of the detailed objectives and detailed experiments planned for the lunar surface will not be jeopardized for the sake of those planned for lunar orbit or coasting flight. The planning will, however, permit the Surface Electrical Properties Experiment to be turned OFF at certain times as defined in the Test Conditions for the Lunar Sounder Experiment.

Priority	Detailed Objectives and Experiments
	Lunar Surface
1	Documented Sample Collection at highest priority traverse station (Part of Lunar Geology Investigation)
2	Heat Flow (S-037) (Part of Apollo 17 ALSEP)
3	Lunar Seismic Profiling (S-203) (Part of Apollo 17 ALSEP)
4	Lunar Surface Gravimeter (S-207) (Part of Apollo 17 ALSEP)
5	Lunar Atmospheric Composition (S-205) (Part of Apollo 17 ALSEP)
6	Lunar Ejecta and Meteorites (S-202) (Part of Apollo 17 ALSEP)
7	Lunar Geology Investigation (S-059) (Portions other than priority items 1 and 8)
8	Drill Core Sample Collection (Part of Lunar Geology Investigation)
9	Surface Electrical Properties (S-204)
10	Lunar Neutron Probe (S-299)
11	Traverse Gravimeter (S-199)
12	Cosmic Ray Detector (Sheets) (S-152) C
	Translunar Coast, Lunar Orbit and Transearth Coast
1	Lunar Sounder (S-209)
2	SM Orbital Photographic Tasks

Translunar Coast, Lunar Orbit and Transearth Coast (Cont.)

3	IR Scanning Radiometer (S-171)
4	Far UV Spectrometer (S-169)
5	S-Band Transponder (CSM/LM) (S-164)
6	Visual Light Flash Phenomenon
7	CM Photographic Tasks
8	Visual Observations from Lunar Orbit
9	Food Compatibility Assessment
10	Protective Pressure Garment D
11	Skylab Contamination Study

3.3 MSC POINTS OF CONTACT

The MSC points of contact for the objectives and experiments are identified below.

Detailed Objectives	Point of Contact
SM Orbital Photographic Tasks	S. N. Hardee/TD4
Visual Light Flash Phenomenon	J. V. Bailey/DD6*
CM Photographic Tasks	S. N. Hardee/TD4
Visual Observations from Lunar Orbit	S. N. Hardee/TD4
Skylab Contamination Study	C. H. Glancy/PD4*
Food Compatibility Assessment	P. C. Rambaut/DB3*
Protective Pressure Garment	R. L. Johnson/DB*

Detailed Experiments	Point of Contact
Heat Flow (ALSEP) (S-037)	W. F. Eichelman/TD4
Lunar Ejecta and Meteorites (ALSEP) (S-202)	W. F. Eichelman/TD4
Lunar Seismic Profiling (ALSEP) (S-203)	W. F. Eichelman/TD4
Lunar Atmospheric Composition (ALSEP) (S-205)	W. F. Eichelman/TD4
Lunar Surface Gravimeter (ALSEP) (S-207)	W. F. Eichelman/TD4

Lunar Geology Investigation (S-059)	W. F. Eichelman/TD4
S-Band Transponder (CSM/LM) (S-164)	P. E. Lafferty/TD4
Far UV Spectrometer (S-169)	S. N. Hardee/TD4
IR Scanning Radiometer (S-171)	P. E. Lafferty/TD4
Traverse Gravimeter (S-199)	W. F. Eichelman/TD4
Surface Electrical Properties (S-204)	W. F. Eichelman/TD4
Lunar Sounder (S-209)	P. E. Lafferty/TD4
Lunar Neutron Probe (S-299)	W. F. Eichelman/TD4
Cosmic Ray Detector (Sheets) (S-152)	W. F. Eichelman/TD4

Passive Experiments	Point of Contact
Biostack IIA (M-211)	J. V. Bailey/DD6*
Biocore (M-212)	R. C. Simmonds/DD5*
Gamma-Ray Spectrometer (S-160)	W. F. Eichelman/TD4
Apollo Window Meteoroid (S-176)	B. G. Cour-Palais/TN6
Soil Mechanics (S-200)	W. F. Eichelman/TD4

Operational Tests	Point of Contact
None	

In-Flight Demonstrations	Point of Contact
Heat Flow and Convection	F. J. Laurentz/PG*

Passive Objectives	Point of Contact
Long Term Lunar Surface Exposure	D. W. Strangway/TN4 C

*A written assessment is due to the Apollo Spacecraft Program Office three months after completion of the mission from the point of contacts indicated by an asterisk. The responsibility for providing the proper action for the remaining detailed objectives, detailed experiments and passive experiments 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, experiments and in-flight demonstrations are as defined below. Sensitometric data curves for each development process are on file in the MSC Photographic Technology Division/JL.

Objective, Experiment or Demonstration	Type Camera	Lens	Type Film**	Development Process	
4.1 SM Orbital Photographic Tasks	Mapping	3 inch	BW(3400)	Fultron/MX-819	
	Stellar	3 inch	BW(3401)	Hi-Speed/D-19	
	Panoramic	24 inch	LBW	Fultron/MX-819	
4.2 Visual Light Flash Phenomenon	35	55 mm	CIN	Houston/ME-4	C
4.3 CM Photographic Tasks	HEC	250 mm	VHBW	Hi-Speed/D-19	
	HEC	250 mm	CEX	Hi-Speed/ME-2A	
	HEC	80 mm	VHBW	Hi-Speed/D-19	
	35	55 mm	VHBW	Hi-Speed/D-19	
4.4 Visual Observations from Lunar Orbit	None	--	--	--	
4.5 Skylab Contamination Study	None	--	--	--	
4.6 Food Compatibility Assessment	None	--	--	--	C
4.7 Protective Pressure Garment	None	--	--	--	
5.1 Heat Flow	HEDC	60 mm	CEX	Hi-Speed/ME-2A	
5.2 Lunar Surface Gravimeter	HEDC	60 mm	CEX	Hi-Speed/ME-2A	
5.3 Lunar Seismic Profiling	HEDC	60 mm	CEX	Hi-Speed/ME-2A	
5.4 Lunar Atmospheric Composition	HEDC	60 mm	CEX	Hi-Speed/ME-2A	
5.5 Lunar Ejecta and Meteorites	HEDC	60 mm	CEX	Hi-Speed/ME-2A	

Objective, Experiment or Demonstration	Type Camera*	Lens	Type Film**	Development Process
5.6 Lunar Geology Investigation	HEDC	60 mm	BW(3401)	Fultron/MX-819
	HEDC	60 mm	CEX	Hi-Speed/ME-2A
	HEDC	500 mm	BW(3401)	Fultron/MX-819 C
5.7 Surface Electrical Properties	HEDC	60 mm	CEX	Hi-Speed/ME-2A
5.8 Traverse Gravimeter	HEDC	60 mm	CEX	Hi-Speed/ME-2A
5.9 Lunar Sounder	Mapping	3 inch	BW(3400)	Fultron/MX-819
	Panoramic	24 inch	LBW	Fultron/MX-819
	OR	Fixed	SO-394	Hi-Speed/D-19
5.10 S-Band Transponder (CSM/LM)	None	--	--	--
5.11 Far UV Spectrometer	Mapping	3 inch	BW(3400)	Fultron/MX-819
	Panoramic	24 inch	LBW	Fultron/MX-819
5.12 IR Scanning Radiometer	Mapping	3 inch	BW(3400)	Fultron/MX-819
	Panoramic	24 inch	LBW	Fultron/MX-819
5.13 Lunar Neutron Probe	HEDC	60 mm	CEX	Hi-Speed/ME-2A
5.14 Cosmic Ray Detector (Sheets)	HEDC	60 mm	CEX	Hi-Speed/ME-2A
6.2.1 Heat Flow and Convection	DAC	10 mm	CIN	RAM/ME-4

*Camera Nomenclature:

DAC - 16 mm data acquisition camera
HEC - 70 mm Hasselblad electric camera
HEDC - Hasselblad electric data camera (with reseau)
35 - 35 mm camera
OR - Optical recorder for Lunar Sounder

**Film Nomenclature:

BW - Black and white (3400, 3401)
CEX - Color exterior (SO-368)
LBW - Low speed, high definition black and white (3414)
VHBW - Very high speed black and white (2485)
CIN - Color interior (SO-168) (ASA 500)
SO-394 - Black and white, blue sensitive

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 objectives were successfully accomplished.

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

a) Flight Plan
b) CSM Experiment/EVA Checklist
c) Lunar Graphics

The passive objective to be accomplished is as follows:

- Long Term Lunar Surface Exposure

A Long Term Lunar Surface Exposure objective will be conducted to compare the long term effects of the lunar surface environment on selected manufactured materials with the long term effects of storage on the earth on similar materials. Selected reflective surfaces of Apollo flight hardware which will be left on the lunar surface during Apollo Mission J-3 will be photographically documented with approximately 80 microns resolution prior to the mission. These photographic records of the flight hardware, along with selected materials, will be stored in the Curator's Office, NASA/MSC. Some of the materials will be similar to those used in constructing the flight hardware. Others will be included as reference materials for possible future chemical analyses. These stored data will be compared with the photographically documented flight hardware if it is retrieved from the lunar surface and returned to earth during a subsequent space mission. C

4.1 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.

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.

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

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

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, when feasible, liquid dumps (urine and waste water) and fuel cell purges should be prohibited for 3 hours prior to and during equipment operation, and RCS jets A2, A4, B1, and B4 should be disabled during equipment operation. All CSM maneuvers performed after jettison 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. B B

FTO 1)
FTO 2) The fields-of-view of both cameras will be unobstructed during operation. 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 $\pm$2.5 degrees about all axes for the 24-Inch Panoramic Camera and $\pm$2.0 degrees about all axes for the 3-Inch Mapping Camera. CSM attitude deadbands will be $\pm$0.5 degrees with $\leq$ 0.05 degrees per second drift while the cameras are in operation on the lunar light side. Postmission pointing knowledge requirements

are $\pm$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. 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(VI), 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.

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 photographic sequence will be scheduled as early as is practical in lunar orbit. The last sequence will finish at the western terminator of the last available orbit. To the extent possible within film limitations, the Panoramic Camera Sequences will provide contiguous 70-degree rectified coverage of the combined sunlit area overflown by the CSM on Apollo 15, Apollo 16 and Apollo Mission J-3. The maximum Panoramic Camera sequence duration during a single light side pass will be no more than approximately 30 minutes. B

The V/h override control of the Panoramic Camera will be operated in accordance with MCC instructions.

FTO 2) The 3-Inch Mapping Camera will be operated in accordance with the requirements of Table 2. To the extent possible, the 3-Inch Mapping Camera sequences will provide at least 55 percent sidelap between consecutive bands of photographic coverage. Concurrent operation of the Laser Altimeter is required, except for oblique Mapping Camera passes and post-TEI Mapping Camera operation. 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 Mapping Camera image motion compensation may be changed in B
real time following evaluation of telemetry data at the MCC.

FTO 3) The Laser Altimeter will be operated as specified in Table 3. The Laser Altimeter will operate whenever the Mapping Camera is operating, except for Mapping Camera oblique passes and post-TEI operation. For Laser Altimeter operation, the SIM bay will be nadir-aligned, with the CSM +X or -X axis aligned to the velocity vector. In-flight pointing accuracy requirements are $\pm$2.0 degrees about all axes. For periods of operating the Laser Altimeter simultaneously with the Mapping Camera on the lunar dark side, it is highly desirable that CSM attitude deadbands be $\pm$0.5 degrees with $\leq$0.05 degrees per second drift. For highly desirable periods of Laser Altimeter operation, the pointing requirement is $\pm$6.5 degrees; CSM attitude deadbands will be $\pm$5.0 degrees with $\leq$0.5 degrees per second drift. Pointing knowledge must be recoverable postmission to within $\pm$2.0 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) 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): (M)

Premission sensitometry of the flight films in accordance with the standard procedures of the Photographic Technology Division.

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.

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	N/A		M(A)	HD
SL 1032 T	Pan Camera Film Mag Temp	PCM	N/A		HD	HD
SL 1038 H	Pan Camera Exposure Command	PCM	N/A		M	HD
SL 1039 T	Pan Camera Lens Barrel Temp	PCM	N/A		HD	HD
SL 1040 T	Pan Camera Fwd Lens Temp	PCM	N/A		HD	HD
SL 1041 T	Pan Camera Aft Lens Temp	PCM	N/A		HD	HD
SL 1042 T	Pan Camera Mech Temp	PCM	N/A		HD	HD
SL 1044 H	Pan Camera Slit Width	PCM	N/A		M(A)	HD
SL 1045 X	Pan Camera GO/NO GO	PCME	N/A		N/A	HD
SL 1094 T	Laser Altimeter Cavity Temp	PCM	N/A		HD	HD
SL 1122 K	Laser Altimeter Output 24 Bit Ser	PCMD	N/A		M(D)	M ** B
SL 1160 T	Temp Metric Lens Front Element	PCM	N/A		HD	HD
SL 1161 T	Temp Metric Lens Barrel	PCM	N/A		HD	HD
SL 1162 T	Temp Stellar Lens Front Element	PCM	N/A		HD	HD
SL 1163 T	Temp Stellar Lens Barrel	PCM	N/A		HD	HD
SL 1164 T	Temp MC Supply Cassette	PCM	N/A		HD	HD
SL 1165 X	MC Image Motion Off/On Cmds	PCME	N/A		HD	HD
SL 1166 R	Metric Shutter Disc Speed	PCM	N/A		M	HD
SL 1172 X	Map Camera GO/NO GO	PCME	N/A		N/A	HD

Measurement Number	Description	TM	Mode	Priority PD*	ESD	EED
SL 1173 X	Film Motion/Metric Exposure	PCME	N/A		HD	HD
SL 1176 Q	Metric Film Remaining	PCM	N/A		HD	HD
SL 1177 X	MC Cycle Rate/Metric Shtr Ctr Exp	PCME	N/A		HD	HD
SL 1181 V	Map Camera V/H Increase Level	PCM	N/A		M	HD

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

**If telemetry data cannot be recorded on the lunar backside, the Laser Altimeter should be operated since the altitude word is automatically recorded on the Mapping Camera film. B

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.

e) Photographs: (M)

Five sets of Panoramic and Mapping Camera photographs.

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)

g) Supporting Data: (HD)

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

(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 tape listed under 3)b).

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

4.1 SM ORBITAL PHOTOGRAPHIC TASKS

Background and Justification

24-Inch Panoramic Camera [FTO 1)]:

High resolution panoramic photographs were obtained of lighted areas overflown during Apollo 15 and Apollo 16. The combined area photographed during the two missions was approximately 15 percent of the lunar surface. Apollo 15 panoramics coverage included photographs of the following high priority targets: the Hadley Rille landing site, the highlands between Mare Crisium and Mare Serenitatis, the LM ascent stage impact area (pre- and post-impact), and general coverage near the terminator, at the sub-solar point, and under intermediate lighting conditions. In addition to multiple coverage of the Descartes landing site, Apollo 16 panoramic photographs included prime target areas at King Crater and the Fra Mauro region.

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

Three-Inch Mapping Camera photographs and simultaneous stellar photographs were obtained on Apollo 15 and Apollo 16. In each case all sunlit areas overflown by the spacecraft were photographed. In addition to cartographic quality vertical photography, the mapping camera was used during Apollo 15 and Apollo 16 to obtain oblique photographs of large areas north and south of the lunar surface groundtracks.

Laser Altimeter [FTO 3)]:

Approximately 30 percent of the planned Apollo 15 Laser Altimeter data were obtained before hardware failure. These data indicate that, in general, the lunar frontside is 2-5 kilometers lower than the mean radius and the backside is 2-5 kilometers higher than the mean radius. During Apollo 16, the laser altimeter was operated on each vertical mapping camera pass, and provided approximately 70 percent of the planned data.

Miscellaneous

Photographs and altitude data to be obtained in support of this detailed objective will supplement the photographs and altitude data obtained on Apollo 15 and 16. Panoramic camera operation will be planned to accomplish the following:

(1) Extend high resolution coverage in the east-west direction beyond the coverage obtained on previous missions. A

(2) Fill gaps in the rectified panoramic coverage of Apollo 15 and Apollo 16.

(3) Provide multiple high resolution coverage of the Taurus-Littrow landing site.

The data obtained in support of this detailed objective will also be provided for data analysis tasks, identified by Reference 8 as the following A lunar orbital photographic experiments: S-213 Selenocentric Reference System; S-214 Lunar Altitude Profile; S-215 Lunar Altimeter: Radii/Gravity; S-216 Laser Altimeter Selenodesy; S-217 IR/Radar Study; S-218 Photo/Altimetry Analyses; S-219 Gravity/Crustal Structure; S-220 Lunar Geology, Eastern Maria; S-221 Structure of Shallow Maria; S-222 Photogeology; S-223 Volcanology and Morphology; S-224 Surface Structure and Processes; and S-225 Morphology of Crater Chains.

Previous Flight Objectives

Objective Number	Title	Mission	
4.5	SM Orbital Photographic Tasks	15	
4.1	SM Orbital Photographic Tasks	16	A

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

Revolution Number	Start Longitude (Degrees)	Stop Longitude (Degrees)	
1/2	152 W**	144 E	C
2	123 E	95 E	
13/14	172 W	100 E	
15	102 E	14 E****	
28	155 E	85 E	
49	80 E	26 E	C
62	133 E	90 E	
62	33 E	27 E***	C
74	67 E	25 E	
74	5 W	45 W	C
Post-TEI	(Provide coverage of visible lunar disc using any remaining film)***		

*Revolutions 1 and 2 are 60 x 170 NM orbits; all other revolutions indicated in the table are approximately 60 NM circular orbits.

**Eastern terminator.

***These sequences will be done in the monoscopic mode. All other sequences will be done in the stereoscopic mode.

****Western terminator.

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

Revolution Number	Start Longitude (Degrees)	Stop Longitude (Degrees)	Comments	
1/2	144 W	26 E	Light side pass	
13/14	162 W	7 E	Light side pass	C
14/15	164 W	63 W	1-1/2 revolutions*	
23/24	168 W	2 W	Light side pass	
26/27	168 W	4 E	40 degrees North oblique - Light side pass	C
27/29	4 E	6 W	2 revolutions*	
35/36	147 W	14 W	40 degrees South oblique - Light side pass	C
38	162 E	177 E	1 revolution*	C
49	167 E	28 W	Light side pass	
62/63	163 E	150 E	1 revolution	C
65	152 E	77 E	40 degrees North oblique - 1/3 light side pass	
	77 E	62 E	Maneuver from North oblique to South oblique	C
	62 E	47 W	40 degrees South oblique - 1/2 light side pass plus 1/2 dark side pass	C
66/67	47 W	41 W	1 revolution	C
73/74	161 W	52 W	Approximately 60 degrees dark side coverage plus 1 light side pass	
Post TEI**			Coverage of visible lunar disc	

*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.

**The Mapping Camera is to be operated as soon as practicable following TEI using the remainder of the film.

Table 3. Requirements for Operation of the Laser Altimeter

Laser Altimeter ON*		Laser Altimeter OFF		
Revolution Number	Longitude (Degrees)	Revolution Number	Longitude (Degrees)	
1	144 W	2	26 E	
13	162 W	14	7 E	C
14	164 W	15	63 W	
23	168 W	24	2 W	
27	4 E	29	6 W	
38	162 E	38	177 E	C
49	167 E	49	28 W	
62	163 E	63	150 E	C
66	47 W	66	41 W	
73	161 W	74	52 W	

*The Laser Altimeter will operate whenever the Mapping Camera is operating, except for oblique Mapping Camera Passes and post-TEI operation.

4.2 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 such that adequate protection of the crew may be provided, if required, in future long-duration manned space flight.

The functional test objectives are as follows:

FTO 1) Obtain data during translunar* coast on the frequency and description of light flashes and on cosmic radiation to facilitate correlation between light flash events and incident primary cosmic rays.

FTO 2) Obtain data during transearth* coast relative to the frequency and description of light flashes and the effect of dark-adaptation on the flashes.

Test Conditions

FTO 1) During translunar coast, one crewman will don the Apollo Light Flash Moving Emulsion Detector (ALFMED). It is highly desirable that two photographs be obtained after the crewman dons the ALFMED. One photograph will be obtained of the side view of the ALFMED on the crewman and the other photograph will be obtained of the bottom view of the ALFMED on the crewman. One crewman will then simultaneously don an eye shield. All three crewmen will then commence a 60-minute test period. It is highly desirable that this test period be scheduled any time during 48 to 72 hours GET after launch. During this test period, each of the two observing crewmen will report the following by voice communications to MCC and one crewman will enter the other two crewmen's comments on written records as backup to the tape recorder data. D

- Deleted
- Deleted
- Deleted

- When ALFMED is turned ON.
- The occurrence of each light flash by saying "Mark", by identifying the observer (e.g., "CMP" or name) and by describing the observed light flash [e.g., star; streak or diffuse flash; which eye; location of event in the eye; color (if other than white); and intensity].
- When ALFMED is turned OFF.
- Deleted
- Deleted D

Highest priority will be given to reporting the occurrence of a light flash. Unfinished descriptions of an event will be terminated when a new light flash is reported, followed by a description of the new event.

At the completion of the 60-minute test period, the crewman will doff his eye shield. One photograph will then be obtained of the side view of the ALFMED on the remaining crewman. It is highly desirable that a photograph also be obtained of the bottom view of the ALFMED on the crewman. All photographs will be obtained with the 35 mm camera using CIN film and a 55 mm lens. The ALFMED will then be removed and stowed for return to earth. D D D

FTO 1) FTO 2) It is highly desirable that the HZE (high Z energy) radiation dosimeter be recovered from the spacecraft to facilitate evaluation of the light flash data.

FTO 2) During transearth coast, two crewmen will simultaneously don eye shields for a period of 60 minutes. The ALFMED will not be worn during this test period. It is highly desirable that this test period be scheduled any time during 24 to 48 hours prior to splashdown. Each crewman will report the following data by voice communications to MCC. One crewman will enter the other two crewmen's comments on written records as backup to the tape recorder data. D

D

- Deleted
- When eye shields are donned and test period begins.
- The occurrence of each light flash by saying "Mark," by identifying the observer (e.g., "CMP" or name) and by

describing the observed light flash [e.g., star; streak or diffuse flash; which eye; location of event in the eye; color (if other than white); and intensity].

- When observations for light flashes are terminated.

- Deleted D

Highest priority will be given to reporting the occurrence of a light flash. Unfinished descriptions of an event will be terminated when a new light flash is reported, followed by a description of the new event.

Success Criteria

FTO 1) The crew comments and photograph of the ALFMED as specified under the Test Conditions for one translunar test period shall be obtained including a copy of the written records from the CSM EXP/EVA Checklist. D

The ALFMED shall be used as specifed under Test Conditions for the translunar coast test period and shall be returned intact for processing and evaluation.

FTO 2) The crew comments as specified under the Test Conditions for the transearth coast test period shall be obtained including a copy of the written records from the CSM EXP/EVA Checklist. D

Evaluation

FTO 1)
FTO 2) The frequency and description of flashes will be determined as a function of crewman's location within the spacecraft, direction head is facing, location of spacecraft with respect to sun, earth, and moon; differences between crewmen; the ALFMED and HZE radiation data. The emulsion plates will be removed from the ALFMED and processed. The fixed emulsion plates will be area-scanned and all events of $Z \geq 6$ will be recorded on computer tape. The moving plates will then be scanned using the previous data plus computer predictions of event locations to aid in the detection of events that occurred during the test period. These events will be accurately measured to reveal the exact trajectory of the cosmic ray particles with respect to the eyeball, the charge, and the energy of the particles. These data will then be correlated with the frequency and description of light flashes reported during the test period. (MSFN tape recording of astronaut comments, astronaut debriefing data, photographs, ALFMED, and HZE radiation dosimeter).

Data Requirements

1) Astronaut Voice Records in Real Time: (M)

   Comments defined under the Test Conditions for one test period during translunar coast and one test period during transearth coast.

2) One copy of the Technical Air-to-Ground Voice Transcription, one copy of MSFN tape recording and one copy of written records of astronaut comments (from the CSM EXP/EVA Checklist) during the above defined test periods. (M) D

3) Astronaut Debriefings: (M)

   One copy of astronaut postmission debriefing transcripts pertaining to comments on each of the test periods.

4) ALFMED: (M)

5) HZE Radiation Dosimeter: (HD)

6) Photographs:

   (a) One photograph showing a side view of the ALFMED on the crewman immediately before commencing the test period defined in FTO 1). (HD)

   (b) One photograph showing the bottom view of the ALFMED on the crewman immediately before commencing the test period defined in FTO 1). (HD) D

   (c) One photograph showing a side view of the ALFMED on the crewman at the conclusion of the test period defined in FTO 1). (M)

   (d) One photograph showing the bottom view of the ALFMED on the crewman at the conclusion of the test period defined in FTO 1). (HD) D

*If it becomes necessary to accomplish the Test Conditions for FTO 1) during transearth coast (rather than during translunar coast), then the intent of FTO 1) will be satisfied but the data may be degreded. In this case, however, the Test Conditions for FTO 2) will be accomplished during translunar coast such that the data from the two FTO's can still be used to correlate the unexplained (that is, decrease) in frequency of light flash events reported during transearth coast on Apollo 15 and Apollo 16.

4.2 VISUAL LIGHT FLASH PHENOMENON

Background and Justification

The crews of Apollo 11 and subsequent missions 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 coast and in lunar orbit. The average frequency of occurrence has been one light flash event every one to two minutes. A A

One hypothesis 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 cerebral 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 cerebral cortex may cause damage. There may be reason for more concern if the light flashes are due to ionizing collisions in the visual apparatus rather than Cerenkov radiation. The biological interactions of HZE ionizing radiation are not well understood. Therefore, data should be obtained during the remaining Apollo mission to permit a better understanding of this phenomenon. A A

Experiments have been conducted at the Lawrence Radiation Laboratory of the University of California at Berkeley which have demonstrated that neutrons, protons and multicharged particles 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 A particles could not have been produced by means of interactions between the incident neutrons and atomic nuclei in the eye. Other mechanisms must therefore be considered as candidate explanations of the phenomenon observed in space.

The observations made during previous missions will be supplemented by more specific test condtiions during Apollo Mission J-3. The intent is to obtain the maximum possible data within the constraints of the timeline and the available test equipment (i.e., eye shields, the ALFMED, and the HZE radiation dosimeter).

The first test [FTO 1)] is intended to determine the frequency and description of the light flashes and the effect 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 cerebral cortex, a dark visual field may be all that is necessary. During the test period, one crewman will don an eye shield (to prevent light from entering his eyes) and report how soon he begins seeing flashes. A minimum of about 60 minutes will be required for the observations in order to allow for dark-adaptation and the collection of adequate statistics concerning the frequency and description of flashes. D

To provide a direct physical measurement of these events, the Apollo Light Flash Moving Emulsion Detector (ALFMED) will be worn by one crew member during the translunar coast test period. The ALFMED consists of two sets of adjacent emulsion plates that surround the head. One set of emulsion plates will be maintained in a fixed position relative to the head of the observer and the second set of emulsion plates will be automatically translated at a constant speed relative to the fixed emulsion plates during the test period. This device will provide accurate time of occurrence measurements, charge and energy measurements, and trajectory of the HZE particles through the emulsion plates and head of the observer. These data, along with verbal reports of the observer, will permit direct correlation of the HZE particles and light flashes. Then, for example, if all diffuse light flashes observed are correlated only with very high energy, High Z particles, this will support the hypothesis that Cerenkov radiation is responsible for the events. However, if there is no correlation between the types of events and characteristics of the incident HZE particles, this finding will support the hypothesis that the light flashes are the result of direct ionization by the HZE particles.

The second test [FTO 2)] concerning observations during transearth coast is required to investigate and correlate the unexplained change (decrease) in frequency of light flash events reported during the transearth coast periods on Apollo 15 and Apollo 16 as compared to the translunar coast periods for both missions. It will also permit direct comparison of frequency and types of events, especially regarding brightness, between all crewmen, and will permit comparison of light flash events during the translunar coast and transearth coast periods. A

The use of eye shields and ALFMED in translunar coast and the use of the eye shields in transearth coast will provide essential data to supplement that obtained during Apollo 15 and Apollo 16. A

Previous Flight Objectives

Objective Number	Title	Mission
4.12	Visual Light Flash Phenomenon	15
4.2	Visual Light Flash Phenomenon	16

A

4.3 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 translunar coast, and to obtain photographs of low brightness astronomical and terrestrial sources.

The functional test objectives are as follows:

FTO 1) Obtain photographs of solar corona after CSM sunset and prior to CSM sunrise.

FTO 2) Obtain photographs of zodiacal light while the CSM is in lunar umbra.

FTO 3) Deleted B

FTO 4) Deleted

FTO 5) Obtain photographs of specific segments of the lunar surface in low light levels near the terminator and in earthshine.

FTO 6) Obtain photographs of lunar surface areas of prime scientific interest.

Test Conditions

FTO 1)
FTO 2)
FTO 5) Type 2485 film will be used for these FTO's. 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, except for the 35 mm camera, prior to removal of a magazine. There will be no protective film advance for FTO 5). The protective film strip will consist of one frame for the HEC and for the 35 mm camera. 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 for FTO 1) only. B

FTO 1) Internal cabin lighting will be minimized. It is desirable that forward firing thrusters not be used if the required attitudes can be maintained without them. The HEC will be used with the 80 mm lens set at f/2.8 and infinity.

Two series of solar corona photographs will be be obtained by bracket-mounted cameras through a CM window, one series after CSM sunset and one series prior to CSM sunrise. Each series will consist of seven HEC photographs.

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Deleted.

For the sunrise series of photographs, the CSM attitude rate will approximate the lunar orbital rate (~3 deg/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 deadbands will be maintained within ±5.0 degrees. For the sunset series of photographs, attitude and rates will be as specified above, except that the -X axis will be pointing along the velocity vector. It is highly desirable that each astronaut in the CM visually observe and sketch the solar corona, looking specifically for streamers, near the time each series of photographs is taken. The astronauts will record the GMT of each observation which is sketched. Exposure periods and shutter speeds for the HEC are as follows:

Time From CSM Sunset (Sec)	Time Prior to CSM Sunrise (Sec)	Shutter Speed (Sec)
10	-10	1/60
20	-20	1/30
30	-30	1/8
40	-40	1/2
50	-50	1
60	-60	4
75	-75	10

FTO 2) Internal spacecraft lighting will be minimized by means of a camera hood or a dark cabin with window shades. If feasible, forward firing thrusters should not be actuated while the camera shutter is open. 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. The aperture will be set to f/1.2 and the focus will be set to infinity.

Photographs of zodiacal light will be obtained as the CSM approaches sunrise, using the 35 mm camera bracket mounted. During each of two lunar orbit nightside passes, a series of 11 photographs of zodiacal light will be obtained while the CSM is in lunar orbital rate (∿3 deg/min). During one of these two nightside passes, the camera will be used with a red color filter. During the other nightside pass, the camera will be used with a blue color filter. During a third nightside pass, a series of 22 photographs of zodiacal light will be obtained while the CSM is in lunar orbital rate. The camera will be used with a polarization filter. The +X axis will be aligned 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 degrees. Times for initiation of each exposure set and their durations are as follows: B B

Time Prior to CSM Sunrise (Min:Sec)	Exposure Duration (Sec)* Color Filters	Polarization Filter
-14:00	90	90
-10:00	60	60
- 7:00	60	30
- 5:00	40	20
- 3:30	20	10
- 2:00	10	5
- 1:30	6	3
- 1:10	2	1
- 0:50	1/2	1/4
- 0:30	1/8	1/15
- 0:10	1/30	1/60

B

*For each series using a color filter, only one photograph will be taken at each time prior to CSM sunrise. For the series using a polarization filter, one photograph each will be taken at the 0-degree and 90-degree positions of the polarization filter.

FTO 3) Deleted

FTO 4) Deleted

FTO 5) Near-terminator photographs will be obtained using the HEC with the 80 mm and 250 mm lenses. B

The photographic sequences, the number of frames per sequence and the exposure settings will be as indicated in Table 1.

Earthshine photographs will be obtained using the 35 mm camera. The camera will be braced against a fixed object and operated to obtain photographs at approximately 30-second intervals. A total of at least 22 photographs will be obtained in two sequences during the same revolution. During the first sequence from 15 degrees West longitude to 40 degrees West longitude, the camera will be pointed south of the groundtrack; during the second sequence from 47 degrees West longitude to C
78 degrees West longitude, the camera will be pointed north of the groundtrack. The 35 mm camera shutter will be set to 1/8 and the aperture set to f/1.2.

C

It is highly desirable that CM cabin lighting be reduced during earthshine photography.

FTO 6) Medium resolution color photographs of particular areas of the lunar surface will be obtained using the HEC (hand-held) with the 80 mm and 250 mm lenses and SO-368 film. 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.

The photographic sequences, the number of frames per sequence and the exposure settings will be as indicated in Table 1.

Success Criteria

FTO 1)
FTO 2)
FTO 5)
FTO 6)
Mandatory data defined under Data Requirements shall be acquired and returned to earth for evaluation.

Evaluation

FTO 1) FTO 2) FTO 5) FTO 6) The photographic and supporting data will be evaluated for general scientific interest. (Premission and experiment evaluation data as defined under Data Requirements) B

Data Requirements

1) Premission Data (PD): (M)

Premission sensitometry of the flight film, including special low-light-level calibration exposures of the 2485 film to be used in FTO's 1), 2), and 5), in accordance with the standard procedures of the Photographic Technology Division. B

2) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

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

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.

c) Astronaut Logs or Voice Records: (HD)

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

(2) One copy of all sketches of solar corona. B

d) Photographs:

(1) All photographs as defined under the Test Conditions for FTO's 1), 2), and 6). (M)

(2) HEC photographs of terminator crossings and twenty-two 35 mm photographs of the lunar surface in earth-shine, as defined under the Test Conditions for FTO 5). (M) B

(3) Deleted B

e) Trajectory: (HD)

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

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

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

4.3 CM PHOTOGRAPHIC TASKS

Background and Justification

Solar corona photographs were first provided from lunar orbit by Apollo 15. Additional photographs of the sun's corona were obtained on Apollo 16. The dynamic nature of the coronal streamers makes it advantageous to obtain redundant coverage. Photographs to be obtained in support of FTO 1) will constitute a third set of observations, providing information on the time variation of the sun's corona.

Apollo 15 provided excellent quality photographs of zodiacal light (taken in the ecliptic plane). On Apollo 16 photographs of zodiacal light were taken in the ecliptic plane both with and without a polarization filter to furnish additional data on the size and composition of the reflecting bodies. Photographs to be obtained in support of FTO 2) will supplement those obtained on Apollo 14, 15, and 16. In particular, photographs will be taken of points out of the ecliptic plane. These photographs will provide information on the distribution of reflecting bodies in a direction normal to the ecliptic. Polarization information will again be obtained from photographs taken in the ecliptic plane.

Deleted

B

FTO 5) will provide photographs of selected lunar surface areas in earthshine and in low light levels near the terminator. Apollo 15 provided the first photographs of the lunar surface in earthshine taken from lunar orbit. The most significant of these photographs are two of the crater Aristarchus and one each of Schroter's Valley and the crater Herodotus. Preliminary analysis indicates that the Aristarchus crater photographs exhibit an anomalously high "apparent albedo". Preliminary analysis of the earthshine photographs of the Aristarchus region provides new data relating to the evolution and modification of impact craters, to circular structures associated with sinuous rilles, and to the history of the plateau in general. Apollo 15 also provided ten sequences of photographs showing lunar surface areas within a few degrees of the terminator. Preliminary scientific results apply to Mare Vaporum (showing maria structure in detail), Aristarchus plateau and the Oceanus Procellarum area west of the Aristarchus Plateau, and highland areas. Many geological features stand out in a manner not normal in lunar photographs taken at high-sun elevation angles, providing additional data on the surface morphology and configuration of a large number of lunar surface structures. Similar photographs were obtained during Apollo Mission 16.

Photographs of lunar surface science targets [FTO 6)] will supplement those obtained on Apollo 15 and Apollo 16. Photographs of all but two planned lunar surface science targets were obtained on Apollo 15. These photographs were of value for general geological interpretation, and also aided the extrapolation of ground truth data to other areas of the moon. Eighteen of the planned 26 lunar surface science targets were obtained on Apollo 16.

In addition, the lunar surface photographs to be obtained in accordance with FTO 5) and FTO 6) 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 photographic coverage during periods when the SIM cameras are not operating (e.g., during portions of the 60 x 9 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.

The photographs obtained in support of this detailed objective will be provided for data analysis tasks, identified by Reference 8 as the following lunar orbital photographic experiments: S-210 Solar Corona Investigation; S-211 Low Brightness Image Analysis; S-212 Corona Photo Analysis; and S-222 Photogeology. A

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
4.6	CM Photographic Tasks	15
4.3	CM Photographic Tasks	16 A

Table 1. Targets for Terminator [FTO 5)] and Scientific Interest Photography [FTO 6)]

Revolution Number	Number of Frames and Time Interval in Seconds*	Start	Stop	Description	Lens
1	12	33 E	28 E	Landing Site-Nearside Terminator	80
1/2	58 @ 20	153 W	146 E	Galois-Orbital Science	80
16	73 @ 7.5	177 E	144 E	Aitken-Orbital Science	250
17	46 @ 20	168 W	144 E	Sniadecki-Orbital Science	80
17	12	3 E	3 W	North of Groundtrack-Nearside Terminator	80
25	24 @ 7.5	33 E	23 E	Landing Site-Orbital Science	250
28	36 @ 20	62 E	25 E	Picard-Orbital Science	80
29	21 @ 20	128 E	109 E	Arabia-Orbital Science	80
29	88 @ 7.5	62 E	25 E	Pierce-Orbital Science	250
29	24	9 E	0	South of Groundtrack-Nearside Terminator	250
36	34 @ 7.5	170 E	155 E	Mare Ingenii-Orbital Science (40 Degrees South Oblique)	250
37	12	173 E	163 E	Aitken-Farside Terminator	250
39	19 @ 20	10 E	10 W	D-Caldera-Orbital Science	80
62	18	148 E	138 E	North Gagarin-Farside Terminator	80
62	24	23 W	33 W	North of Groundtrack-Nearside Terminator	250
65	28 @ 20	4 W	34 W	Imbrium (South)-Orbital Science (40 Degrees South Oblique)	80
66	24	27 W	37 W	South of Groundtrack-Nearside Terminator	250
74	18	35 W	45 W	South of Groundtrack-Nearside Terminator	250

*Where specific time intervals are not specified, this indicates that the intervalometer is not to be used.

C

4.4 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 objective is as follows:

FTO 1) Obtain astronaut comments on observations of particular lunar features and processes.

Test Conditions

FTO 1) 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.

Success Criteria

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

Evaluation

FTO 1) 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 geological interpretation and general scientific interest. (Astronaut records and debriefings)

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.

c) Trajectory: (M)

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

Visual targets were observed by the CMP on Apollo 15. The geologically significant observations included the following:

(a) Fields of cinder cones made by volcanic eruptions in the Taurus Mountains near the crater Littrow.

(b) Delineation of a landslide or rock glacier on the rim of crater Tsiolkovsky.

(c) Interpretation of the ray-excluded zone around crater Proclus as being the result of a fault system at the crater's west rim.

(d) Layers on interior walls of craters Picard and Pierce which were interpreted as volcanic collapse craters.

Visual targets were also observed on Apollo 16. The geologically significant observations included the following:

(a) Furrowed terra at the Smoky Mountains (north of the landing site) is similar to the furrowed terra at Stone Mountain (south of the landing site). A

(b) North Ray Crater appears to consist of the same material as Smoky Mountain (rather than being part of the Cayley formation).

Visual observations made in support of this detailed objective will supplement those made on Apollo 15 and 16. A

Previous Flight Objectives

Objective Number	Title	Mission
4.11	Visual Observations from Lunar Orbit	15
4.4	Visual Observations from Lunar Orbit	16

A

Table 1. Targets for Visual Observations

Revolution Number	Description	Start Longitude (Degrees)	Stop Longitude (Degrees)
1	Copernicus (Earthshine)	15 W	22 W
15	Landing Site	33 E	27 E
27	Aitken	177 E	165 E
	Arabia (North)	133 E	109 E
	Crisium - Serenitatis	62 E	27 E
28	Copernicus (Earthshine)	15 W	22 W
	Reiner γ (Earthshine)	65 W	80 W
40	Landing Site	33 E	28 E
	D - Caldera	7 E	4 E
62	Mare Smythii	90 E	80 E
	Landing Site	33 E	28 E
64	Tsiolkovsky	135 E	120 E

C

4.5 SKYLAB CONTAMINATION STUDY

Obtain data on Apollo spacecraft induced contamination.

Purpose

The purpose is to obtain data on spacecraft induced contamination as measured with the Far UV Spectrometer and IR Scanning Radiometer.

The functional test objectives are as follows:

FTO 1) Obtain data on the UV spectrometer optics degradation as a result of contaminant deposition with time.

FTO 2) Obtain UV spectrometer data on spectral scattering and contamination cloud intensity as a function of sun angle.

FTO 3) Obtain contamination data by using the IR Scanning Radiometer and UV spectrometer to monitor the contamination cloud produced by RCS thruster firings and waste water/urine dumps.

Test Conditions

FTO 1)
FTO 2)
FTO 3) During TEC the Far UV Spectrometer will be operated to obtain data on optics degradation. The data obtained in support of Mode V and Mode VI operation of the Far UV Spectrometer Experiment (S-169) will provide the necessary UV Spectrometer data in support of this Skylab Contamination Study detailed objective.

FTO 3) During TEC (preferably midway between the earth and moon) the IR Scanning Radiometer will be operated to monitor the contamination environment in the vicinity of the spacecraft and measure the additional contaminants produced during waste water/urine dumps. The IR Scanning Radiometer will be turned ON at least 10 minutes prior to a waste water/ urine dump. It will remain ON for a minimum of one hour and a maximum of three hours after the dump for this objective. During the MCC-7 burn the IR Scanning Radiometer will be operated to monitor the contamination environment created by RCS thruster activity. The IR Scanning Radiometer can be turned off approximately 10 minutes following the MCC-7 burn. D

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) The spectral output of the spectrophotometer will be examined each time a scan is made over the calibration source. Changes in response of the instrument that can be attributed to contamination of the optics will be noted. This will set an upper limit on the contamination effects on optics exposed to the induced environment associated with spacecraft. Such effects, if observed, will be correlated with events such as waste water/urine dumps and RCS thruster firings. (BET, spacecraft attitude data, CF 0009 Q, CH 3546 X through CH 3560 X and reduced data from SL 1100 K)

FTO 2) FTO 3) The spectral scattering from the contamination cloud will be obtained as a function of sun angle. This can be interpreted in terms of the number density and size distribution of the contamination cloud surrounding the spacecraft. By performing similar analyses on cloud created by thruster firings and waste water/urine dumps, the impact of such events and their clearing time can be assessed. (BET, spacecraft attitude data, CF 0009 Q, CH 3546 X through CH 3560 X, and reduced data from SL 1100 K, SL 1126 K, SL 1127 K and SL 1128 K)

Data Requirements

1) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority
CF 0009 Q	Quantity Waste Water Tank	PCM+	2	M
CH 3546 X	RCS Solenoid Activate C3/13/+X	PCME	1	M
CH 3547 X	RCS Solenoid Activate A4/14/+X	PCME	1	M
CH 3548 X	RCS Solenoid Activate A3/23/-X	PCME	1	M
CH 3549 X	RCS Solenoid Activate C4/24/-X	PCME	1	M
CH 3550 X	RCS Solenoid Activate D3/25/+X	PCME	1	M
CH 3551 X	RCS Solenoid Activate B4/26/+X	PCME	1	M
CH 3552 X	RCS Solenoid Activate B3/15/-X	PCME	1	M
CH 3553 X	RCS Solenoid Activate D4/16/-X	PCME	1	M
CH 3554 X	RCS Solenoid Activate B1/11/+Z	PCME	1	M
CH 3555 X	RCS Solenoid Activate D2/22/+Z	PCME	1	M
CH 3556 X	RCS Solenoid Activate D1/21/-Z	PCME	1	M
CH 3557 X	RCS Solenoid Activate B2/12/-Z	PCME	1	M
CH 3558 X	RCS Solenoid Activate A1/+Y	PCME	1	M
CH 3559 X	RCS Solenoid Activate C2/+Y	PCME	1	M
CH 3560 X	RCS Solenoid Activate A2/-Y	PCME	1	M
SL 1100 K	UVS Spectrum Count-16 Bit Ser	PCMD	1	M*
SL 1126 K	IRS Data Channel No 1	PCM	1	M*

4.5 SKYLAB CONTAMINATION STUDY

Obtain data on Apollo spacecraft induced contamination.

Purpose

The purpose is to obtain data on spacecraft induced contamination as measured with the Far UV Spectrometer and IR Scanning Radiometer.

The functional test objectives are as follows:

FTO 1) Obtain data on the UV spectrometer optics degradation as a result of contaminant deposition with time.

FTO 2) Obtain UV spectrometer data on spectral scattering and contamination cloud intensity as a function of sun angle.

FTO 3) Obtain contamination data by using the IR Scanning Radiometer and UV spectrometer to monitor the contamination cloud produced by RCS thruster firings and waste water/urine dumps.

Test Conditions

FTO 1)
FTO 2)
FTO 3) During TEC the Far UV Spectrometer will be operated to obtain data on optics degradation. The data obtained in support of Mode V and Mode VI operation of the Far UV Spectrometer Experiment (S-169) will provide the necessary UV Spectrometer data in support of this Skylab Contamination Study detailed objective.

FO 3) Approximately one revolution prior to the TEI burn the IR Scanning Radiometer will be operated to monitor the contamination environment created by RCS thruster activity and the SPS burn. The IR Scanning Radiometer can be turned off approximately 10 minutes following the burn. If the IR Scanning Radiometer survived the TEI environment, then approximately midway in TEC, the radiometer will be operated to monitor the contamination environment in the vicinity of the spacecraft and measure the additional contaminants produced during waste water/urine dumps and RCS thruster firings. The IR Scanning Radiometer will be turned ON at least 10 minutes prior to a waste water/urine dump. It will remain ON for a minimum of one hour and a maximum of three hours after the dump for this objective. C

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) The spectral output of the spectrophotometer will be examined each time a scan is made over the calibration source. Changes in response of the instrument that can be attributed to contamination of the optics will be noted. This will set an upper limit on the contamination effects on optics exposed to the induced environment associated with spacecraft. Such effects, if observed, will be correlated with events such as waste water/urine dumps and RCS thruster firings. (BET, spacecraft attitude data, CF 0009 Q, CH 3546 X through CH 3560 X and reduced data from SL 1100 K)

FTO 2) FTO 3) The spectral scattering from the contamination cloud will be obtained as a function of sun angle. This can be interpreted in terms of the number density and size distribution of the contamination cloud surrounding the spacecraft. By performing similar analyses on cloud created by thruster firings and waste water/urine dumps, the impact of such events and their clearing time can be assessed. (BET, spacecraft attitude data, CF 0009 Q, CH 3546 X through CH 3560 X, and reduced data from SL 1100 K, SL 1126 K, SL 1127 K and SL 1128 K)

Data Requirements

1) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority
CF 0009 Q	Quantity Waste Water Tank	PCM+	2	M
CH 3546 X	RCS Solenoid Activate C3/13/+X	PCME	1	M
CH 3547 X	RCS Solenoid Activate A4/14/+X	PCME	1	M
CH 3548 X	RCS Solenoid Activate A3/23/-X	PCME	1	M
CH 3549 X	RCS Solenoid Activate C4/24/-X	PCME	1	M
CH 3550 X	RCS Solenoid Activate D3/25/+X	PCME	1	M
CH 3551 X	RCS Solenoid Activate B4/26/+X	PCME	1	M
CH 3552 X	RCS Solenoid Activate B3/15/-X	PCME	1	M
CH 3553 X	RCS Solenoid Activate D4/16/-X	PCME	1	M
CH 3554 X	RCS Solenoid Activate B1/11/+Z	PCME	1	M
CH 3555 X	RCS Solenoid Activate D2/22/+Z	PCME	1	M
CH 3556 X	RCS Solenoid Activate D1/21/-Z	PCME	1	M
CH 3557 X	RCS Solenoid Activate B2/12/-Z	PCME	1	M
CH 3558 X	RCS Solenoid Activate A1/+Y	PCME	1	M
CH 3559 X	RCS Solenoid Activate C2/+Y	PCME	1	M
CH 3560 X	RCS Solenoid Activate A2/-Y	PCME	1	M
SL 1100 K	UVS Spectrum Count-16 Bit Ser	PCMD	1	M*
SL 1126 K	IRS Data Channel No 1	PCM	1	M*

Measurement Number	Description	TM	Mode	Priority
SL 1127 K	IRS Data Channel No 2	PCM	1	M*
SL 1128 K	IRS Data Channel No 3	PCM	1	M*

*Reduced data from these measurements during the TEC period in support of FTO 1), FTO 2) and FTO 3) of this detailed objective will not be provided by MSC but will be obtained through arrangements with the Far UV Spectrometer and IR Scanning Radiometer Principal Investigators.

2) Trajectory: (M) B

One copy of tab listing containing the best estimate of trajectory (BET) including spacecraft attitude, for the periods when the telemetry data were obtained in support of FTO 1), FTO 2) and FTO 3).

4.5 SKYLAB CONTAMINATION STUDY B

Background and Justification

Apollo 15 and 16 provided limited photographic data on contamination B

during transearth coast. In addition, data were obtained from the mass spectrometer experiment to further the understanding of the contamination cloud that surrounds the spacecraft.

The fact that spacecraft produce their own environment, which may interfere with their intended mission, was first regognized when "fireflies" were observed surrounding the first manned orbital Mercury capsule. Similar observations have been made on all subsequent manned spacecraft, particularly when liquids are dumped overboard forming ice crystals which act as scattering centers. The amount of light scattered from such particles is significant; for example, the forward scattering just from edge diffraction of sunlight on a 100 micron sphere at a distance of 13 kilometers is equivalent to a third magnitude star. A cloud of such particles will scatter sufficient light to prevent most astronomical experiments from being performed from spacecraft on the sunlit portion of the orbit.

Analyses, assuming some fraction of escaping cabin gases nucleate into ice crystals with sizes of the order of microns, indicate that the scattered light background associated with Gemini and Apollo will be several orders of magnitudes higher than the solar corona and the zodiacal light. These arguments have been disputed on the grounds that the maximum size particles that could be produced by such a nucleation process is on the order of 0.01 microns, which would produce negligible scattering. Laboratory tests to determine the size distribution of such particles have been inconclusive. The problem has been avoided on previous dim light photography experiments performed on Gemini and Apollo missions by photographing only when the spacecraft is in shadow. However, experiments using the ATM to observe the sun or the solar corona cannot avoid the problem in this manner. The future role of manned space flight in astronomical missions depends on whether or not space vehicles can be designed such that the optical environment does not interfere with the measurements.

Optical samples exposed to vacuum chamber indicate significant degradation, particularly in the far ultraviolet, unless careful material control and cleanliness precautions are exercised. It was found that surfaces exposed to a contaminating environment in the presence of ultraviolet radiation were permanently damaged, presumably because of much stronger chemical bond between the contaminant and substrate is formed when UV photons are available to supply the activation energy.

These findings have produced a major concern in the ATM/Skylab program. Strict material selection criteria have been incorporated to reduce the amount of outgassing. Elaborate cleaning and testing have been incorporated into preparation of vacuum chambers to be used in thermal vacuum tests. One major unknown is the cloud dynamics of material emanating from the spacecraft. If the molecules leaving the spacecraft continued along their trajectories with no external forces, the only contamination threats would be those in direct line of sight of the optics in question. However, collisions, adsorption, and re-emission from ice or dust particles, and electrostatic effects are mechanisms which may transport contaminating molecules from one part of the spacecraft to another. The Apollo 15 and 16 Mass Spectrometer detected large quantities of contamination throughout the use of the spectrometer. This contamination was collected either internally from the SIM bay or externally from a contamination cloud. B

The IR Scanning Radiometer to be flown on Apollo Mission J-3 can detect and measure ice crystals in the vicinity of the spacecraft, and therefore can be used as a contamination monitor. Detection can take place by looking toward deep space to minimize the background. On the dark side of the moon, the ice crystals can be detected from their own infrared radiation. Since their temperatures can be predicted, the total radiated power can be interpreted in terms of a combined size and spatial density distribution. When the crystals are illuminated by sunlight, they will be detected as a result of the scattered sunlight. Measured intensity, as a function of phase angle, will provide additional data to separate size and spatial distribution functions. Operation of the IR Scanning Radiometer during and after a controlled liquid and thruster firings will provide information on the interference produced by these events and on B the clearing time required after such events. B

Information on the contamination environment associated with manned spacecraft and its effects can be obtained as a by-product of the Apollo Mission J-3 Far UV Spectrometer experiment. The instrument operates in the region from 1175-1675 Å and can provide the following information: (1) The degradation of the optics by contamination; (2) The adsorption of the contamination cloud surrounding the spacecraft; (3) The scattering from particles in the cloud; and (4) The duration of a contamination cloud from a specific waste water/urine dump.

Deleted B

Absorption by a contamination cloud can be obtained by observation of absorption lines against a continuum source, such as the lunar surface. Fluctuations in this adsorption can be correlated to vehicle activity such as thruster firings and waste water/urine dumps.

Since any particles in the vicinity of the spacecraft will act as Mie scatterers, which scatter predominately in the forward direction, the presence of such particles will be identifiable by observing a strong increase in output as the angle between the instrument and the sun is decreased. Some information regarding particle size distribution and spatial density can be obtained from the measured intensity versus sun angle.

The fact that the presence of particles can be sensed allows the duration of particles created by wasted dumps to be measured. Photographs on Apollo 15 indicated that particles apparently emerge from the vents as much as 25 minutes after the dump is completed. UV photometer data during and after the dump will permit a determination of some of the characteristics of the source of the contaminants and its contribution to the contamination cloud.

Previous Flight Objectives

Objective Number	Title	Mission
4.5	Skylab Contamination Study	16

B

4.6 FOOD COMPATIBILITY ASSESSMENT

Obtain data on whole body metabolic gains or losses, together with associated endocrinological controls.

Purpose

The purposes are to assess food compatibility, and to determine the effect of space flight on the overall body compositions and on the circulating and excretory levels of certain hormonal constituents which are responsible for maintaining homeostasis.

The functional test objectives are as follows:

FTO 1) Collect samples of urine passed during specified time periods prior to, during and after the mission.

FTO 2) Return to earth all fecal matter collected in the Command Module.

FTO 3) Determine the amount of fluid and nutrient ingested by each crewman during specific time periods.

C

Test Conditions

FTO 1) For a period commencing 72 hours prior to launch and continuing until the crew arrives at EAFB after recovery, urine will be collected, measured, sampled, and the samples returned for analysis. The urine will be collected in individual Biomedical Urine Sample Systems (BUSS) and a sample will be transferred into individual return sample bags.

The Urine Collection schedule will be as shown in Table 1.

FTO 2) All fecal matter excreted in the CM will be collected and identified as to crew member and time and stowed for return to earth. In addition, all fecal matter excreted during the last 72 hours before launch and until the crew arrives at EAFB after recovery will be collected and identified as to crew member and time.

FTO 3) All nutrient intake will be logged and reported to the MCC on a daily basis. All fluid intake during the time periods defined in FTO 1) will be either logged or reported to the MCC on a daily basis. Nutrient intake reports will include deviations from the nominal menu and any snack foods consumed. In addition, all fluid and nutrient intake during the 72 hours immediately before launch and until the crew arrives at EAFB after recovery will be recorded.

Success Criteria

FTO 1) The urine collected during the pre-flight, inflight, and post-flight periods specified in the Test Conditions shall be sampled and returned.

FTO 2) The fecal matter collected during the pre-flight, inflight, and post-flight periods specified in the Test Conditions shall be collected and returned.

FTO 3) Data shall be obtained on all fluid and nutrient intake during the periods specified in the Test Conditions.

Evaluation

FTO 1) All returned urine samples will be analyzed for the constituents of interest. [Collected urine samples as defined in the Test Conditions for FTO 1)]

FTO 2) The quantity of returned fecal matter will be measured and chemical analysis performed. [All fecal matter as defined in Test Conditions for FTO 2)] C

FTO 3) The fluid and nutrient intake for each crewman will be calculated for the time periods specified in the Test Conditions. (Astronaut records and pre-flight and post-flight records of fluid and nutrient intakes)

Data Requirements

1) Astronaut Logs or Voice Records: (M)

One copy of records containing the quantity and type of fluid and nutrient ingested during the time periods specified in the Test Conditions for FTO 3).

2) BUSS Sample bags containing the urine collected during flight as specified in the Test Conditions for FTO 1). (M)

3) All urine collected for the 72-hour period before launch and until the crew arrives at EAFB after recovery as specified in the Test Conditions for FTO 1). (M)

4) All fecal matter collected in the CM as specified in the Test Conditions for FTO 2). (M)

5) All fecal matter excreted by each crewman during the last 72 hours before launch and until the crew arrives at EAFB after recovery as specified in the Test Conditions for FTO 2). (M)

6) Record of all fluid and nutrient intake for each crewman during the last 72 hours before launch and until the crew arrives at EAFB after recovery as specified in the Test Conditions for FTO 3). (M) C

4.6 FOOD COMPATIBILITY ASSESSMENT

Background and Justification

Fluid and electrolyte anomalies have been detected in flights of the Gemini, Apollo, Vokshod and Soyuz series. These anomalies were particularly pronounced on Apollo 15 and may have been associated with inflight cardiac arrhythmias and postflight decrements in exercise performance and cardiovascular responses. Certain therapeutic measures including the elevation of dietary potassium intake are thought to be in part responsible for the lack of significant metabolic aberrations following Apollo 16. This investigation will quantitate the metabolic gains and losses previously observed, and will assist in assessing the efficacy of inflight countermeasures. The investigation will also provide information of a precise enough nature to be useful in drawing comparisons between Apollo and the SL-2 mission. Measurement of potassium balance is thought to be especially critical in order to verify the Apollo 16 finding that exposure to weightless flight may be associated with changes in the availability of body potassium pools. It will be possible to correlate chemically measured changes in potassium balance with the exchangeable isotopically measured potassium pool. In addition, measurement of nitrogen balance will enable a rigorous interpretation to be made of the physiological nature of the body potassium changes. Investigators will be able to conclude whether potassium and nitrogen are being lost at a rate which is explicable by total cellular loss or whether cellular potassium concentrations are themselves being diminished. C

Previous Flight Objectives

Objective Number	Title	Mission
4.10	Body Fluid Balance Analysis	J-2

Table 1. Urine Collection Schedule

GET in hours	
Start	End
07:00	18:30
18:30	35:00
35:00	58:45
58:45	83:30
83:30	107:00
*107:00	*133:00
*133:00	*156:10
*156:10	*180:45
*180:45	*208:00
208:00	230:25
230:25	252:50
252:50	276:50
276:50	300:30
300:30	303:30

*CMP Only

C

4.7 PROTECTIVE PRESSURE GARMENT

Obtain data on the use of the protective pressure garment.

Purpose

The purpose is to obtain data on the ability of the protective pressure garment to counteract the post-flight orthostatic intolerance.

The functional test objective is as follows:

FTO 1) Obtain data on the effectiveness of the protective pressure garment in counteracting orthostatic intolerance.

Test Conditions

FTO 1) Prior to entry interface, the CMP will don the protective pressure garment. The capstan will be inflated to a pressure of 130 mm of mercury no later than just prior to the first time that the CMP stands up after splashdown. This pressure will be maintained from the time the CMP first stands up after splashdown until the medical check aboard the recovery ship. C

Success Criteria

FTO 1) Mandatory data defined under data requirements shall be acquired for evaluation.

Evaluation

FTO 1) The CMP post-mission orthostatic tolerance will be compared to the standing tests made with and without the garment at launch minus 15 days. (Premission and postmission data)

Data Requirements

1) Premission measurement of orthostatic tolerance during the standing tests made with and without the garment at launch minus 15 days. (M)

2) Postmission measurement of orthostatic tolerance during and after wearing the garment. (M)

4.7 PROTECTIVE PRESSURE GARMENT

Background and Justification

Post-flight results from previous space missions have shown an intolerance to orthostatic stress. This intolerance has been demonstrated by specific tests and shown to exist in varying degrees in different crewmen.

Earth based studies have indicated that pressure applied to the lower portion of the body is effective in counteracting this situation. C

The data acquired from the Apollo 17 Mission will provide data for the Skylab Missions.

Previous Flight Objectives

Objective Number	Title	Mission
None		

5.0 EXPERIMENTS

This section contains the experiments recommended by the Manned Space Flight Experiments Board and assigned by the Office of Manned Space Flight (Reference 1).

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 (covers EVA period only)
b) LM Lunar Surface Checklist (covers touchdown to lift-off)
c) Flight Plan
d) CSM Experiment/EVA Checklist
e) Lunar Graphics

Passive Experiments to be accomplished as follows:

Deleted

B

- Apollo Window Meteoroid

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 heat shield windows (numbers 1, 3 and 5) to MSC following recovery of the spacecraft.

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

- Soil Mechanics

The Soil Mechanics Experiment (S-200) will provide data on the in-place physical properties of the upper part of the lunar regolith in the vicinity of the landing site for use in the interpretation of lunar history and processes. Observational data on the lunar surface and information on soil grain size and grain-size distribution obtained from returned soil samples and core tube samples will enable estimation of in-place density and porosity profiles in the upper few tens of centimeters. The mechanical behavior of the lunar surface material will be assessed through analysis of crew comments and photographs of the LM footpad-lunar interactions, soil accumulation on the LM vertical surfaces, and records of lunar soil-LRV interaction, as well as through study of the samples of returned lunar surface material. No specific crew tasks are required for this experiment. LM mass, position, velocity and acceleration with respect to the LM landing point, and descent engine thrust level during final approach will 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.) D

- Biostack IIA

The Biostack IIA Experiment (M-211) will be accomplished to investigate the biological effects of individual heavy nuclei of cosmic radiation during space flight. These effects will be determined by flying biological materials interlaced with dosimeters. The test materials will be evaluated for response changes and compared to the tracks of heavy nuclei particles as detected by the dosimeters. Additional information concerning the biological effects of specific radiation sources will also be obtained. No in-flight data or specific in-flight crew tasks are required.

- Biocore

The Biocore Experiment (M-212) will be accomplished to determine if heavy cosmic particles of known trajectory terminating in the brain and eyes will produce morphologically demonstrable damage. Six pocket mice contained within the experiment package will be subjected to the cosmic radiation encountered in-flight. No specific crew tasks are required to support this experiment. The requirements consist of returning the experiment package and mice to the experimenter on the recovery ship as soon as possible after splashdown. Brains and eyes will be fixed and sectioned postflight and the existence of lesions will be ascertained.

This experiment will be deleted in case the T-24 hour launch opportunity is utilized. This deletion will be caused by the necessity of stowing additional LiOH cannisters in stowage area A6 which is the same area to be used by the experiment package.

- Gamma-Ray Spectrometer

The Gamma-Ray Spectrometer Experiment (S-160) will be accomplished to obtain data that will permit the removal of background noise from the galactic observations portion of the experiment as conducted during Apollo 16. The data will be obtained by use of a sodium iodide crystal exposed to the space cosmic ray flux within the CM. The cosmic rays will induce radioactive isotopes within the crystal. No specific in-flight crew tasks are required for this experiment. The value of the data is dependent upon the time that elapses between reentry and the start of the data reduction. Therefore, special procedures will be accomplished in order to deliver the crystal to the recovery ship as soon as feasible after splashdown. This will permit measurement of the short-period half-life of various types of isotopes.

5.1 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.

FTO 4) Measure the brightness temperature of the local lunar surface.

Test Conditions

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

The Heat Flow Experiment (HFE) is part of Apollo 17 ALSEP which will be deployed on the lunar surface during the first EVA.

It is highly desirable that the drill core sample from the Lunar Geology Investigation (S-059) be taken within 16 meters of the deployed Heat Flow Experiment probes. B

Astronaut activities will be accomplished as follows:

a) The astronaut will deploy and align and 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 a minimum of 9 meters apart and at least 2.44 meters 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 0.15 to 0.30 meters of bore stem protruding above the surface. The astronaut will insert a sensor/heater probe and radiation shield into each bore stem, and push the probe and shield down into the bore stem using the emplacement tool.

The proper emplacement depth to accomplish FTO 4) will be realized when the top cable thermocouple remains just outside the bore stem. The top cable thermocouple is to lie on the south side of the bore stem with the thermocouple longitudinal axis approximately in a north-south direction. With the probe fully inserted, the astronaut will report the lowest visible alphanumeric marking on the emplacement tool to indicate the depth of penetration. The correct depth of the probe within the bore stem will have been obtained when the lowest visible marking on the emplacement tool is P1. Utilizing the emplacement tool, the astronaut will push a second radiation shield down into the bore stem to a depth indicated by the F1 marking on the emplacement tool. Again utilizing the emplacement tool, the extension of the bore stems above the lunar surface will be determined and reported. The correct extension of the bore stem above the lunar surface will have been obtained when the top of the bore stem is approximately level with the B6 marking on the emplacement tool. The emplacement tool will then be discarded and each bore stem will be capped with a third radiation shield.

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 11 feet.

   (2) One stereo pair of photographs of each bore stem with probe emplaced, taken cross-sun at a distance of 7 feet.

   (3) One highly desirable photograph of the electronics package taken cross-sun at a distance of 7 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 2-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 F of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Vol. V, ALSEP Data Book. C

Each conductivity experiment in the low conductivity mode (Mode 2) requires 36 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. The repeat test will be scheduled with the guidance of the Principal Investigator. 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)
FTO 4) 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)]

FTO 2) The absolute temperature of the lunar subsurface 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)]

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)]

FTO 4) The brightness temperature of the local lunar surface will be determined. [Premission, experiment support and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under 3)a)]

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

Data Requirements

1) Premission Data (PD): (M)

Calibration and Checkout Data:

Premission calibration data included in the Apollo 17 ALSEP Final Acceptance Data Package Provided to NASA/MSC by the 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.

b) Voice Comments:

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

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

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
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

Measurement Number	Description	TM	Priority PD*	ESD	EED
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

*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.

c) Astronaut Logs or Voice Records: (M)

One copy each of astronaut logs or voice records containing alphanumeric markings on the emplacement tool at completion of each HFE probe insertion indicating both the probe depths and the bore stem extensions above the lunar surface.

d) Astronaut Debriefings: (HD)

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

e) Still Photographs:

(1) One copy each of the photographs defined under items c)(1) and c)(2) of the Test Conditions. (M)

(2) One copy of the photograph defined under item c)(3) of the Test Conditions. (HD)

(3) 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. (HD)

f) Sequence Photographs: (HD)*

One copy of photographs of ALSD operation during bore stem emplacement and probe emplacement.

g) Supporting Data: (HD)

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.

h) Television Coverage: (HD)**

One kinescope recording of any TV coverage of ALSD operation during bore stem emplacement and probe emplacement.

*No specific crew tasks are required. The sequence photographs are to be provided to the Principal Investigator only if they are obtained in support of operational tasks, detailed objectives or other detailed experiments.

**No specific crew tasks are required. The kinescope recording will be provided to the Principal Investigator only if the television camera is used during this time period in support of operational tasks, detailed objectives or other detailed experiments.

5.1 HEAT FLOW

Background and Justification

This experiment is designed to measure the heat flux through the upper 2.44 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 of the first 2.44 meters of the moon's crust;

e) Surface temperature versus time, and surface thermal properties.

The HFE was successfully deployed during Apollo 15. A

Deployment was off-nominal during Apollo 15, i.e., probe emplacement was shallower than desired, but astronaut records and photographs provided information for compensating for the off-nominal sensor depths. Experiment results to date indicate a net outward flow of heat from the lunar interior, approximately 1/2 that of the earth's average heat flow. During deployment of the HFE on Apollo 16 the electronics package cable was inadvertently broken, resulting in inability to operate. A

The seven photographs and TV coverage 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, the configuration of the deployed HFE (e.g., the lie of the cables), and the drilling and probe emplacement processes. These photographic and TV data are important in interpreting and compensating for any off-nominal experiment operation or anomalous results.

Previous Mission Experiments

Experiment Number	Title	Mission	
S-037	Heat Flow Experiment	15	
S-037	Heat Flow Experiment	16	A

5.2 LUNAR SURFACE GRAVIMETER

Conduct the Lunar Surface Graivmeter Experiment (S-207)

Purpose

The purpose is to obtain highly accurate measurements of lunar gravity and its temporal variations at a selected point on the lunar surface.

The functional test objectives are as follows:

FTO 1) Determine the value of lunar gravity relative to earth gravity with an accuracy of approximately 1 part in 10^5 (i.e., approximately ± 1.6 milligals).

FTO 2) Determine the magnitude of lunar surface deformation due to tidal forces.

FTO 3) Measure vertical components of lunar natural seismicity.

FTO 4) Monitor free oscillations of the moon which may be induced by gravitational radiation from cosmic sources.

Test Conditions

FTO 1)
FTO 2)
FTO 3)
FTO 4)
The Lunar Surface Gravimeter is part of Apollo 17 ALSEP which will be deployed on the lunar surface. Astronaut activities will be accomplished as follows:

a) The instrument sunshade will be deployed and the instrument aligned in azimuth using the sunshade shadow and alignment mark. The instrument will be leveled with the aid of the bubble level. The instrument will be uncaged while maintaining the instrument leveled and aligned. The astronaut will visually check the bubble level and sunshade shadow alignment to insure that the uncaging process has not affected the instrument level or alignment, and relevel or realign the instrument, if necessary.

b) It is highly desirable that the astronaut obtain two photographs of the deployed experiment using the HEDC as follows:

(1) One photograph of the instrument taken approximately cross-sun from a distance of 3 feet showing the bubble level, uncaging flag, sunshade alignment shadow, and at least two of the instrument legs. B

(2) One photograph of the instrument taken from a distance of 3 feet and showing the remaining two instrument legs.

c) It is highly desirable that the astronaut transmit to MCC comments on bubble level, sunshade shadow, and sunshade tilt indications.

After the experiment is deployed and the ALSEP central station is activated, MCC will initiate commands to accomplish experiment TURN-ON. Data will be transmitted to earth and recorded for as much of the planned 2-year ALSEP operational period as possible, consistent with equipment capabilities and operational requirements of other ALSEP experiments. Experiment adjustments will be made as required during periods of MCC monitoring. The commands to be issued by MCC will be defined in Appendix F of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Vol. V, ALSEP Data Book. C

Success Criteria

FTO 1) FTO 2) FTO 3) FTO 4) Experiment data defined as mandatory under Data Requirements shall be transmitted to earth and provided to the Principal Investigator and shall include telemetry data for a minimum of two lunations for FTO's 1), 2), and 3), and two weeks of quiet data (low background noise data) for FTO 4), after activation of the ALSEP central station on the lunar surface.

Evaluation

FTO 1) FTO 2) FTO 3) FTO 4) Evaluation will consist of analysis of data and determination of proper equipment operation. Data tapes will be reformatted at MSC for processing by the Principal Investigator. [Premission, experiment support, and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under paragraph 3)a)]

FTO 1) The value of lunar gravity at the instrument site, relative to earth gravity will be determined from the telemetered data with an accuracy of 1 part in 10^5 (i.e., approximately $\pm$1.6 milligals). [Premission and experiment evaluation data as defined under Data Requirements, including all telemetry measurements listed under paragraph 3)a)]

FTO 2) The magnitude of lunar surface deformation due to tidal forces will be determined by analysis of telemetered experiment data. [Premission and experiment evaluation data as defined under Data Requirements, including all telemetry measurements listed under paragraph 3)a)]

FTO 3) The vertical components of lunar natural seismicity at the instrument site will be determined from telemetered experiment data. [Premission and experiment evaluation data as defined under Data Requirements, including all telemetry measurements listed under paragraph 3)a)]

FTO 4) Telemetered experiment data will be analyzed and compared with data from earth-based gravimeters to search for simultaneously induced free oscillations which may establish the existence of gravitational radiation from cosmic sources. [Premission and experiment evaluation data as defined under Data Requirements, including all telemetry measurements listed under paragraph 3)a)]

Data Requirements

1) Premission Data (PD): (M)

Calibration and Checkout Data:

Premission calibration and checkout data included in the Apollo 17 ALSEP Final Acceptance Data Package provided to NASA/MSC by the integration contractor.

2) Experiment Support Data (ESD):

a) Telemetry Measurements:

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

b) Voice Comments: (HD)

Comments on bubble level, sunshade shadow, and sunshade tilt alignment conditions. B

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Priority PD*	ESD	EED
DG-1	Seismic	PCM		M(A)	M
DG-2	Tide	PCM		M(A)	M
DG-3	Free Mode	PCM		M(A)	M
DG-4	Sensor Temperature	PCM		M(A)	M
	Deleted				
	Deleted				
DG-7	Coarse Encoder (MSB)	PCM		M(D)	HD
DG-8	Coarse Encoder (LSB)	PCM		M(D)	HD
DG-9	Fine Encoder (MSB)	PCM		M(D)	HD
DG-10	Fine Encoder (LSB)	PCM		M(D)	HD

B

Measurement Number	Description	TM	Priority PD*	ESD	EED
DG-11	Temperature Relay Status	PCM		M(D)	M
DG-12	Mass Change Motor Status	PCM		M(D)	M
DG-13	Coarse/Fine Screw Servo Motor Status	PCM		M(D)	M
DG-14	Tilt Servo Motor Status	PCM		M(D)	M
DG-15	Command Decoder Power Status	PCM		M(D)	HD
DG-16	Instrument Housing Heater Power Status	PCM		M(D)	HD
DG-17	Pressure Transducer Status	PCM		M(D)	HD
DG-18	Seismic Gain Status	PCM		M(D)	HD
DG-19	Command Counter Status	PCM		M(D)	HD
AG-1	LSG Seismic Signal	PCM		M(A)	HD
AG-2	LSG Tide Signal	PCM		M(A)	HD
AG-3	LSG Free Mode Oscillation Signal	PCM		M(A)	HD
AG-4	LSG Sensor Temperature	PCM		M(A)	HD
AG-5	LSG Instrument Housing Pressure	PCM		M(D)	HD
AG-6	LSG Mass Position Signal	PCM		M(D)	HD
AG-7	LSG Oscillator Amplitude	PCM		M(D)	HD
AG-8	LSG Power Converter (+15V)	PCM		M(D)	HD
AG-9	LSG Power Converter (-15V)	PCM		M(D)	HD
AG-10	LSG Power Converter (+5V)	PCM		M(D)	HD

B

B

*There are no requirements for Premission Data (PD)

b) Telemetry Measurement Tapes: (M)

One copy of 7-track, 800-BPI tapes containing the EED telemetered measurements listed under 3)a). The tapes are to be compatible with a UNIVAC 1108 computer.

c) Astronaut Logs or Voice Records: (HD)

One copy of astronaut logs or voice records pertaining to experiment deployment.

d) Astronaut Debriefings: (HD)

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

e) Photographs: (HD)

One copy of each of the photographs defined under Test Conditions.

5.2 LUNAR SURFACE GRAVIMETER

Background and Justification

This experiment will measure the value of lunar gravity and its temporal variations as a function of time for two years or longer. The average absolute value of lunar gravity [FTO 1)] will be determined to an accuracy of 1 part in 10^5. Variations in lunar gravity as small as 1 part in 10^8 (i.e., approximately $\pm$1.6 microgals) will be detected [FTO 2), FTO 3), and FTO 4)].

Long-period variations (e.g., one cycle per several days or longer) will enable the determination of the magnitude of lunar surface deformation due to tidal (i.e., external gravitational) forces [FTO 2)]. Conclusions may then be drawn concerning the internal constitution of the moon.

Short-period variations of about 0.2 Hz or greater in lunar gravity (vertical components only) will indicate natural lunar seismicity [FTO 3)] or free oscillations of the moon which may be induced by gravitational radiation from cosmic sources [FTO 4)]. These observations will make use of the moon as a mass quadrupole detector for gravitational waves. The lunar free oscillations may be observed to be excited by such waves if the power spectrum is sufficiently intense over the frequencies of certain of the moon's normal modes. Simultaneous observation of the earth's normal mode excitation will make it very likely that the effects are due to gravitational waves. A

This experiment partly overlaps the lunar passive seismometer experiment in that it yields vertical acceleration and seismic data. The difference is primarily that a different frequency range is covered, and this is of prime interest in geophysics and general relativity physics. These seismic data yield information on the collective motion, and internal constitution of the moon as a whole. In addition, the Lunar Traverse Gravimeter experiment, also planned for the Apollo Mission J-3, is expected to complement the Lunar Surface Gravimeter experiment.

The photographs called for under the Test Conditions are to provide a permanent record of the condition of the deployed experiment and its location with respect to the ALSEP central station. These data are important in compensating for any off-nominal experiment operation or anomalous results. A

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.3 LUNAR SEISMIC PROFILING

Conduct the Lunar Seismic Profiling Experiment (S-203)

Purpose

The purposes are to acquire data on the physical properties of the lunar near-surface materials and to monitor moonquakes or impacts of meteorites.

The functional test objectives are as follows:

FTO 1) Measure the lunar seismic signals produced by detonations of explosive charges on the lunar surface.

FTO 2) Monitor natural seismic activity resulting from moonquakes or meteorite impacts.

FTO 3) Record the seismic signals resulting from ascent of the LM from the lunar surface.

FTO 4) Record the seismic signals resulting from impact of the spent LM ascent stage on the lunar surface.

Test Conditions

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

The Lunar Seismic Profiling Experiment (LSPE) is part of ALSEP 17 which will be deployed on the lunar surface.

Astronaut activities will be accomplished as follows:

a) The astronaut will deploy the geophone module package and four geophones as shown in Figure 1. Three of the geophones will be deployed such that they comprise the vertexes of an approximately equilateral triangle with approximately 90-meter sides. The fourth geophone will be deployed within the triangle. A marker flag will be emplaced at each geophone and at the geophone module package. A gnomon will be emplaced within the triangle beside the fourth geophone. The LSPE remote transmitting antenna will be deployed approximately 12 meters northwest of the ALSEP central station. The geophone module package will be located approximately 9 meters south of the ALSEP central station.

b) The astronaut will photographically document the geophone array using a HEDC as follows:

(1) From each of two photographic positions as shown in

Figure 1, approximately 8 meters from the geophone within the triangle, the astronaut will obtain 3 photographs, one in the direction of each of the 3 geophones that form the triangle. The photographs of the most westerly and most easterly geophones, respectively, will include the gnomon and the center geophone in the field of view.

(2) The astronaut will obtain panoramic photographs with a HEDC from a location near the center geophone.

During the periods that LSPE data are being transmitted from the moon to earth, experiment data from the other four ALSEP experiments will be interrupted. The commands to be issued by MCC will be defined in Appendix F of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Vol. V, ALSEP Data Book. C

FTO 1) The astronaut will unstow each of the two explosive charge transporters from the LM. Each transporter, containing four explosive charge packages of various weights, will be placed in an unshaded area for at least two hours prior to stowage on the LRV (to assure that the timers will have reached the minimum allowable operating temperature when they are subsequently deployed and armed). The two-hour minimum time in the unshaded area will be adequate, provided that the charges are not subsequently placed in the shade prior to deployment. If stowage in the shade is anticipated after placing the charges in the unshaded area, then the initial period in the unshaded area must be increased so that the timer mechanisms will not have cooled to below 40°F when the charges are deployed and armed. The explosive charge packages may be deployed during the outbound portion of the traverse as well as during the inbound portion. The heaviest package will be deployed at the site most distant from the geophone array, not to exceed approximately 2.5 kilometers. The lightest charge will be deployed no closer than 150 meters from the nearest geophone. Each explosive charge package will include a receiving antenna which will be extended during emplacement of the package. After the receiving antenna has been extended, the astronaut will arm the explosive charge package by pulling three rings on the package. The specific deployment locations for the eight explosive charges will be along the geologic traverse(s) at approximately the following distances from the nearest geophone:

160 + 40 - 0*	meters	-	57 gram (1/8 lb) charges (2 each)
250 + 130 - 50	meters	-	113 gram (1/4 lb) charges (2 each)
800 + 100 - 100	meters	-	227 gram (1/2 lb) charge
1300 + 0** - 400	meters	-	454 gram (1 lb) charge
2000 + 100 - 300	meters	-	1361 gram (3 lb) charge
2400 + 300 - 300	meters	-	2722 gram (6 lb) charge

C

*Science rationale would permit the charge to be placed closer to the geophone but safety requirements dictate a 160 meter minimum displacement distance.

**Science rationale would permit the charge to be placed further from the geophone but operational considerations dictate a maximum of 1300 meters displacement distance.

At each charge deployment site that is less than 2000 meters from the nearest geophone, a partial panorama including within the field of view features that are expected to be recognizable on the SIM bay panoramic camera film will be obtained using a HEDC, to aid in determining the charge deployment location. In addition, the LRV navigation data (i.e., BEARING and RANGE) will be transmitted to MCC at each charge deployment location.

The MCC will initiate the commands to cause the LSPE explosive charges to detonate in the planned sequence after the astronauts have departed the lunar surface, and to monitor the resulting lunar seismic signals.

FTO 2)
FTO 3)
FTO 4) The MCC will initiate a command for LSPE TURN-ON prior to each period of data collection (i.e., prior to ascent of the LM from the lunar surface, impact of the spent LM ascent stage on the lunar surface, and other periods of passive listening mode operation).

FTO 4) The LM ascent stage will be targeted for impact on the lunar surface at latitude 19.93°N and longitude 30.54°E as determined by analytical triangulation of Apollo 15 photography. D

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 telemetry data recorded during the periods of explosive charge detonations, ascent of the LM from the lunar surface, and impact of the spent LM ascent stage on the lunar surface.

Evaluation

FTO 1)
FTO 2)
FTO 3)
FTO 4) Evaluation will consist of analysis of experiment data and determination of proper equipment operation. Data tapes will be reformatted at MSC for processing by the Principal Investigator. [Premission, experiment support, and experiment evaluation data as defined under Data Requirements, including all telemetry measurements listed under 3)a)]

FTO 1) Telemetry data on the lunar seismic signals produced by detonations of explosive charges on the moon will be analyzed to determine seismic velocity and density relations of the lunar near-surface materials. [Premission and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under 3)a)]

FTO 2) Telemetry data recorded during periods of experiment passive listening mode operation will be analyzed to obtain information on the number and character of the natural lunar seismic events which may occur during these periods. [Premission and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under 3)a)]

FTO 3) Telemetry data recorded during and for four hours after ascent of the LM from the lunar surface will be analyzed to determine seismic velocity and density relations in the lunar material in the area of the Apollo 17 ALSEP. [Premission and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under 3)a)]

FTO 4) Telemetry data recorded during and for four hours after impact of the spent LM ascent stage will be analyzed to determine seismic velocity and density relations in the lunar material between the Apollo 17 ALSEP and the impact point. [Premission and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under 3)a)]

Data Requirements

1) Premission Data (PD): (M)

Calibration and Checkout Data:

Premission calibration data included in the Apollo 17 ALSEP Final Acceptance Data Package provided to NASA/MSC by the integration contractor.

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

Telemetry Measurements:

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

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Priority PD*	ESD	EED	
AB-4	Experiments 1 & 2 Power Distribution Status	PCM		N/A	HD	
AB-5	Experiments 3 & 4 Power Distribution Status	PCM		N/A	HD	
AE-3	PC #1 Input Voltage	PCM		N/A	HD	
AE-4	PCU Input Current	PCM		N/A	HD	
AE-17	Transmitter A, 23 Volt Regulator Output	PCM		N/A	HD	
AT-4	Thermal Plate #2 Temperature	PCM		N/A	HD	B
DA-8	Reserve Current	PCM		N/A	HD	
DP-1	Geophone #1 Data	PCM		M(A)	M	
DP-2	A/D Calibration #1	PCM		N/A	HD	
DP-3	DC/DC Converter Output	PCM		N/A	HD	
DP-5	A/D Calibration #2	PCM		N/A	HD	
DP-6	Geophone #2 Data	PCM		M(A)	M	
DP-10	Geophone Calibration Pulse Amplitude	PCM		N/A	M	
DP-11	Geophone #3 Data	PCM		M(A)	M	B

Measurement Number	Description	TM	Priority		
			PD*	ESD	EED
DP-14	Electronics Temperature	PCM		N/A	HD
DP-16	Geophone #4 Data	PCM		M(A)	M
DP-17	Frame Synchronization	PCM		N/A	M
DP-18	Geophone Calibration Pulse Status	PCM		N/A	M
DP-19	Geophone Amplifier Gain Status	PCM		N/A	M
DP-20	RF Fire Pulses Status	PCM		M(A)	M
DP-21	Subframe Identification	PCM		N/A	M

*There are no requirements for Premission Telemetry Data.

b) Telemetry Measurement Tapes: (M)

One copy of 7-track/Fortran, 800-BPI tapes containing the EED telemetered measurements listed under 3)a). The tapes are to be compatible with an IBM 360/67 computer. D

c) Astronaut Debriefings: (HD)

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

d) Photographs: (M)

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

(2) One copy each of any partial or total panoramas of the explosive charge deployment sites that are required in support of Data Requirements, paragraph 4)b).

4) Supporting Data: (M)

a) One copy of a map or coordinates of the geophones and geophone array showing the relative locations of the geophones to within ±3 meters and the azimuths of lines through any pair of geophones to within ±10 degrees. These data are to be provided by the S&AD of NASA/MSC.

b) One copy of a map or coordinates of the deployment locations of the eight explosive charge packages to within ±5 percent of the distance between a charge package and the nearest geophone. These data are to be provided by the S&AD of NASA/MSC.

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

(1) APS ignition time. D

(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.

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

(1) Mass at impact.

(2) Velocity at impact.

(3) Heading at impact. D

(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 all operating ALSEP sites.

5) Astronaut Logs or Voice Records: (M)

One copy of the records of LRV navigation readings that are required in support of Data Requirements, paragraph 4)b).

*Panoramas obtained in support of detailed objectives or other experiments, such as Lunar Geology Investigation, will be satisfactory.

5.3 LUNAR SEISMIC PROFILING

Background and Justification

Seismology is a key tool in determining the present geological characteristics of the moon and its evolutionary history. The passive seismometers deployed during previous Apollo missions have yielded important information on the lunar interior for depths greater than 20 km. The artificial sources used in the seismic profiling experiment provide seismic energy usable in determining lunar interior layering at shallower depths.

This lunar surface experiment utilizes an array of four geophones to record seismic waves generated by explosive charges deployed by the astronauts. The explosive charges, of different energy content and deployed in the neighborhood of the geophone array, will be detonated after the astronauts depart the moon. After data on the artificially induced seismic activity has been telemetered to earth via the ALSEP central station, the geophone array can be operated in a passive listening mode at selected times to monitor any natural seismic activity.

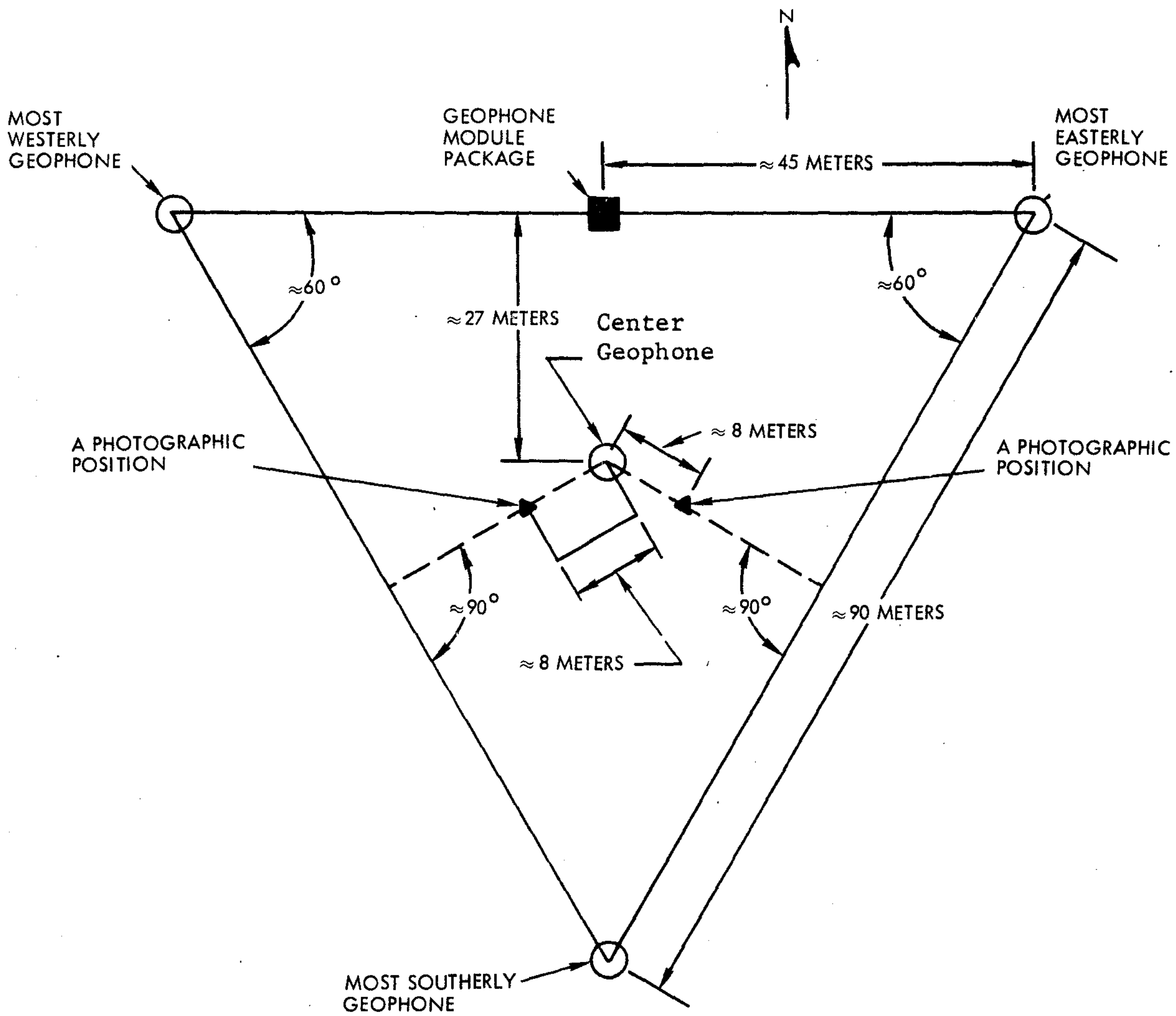
The known locations and energies of LM ascent from the lunar surface and planned impact of the spent LM ascent stage on the lunar surface will provide valuable calibration data for experiment data analysis as well as provide additional artificial sources for seismic profiling.

The kindred Active Seismic experiments, deployed during Apollo 14 and 16 , differ from the Seismic Profiling experiment in that azimuth of approach of the seismic waves cannot be determined, whereas the configuration of the geophone array for the Seismic Profiling experiment allows a determination of approach azimuth and hence more accurate seismic wave velocities. A

This experiment will yield important detailed information on the geologic characteristics of the lunar surface and subsurface to depths of approximately 3 kilometers.

Previous Mission Experiments

Experiment Number	Title	Mission	
S-033	Active Seismic Experiment	14	
S-033	Active Seismic Experiment	16	A



A

Figure 1. LSPE Geophone Deployment and Photographic Locations

5.4 LUNAR ATMOSPHERIC COMPOSITION

Conduct the Lunar Atmospheric Composition Experiment (S-205).

Purpose

The purposes are to obtain data on the composition of the lunar ambient atmosphere in the mass range of 1 to 110 amu at the lunar surface and to detect transient changes in composition due to venting of gases from the surface or from other sources.

The functional test objectives are as follows:

FTO 1) Obtain data to identify the gases in the native lunar atmosphere at the lunar surface and determine their concentrations. A

FTO 2) Obtain data to determine the variations in these gas concentrations over two or more lunations.

FTO 3) Obtain data on short-term transient changes in the lunar atmospheric composition.

Test Conditions

FTO 1) FTO 2) FTO 3) The Lunar Atmospheric Composition Experiment (LACE) is part of Apollo 17 ALSEP which will be deployed on the lunar surface. A

Astronaut activities will be as follows:

a) To minimize the effect of reaction forces, the astronaut will pull the vent lanyard prior to removing the LACE from the pallet. This will allow the escape of the krypton with which the LACE was backfilled on earth. The astronaut will then deploy the LACE on the lunar surface 15 meters or more from the ALSEP Central Station, preferably on the side away from the LM and in a level, boulder-free area, if feasible. The instrument will be leveled to within ±15 degrees with the aid of the bubble level, and oriented such that the cable leaves the LACE in the direction of the Central Station and lies as flat as possible on the lunar surface. It is highly desirable that the deployment location and level condition be such that the plane containing the entrance aperture does not intersect any lunar terrain within a radius of 15 meters from the instrument. In addition, the deployment location will be such that the remaining ALSEP packages, LRV, and LM descent stage will cast no shadows on the LACE during the lunar morning and evening. A

After deploying the LACE on the lunar surface, the astronaut will open and remove the entrance aperture cover, using the UHT, and deposit the cover on the lunar surface. The cover should be carefully released from the UHT to avoid striking the LACE and to minimize the possibility of depositing lunar dust on the LACE.

b) The astronaut will photographically document the deployed LACE as follows:

(1) One photograph of the deployed LACE, using the HEDC, taken from a distance of 3 feet showing the entrance aperture after the cover has been removed, the bubble level, the vent valve, and the cable as it leaves the instrument.

(2) Panoramic photographs taken with the HEDC showing the lunar terrain and other objects which surround the LACE. (Note: These may be the same panoramic photographs taken in the vicinity of the ALSEP central station or the LSPE geophone array provided the LACE and the ALSEP central station are in the field of view.)

c) It is highly desirable that the astronaut transmit to MCC comments on the bubble level indication and the lay of the cable between the LACE and the ALSEP central station.

d) After the experiment is deployed and the ALSEP central station is activated, MCC will initiate commands to accomplish experiment TURN-ON. Data will be transmitted to earth and recorded for as much of the planned 2-year ALSEP operational period as possible, consistent with equipment capabilities and operational requirements of other ALSEP experiments. Experiment adjustments will be made as required during periods of MCC monitoring. The commands to be issued by MCC will be defined in Appendix F of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Vol. V, ALSEP Data Book. C

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 two lunations.

Evaluation

FTO 1)
FTO 2)
FTO 3) Evaluation will consist of analysis of data and determination of proper equipment operation. Tapes will be reformatted at MSC for processing by the Principal Investigator. [Premission, experiment support, and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under paragraph 3)a)]

FTO 1) Experiment data will be analyzed to identify gases in the lunar atmosphere and determine their concentrations. [Premission and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under paragraph 3)a)]

FTO 2) Experiment data will be analyzed to determine the variations of these gas concentrations in the lunar atmosphere over two or more lunations. [Premission and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under paragraph 3)a)]

FTO 3) Experiment data will be analyzed to study short term variations in the lunar atmosphere which may arise from surface venting, solar wind phenomena or other sources. [Premission and experiment evaluation data as defined under Data Requirements, including all EED telemetry measurements listed under paragraph 3)a)]

Data Requirements

1) Premission Data (PD): (M)

Calibration and Checkout Data:

Premission calibration and checkout data included in the Apollo 17 ALSEP Final Acceptance Data Package provided to NASA/MSC by the 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.

b) Voice Comments: (HD)

Comments on the bubble level indication, the lay of the cable for the deployed instrument, and the nature of the nearby terrain.

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Priority PD*	Priority ESD	Priority EED	
AM-1	Marker ID (Eight 1's)	PCM		HD(D)	HD	
AM-2	Experiment Current	PCM		HD(D)	HD	B
AM-3	Ion Pump Current	PCM		HD(D)	HD	
AM-4	Ion Pump Voltage	PCM		HD(D)	HD	

Measurement Number	Description	TM	Priority PD*	ESD	EED	
AM-5	Baseplate Temperature	PCM		HD(D)	HD	
AM-6	Ion Source Temperature	PCM		M(D)	M	
AM-7	+12 VDC Supply Voltage	PCM		HD(D)	HD	
AM-8	+5 VDC Supply Voltage	PCM		HD(D)	HD	
AM-9	-12 VDC Supply Voltage	PCM		HD(D)	HD	
AM-10	-15 VDC Supply Voltage	PCM		HD(D)	HD	
AM-11	Emission Current Monitor	PCM		M(D)	M	
AM-12	Filament #1 Current	PCM		HD(D)	HD	
AM-13	Filament #2 Current	PCM		HD(D)	HD	B
AM-14	Multiplier High Voltage	PCM		HD(D)	HD	
AM-15	Low Voltage Power Supply Temperature	PCM		HD(D)	HD	
AM-41	Electronics Temperature	PCM		HD(D)	HD	B
AM-44	Sweep High Voltage	PCM		HD(D)	HD	
DM-1	Command Readback Status	PCM		HD(D)	HD	
	Deleted					B
DM-3	Low Mass (A) Range	PCM		M(D)	M	
DM-4	Intermediate Mass (B) Range	PCM		M(D)	M	
DM-5	High Mass (C) Range	PCM		M(D)	M	
DM-12	Multiplier Voltage Status	PCM		M(D)	M	
DM-13	Discriminator Level Status	PCM		M(D)	M	
DM-14	Mass Step Status	PCM		M(D)	M	
DM-15	Auto Step-Lock (Manual) Status	PCM		M(D)	M	B
DM-16	Ion Pump Status	PCM		M(D)	M	
DM-17	Dust Cover Status	PCM		M(D)	M	
DM-18	Bake Out Heater Status	PCM		M(D)	M	
DM-19	Mult. and Sweep HV Status	PCM		M(D)	M	
DM-20	Filaments Status	PCM		M(D)	M	

*There are no requirements for Premission Telemetry Data.

b) Telemetry Measurement Tapes: (M)

One copy of 7-track, 800-BPI tapes containing EED telemetered measurements listed under 3)a). The tapes are to be compatible with an IBM 360/50 computer.

c) Astronaut Logs or Voice Records: (HD)

One copy each of astronaut records containing comments on the bubble level indication, the azimuth orientation with respect to the cable for the deployed experiment, and the lunar-terrain descriptions.

d) Astronaut Debriefings: (HD)

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

e) Photographs: (M)

(1) One copy of the photograph of the deployed experiment defined under b)(1) of the Test Conditions.

(2) One copy of the panoramic photographs defined under b)(2) of the Test Conditions.*

*Panoramas obtained in support of detailed objectives or other experiments will be satisfactory.

5.4 LUNAR ATMOSPHERIC COMPOSITION

Background and Justification

Measurements of the lunar ambient atmospheric composition in the mass range 1 to 110 amu at the lunar surface, and the detection of transient changes in composition due to venting of gases from the surface or from man made sources will provide inputs to the study of the lunar atmosphere, its sources, sinks and transport mechanisms. Such determinations are important in investigating the suggestion that noble gases, carbon monoxide, hydrogen sulfide, ammonia, sulphur dioxide and water vapor may be released by lunar volcanism and from rocks and magma. The mechanisms of release of gases from the surface, e.g., solar wind bombardment, can, perhaps, be affirmed when the effluent gases are known. Likewise, data on released gases will afford some knowledge of the chemical processes underlying the lunar surface. A A

This instrument has an extended mass range to include hydrogen and helium at the low end and krypton at the high end. These capabilities were not present in the orbital Mass Spectrometer experiments. Improved time resolution with respect to diurnal variations is expected due to the longer diurnal period when operating on the lunar surface as compared to collecting data in lunar orbit. In addition, data will be taken very close to a well defined boundary condition, namely, the lunar surface. Background gas levels are expected to be very low due to extended experiment operation time which permits long-time outgassing of the experiment area. A

The photographs described under Test Conditions are to provide a permanent record of the physical conditions of the deployed experiment and the nearby lunar terrain including any nearby boulders and craters. These photographic data are important in interpreting and compensating for any off-nominal experiment operation or anomalous results. A

Previous Mission Experiments

Experiment Number	Title	Mission
S-165	Mass Spectrometer	15
S-165	Mass Spectrometer	16

A

5.5 LUNAR EJECTA AND METEORITES

Conduct the Lunar Ejecta and Meteorites Experiment (S-202)

Purpose

The purpose is to measure physical parameters of primary cosmic dust particle impacts on sensors in cislunar space, and of lunar ejecta emanating from the sites of meteorite impacts on the lunar surface.

The functional test objectives are as follows:

FTO 1) Determine the background and long-term variations in cosmic dust influx rates in cislunar space.

FTO 2) Determine the extent and nature of lunar ejecta produced by meteorite impacts on the lunar surface.

FTO 3) Determine the relative contributions of comets and asteroids to the earth's meteoroid ensemble.

FTO 4) Study possible correlations between the associated ejecta events and the times of earth's crossings of cometary orbital planes and meteor streams.

FTO 5) Determine the extent of contribution of interstellar particles toward the maintenance of the zodiacal cloud as the solar system passes through galactic space.

FTO 6) Investigate the existence of an effect called "earth focusing of dust particles."

Test Conditions

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

The Lunar Ejecta and Meteorites experiment is part of ALSEP 17 which will be deployed on the lunar surface.

Astronaut activities will be accomplished as follows:

a) The astronaut will deploy the experiment package approximately 8 meters from the RTG, but not adjacent to a boulder or in a crater. The intent is to provide a location such that no objects are at an elevation of 10 degrees or greater as measured in all azimuths from the horizontal plane containing the sensor aperture on top of the experiment package. He will then level and align the instrument with the aid of the bubble level, gnomon and shadowgraph. The astronaut will report the bubble level and shadowgraph indications to MCC. A

b) It is highly desirable that the astronaut obtain two photographs of the deployed experiment using the HEDC as follows:

   (1) One photograph of the deployed experiment showing the bubble level and shadowgraph, taken cross-sun from a distance of 3 feet.

   (2) One photograph of the deployed experiment taken from a distance of 7 feet showing the ALSEP central station in the background.

After providing at least two hours to allow the debris from detonation of the Lunar Seismic Profiling Experiment explosive charges to settle to the lunar surface, MCC will initiate commands to remove the sensor cover and accomplish TURN-ON of this experiment. Data will be transmitted to earth and recorded for as much of the planned two year ALSEP operational period as possible, consistent with equipment capabilities and operational requirements of other ALSEP experiments. Experiment adjustments will be made as required during periods of MCC monitoring. The commands to be issued by MCC will be defined in Appendix F of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Vol. V, ALSEP Data Book. C

Success Criteria

FTO 1) Experiment data defined as mandatory under Data Requirements
FTO 2) shall be transmitted to earth and provided to the Principal
FTO 3) Investigator and shall include telemetry data for a minimum
FTO 4) time period of six months after activation of the ALSEP
FTO 5) central station on the lunar surface.
FTO 6)

Evaluation

FTO 1) Evaluation will consist of analysis of data and determination
FTO 2) of proper equipment operation. Data tapes will be reformatted
FTO 3) at MSC for processing by the Principal Investigator. [Pre-
FTO 4) mission, experiment support, and experiment evaluation data,
FTO 5) including all telemetry measurements listed under paragraph
FTO 6) 3)a)]

FTO 1) The background and long-term variations in cosmic dust influx rates on the lunar surface will be determined by analysis of experiment data. [Premission and experiment evaluation data as defined under Data Requirements, including all telemetry measurements listed under paragraph 3)a)]

FTO 2) The extent and nature of lunar ejecta produced by impacts of meteorites on the lunar surface will be determined by analysis of experiment data. [Premission and experiment evaluation data as defined under Data Requirements, including all telemetry measurements listed under paragraph 3)a)] A

FTO 3) The relative contributions of comets and asteroids to the earth's meteoroid ensemble will be determined by analysis of experiment data. [Premission and experiment evaluation data as defined under Data Requirements, including all telemetry measurements listed under paragraph 3)a)] A

FTO 4) Experiment data will be analyzed to determine the correlations between associated ejecta events and the times of earth's crossings of cometary orbital planes and meteor streams. [Premission and experiment evaluation data as defined under Data Requirements, including all telemetry measurements listed under paragraph 3)a)] A

FTO 5) The extent of the contribution of interstellar particles toward the maintenance of the zodiacal cloud as the solar system passes through galactic space will be determined by analyzing the experiment data. [Premission and experiment support data as defined under Data Requirements, including all telemetry measurements listed under paragraph 3)a)] A

FTO 6) Experiment data will be analyzed to facilitate investigation of the existence of an effect called "earth focusing of dust particles." [Premission and experiment evaluation data as defined under Data Requirements, including all telemetry measurements listed under paragraph 3)a)] A

Data Requirements

1) Premission Data (PD): (M)

Calibration and Checkout Data:

Premission experiment calibration data included in the Apollo 17 ALSEP Final Acceptance Data Package provided to NASA/MSC by the integration contractor.

2) Experiment Support Data (ESD): A

a) Telemetry Measurements: (M)

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

b) Voice Comments: (HD)

Comments on bubble level and shadowgraph indications for the deployed experiment.

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Priority		
			PD*	ESD	EED
AJ-1	+5V Supply	PCM		HD	HD
AJ-2	Sensor Dust Cover Status	PCM		HD	HD
AJ-3	Mirror Dust Cover Status	PCM		HD	HD
AJ-4	Power Supply Monitor	PCM		HD	HD
AJ-5	Bias Voltages Monitor	PCM		HD	HD
AJ-6	Up Microphone Temperature	PCM		HD	HD
AJ-7	East Microphone Temperature	PCM		HD	HD
AJ-8	West Microphone Temperature	PCM		HD	HD
AJ-9	Central Electronics Temperature	PCM		M	M
AJ-10	-5V Supply	PCM		HD	HD
AJ-11	Survival Temperature	PCM		HD	HD
DJ-1	Front Film ID	PCM		M(D)	M
DJ-2	Front Film PHA (Pulse Height Analysis)	PCM		M(D)	M
DJ-3	Front Film Accumulator	PCM		M(D)	M
DJ-4	Rear Film ID	PCM		M(D)	M
DJ-5	Rear Film PHA	PCM		M(D)	M
DJ-6	Rear Film Accumulator	PCM		M(D)	M
DJ-7	Front Collector ID	PCM		M(D)	M
DJ-8	Microphone PHA	PCM		M(D)	M
DJ-9	Microphone Accumulator	PCM		M(D)	M
DJ-10	Rear Collector ID	PCM		M(D)	M
DJ-11	Elapsed Time	PCM		M(D)	M
DJ-12	Front Film ID	PCM		M(D)	M
DJ-13	Front Film PHA	PCM		M(D)	M
DJ-14	Front Film Accumulator	PCM		M(D)	M
DJ-15	Rear Film ID	PCM		M(D)	M
DJ-16	Rear Film PHA	PCM		M(D)	M
DJ-17	Rear Film Accumulator	PCM		M(D)	M
DJ-18	Front Collector ID	PCM		M(D)	M
DJ-19	Microphone PHA	PCM		M(D)	M
DJ-20	Microphone Accumulator	PCM		M(D)	M
DJ-21	Rear Collector ID	PCM		M(D)	M
DJ-22	Elapsed Time	PCM		M(D)	M
DJ-23	Film ID	PCM		M(D)	M
DJ-24	Collector ID	PCM		M(D)	M
DJ-25	Film PHA	PCM		M(D)	M
DJ-26	Film Accumulator	PCM		M(D)	M
DJ-27	Secondary Microphone Accumulation	PCM		M(D)	M
DJ-28	Analog Data Synchronization ID Bit	PCM		M(D)	M
DJ-29	Heater Status	PCM		HD(D)	HD
DJ-30	Main Microphone PHA	PCM		M	M
DJ-31	Main Microphone Accumulator	PCM		M	M

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

b) Telemetry Measurement Tapes: (M)

One copy of 7-track 800 or 1600 BPI tape 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 360/91 computer. D

c) Astronaut Logs or Voice Records: (HD)

One copy each of astronaut records containing comments on bubble level and shadowgraph indications for the deployed experiment.

d) Astronaut Debriefings: (HD)

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

e) Photographs: (HD)

One copy each of the photographs of the deployed experiment as defined under Test Conditions.

5.5 LUNAR EJECTA AND METEORITES

Background and Justification

The history of in situ measurements of the spatial distribution of cosmic dust covers almost 2 decades. Still a severe disagreement concerning the cosmic dust influx rates near the earth persists and varies over several orders of magnitude. The two extremes of this disagreement are defined by zodiacal light measurements on the low spatial density and microphone measurements on the high spatial density end. The conclusions drawn from each of these two types of measurements are persistently exposed to questions and criticism due to assumptions concerning the cosmic particle characteristics.

This experiment on the lunar surface will provide reliable data on long term variations of cosmic dust flux densities in the vicinity of earth. This will be accomplished by measuring the mass distribution, speed, and direction of cosmic dust particles of mass 10^{-9} grams and less which impact on the moon during annual meteor showers as well as during normal periods of activity. This mass distribution can readily be extrapolated to particle masses which produce significant lunar ejecta and surface erosion.

In addition, the experiment will measure the extent and nature of the lunar ejecta which is crucial to our full understanding of the origin and nature of the lunar soil.

The Lunar Ejecta and Meteorite experiment is related to, and complementary with, the similar satellite experiments carried on Pioneers 8 and 9.

The Apollo Window Meteoroid experiment was conducted during Apollo 14, 15 and 16. Ten possible meteoroid craters have been detected on various Apollo CM heat shield windows. The Apollo 11, 15 and 16 windows have not been analyzed. A

Previous Mission Assignments

Experiment Number	Title	Mission
S-176	Apollo Window Meteoroid	14
S-176	Apollo Window Meteoroid	15
S-176	Apollo Window Meteoroid	16 A

5.6 LUNAR GEOLOGY INVESTIGATION

Collect and document samples, and study lunar surface geology.

Purpose

The purposes are to obtain a better understanding of the nature and development of the Taurus-Littrow area and the processes which have modified the lunar 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 Apollo Mission J-3, in consultation with the Science Working Panel representing the requirements of Principal Investigators for sample analysis.]

The functional test objectives are as follows:

FTO 1) Examine, describe, photograph, and collect lunar geologic samples from craters for return to earth.

FTO 2) Examine, describe, photograph, and collect lunar geologic samples from boulders for return to earth.

FTO 3) Examine, describe, photograph, and collect lunar geologic samples of rocks and soils including special soil and special container samples.

FTO 4) Examine, describe, and photograph field relationships (such as shape, size, range, patterns of alignment, or distribution) of all accessible types of lunar features such that theoretical models pertaining to the origin of lunar features and the nature of lunar processes can be evaluated. C

FTO 5) Return an organic control sample in each SRC.

Test Conditions

Test Conditions for each of the FTO's are presented in tabular form in Table 1. This format had been adopted for ease of reference in the preparation of crew training procedures and timelines. Sample procedures referring to similar situations are grouped to facilitate integration of activities.

Information on procedural requirements which would not fit into this table are presented on the following page.

The following procedures are applicable to the activities and photographs as shown in Table 1.

A. Documented Sample Procedures (applies to activity numbers 1 through 8, 10, 11, 19 and 20).

- Documented sample areas should include a sample of each recognizable rock type and a scoop of soil (∿200 gm)
- Select different types of rocks and soil showing variations in color, texture, shape, degree of rounding and mineral composition.
- Where rocks are too large to be collected, it is highly desirable that chips be removed by chipping or prying. The number and location of chips to be taken will be determined by rock texture, mineralogy, structure and surface exposure. Chips should be taken from each recognizable rock type. If different types cannot be distinguished, it is highly desirable that a chip be taken from two or three separate large rocks.
- Rake/soil samples should include up to one kilogram of rock fragments from 1 to 4 centimeters in diameter taken from a smooth area relatively free from recent small craters and ejecta. In addition, a sample of approximately 200 grams of undisturbed soil will be taken from just outside the raked area. A sample of approximately 1 kilogram (rather than 200 grams) of undisturbed soil will be taken from just outside the raked area on five occasions (once at each of the major geologic units to include dark mantle, subfloor, South Massif/light mantle, North Massif and Sculptured Hills). C
- Documented samples will be placed individually in prenumbered sample bags whose identity will be called out at the time the sample is placed in the bag. Soil and rock samples may at crew discretion be placed in the same bag, except if the rock is friable or fragile. The sample bags will be stored in an SRC or a sample collection bag (SCB). Samples too large to fit in the sample bags will be stored in an SCB.
- These sampling procedures will be carried out where the specified field relations can be observed, documented, and sampled. Where the geologic circumstances permit, integration of these procedures with each other or with mandatory sampling procedures as described above is preferred in order to satisfy more than one requirement with the same sample.

B. Photographic Procedures

1) Documented Sample Photography

Single geologic samples and the rake/soil 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.

- Four photographs will be taken before sampling. One photograph will be taken down-sun at a distance of 11 feet. Immediately following, a location photograph will be taken from the same spot. It will include some identifiable landmark or object (preferably the LRV or LM), and horizon with the camera focused at the far-field detent. A stereo pair will be taken cross-sun at a distance of 7 feet and will include the photometric chart.

- If a down-sun photograph is not taken, a location photograph will be taken approximately cross-sun at a distance of 15 feet before or after the sampling and will include the sample area and identifiable landmark or object as described above.

- 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.

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 after-sampling photograph are mandatory. It is highly desirable that a location photograph be taken approximately cross-sun at a distance of of 15 feet as described above.

2) Panoramic Photography with 60-mm Lens

Large areas of the landing site will be documented by panoramic photographs. The far-field (74-foot) detent will be used for all panoramic photographs. The astronaut will aim the HEDC with 60-mm lens so that the horizon will appear in the top half of each photograph. In the down-sun photograph, the picture must include the astronaut's shadow. If the shadow is so short that it cannot be photographed in the same frame with the horizon, a second photograph will be taken in the same direction to include the shadow.

One panorama at each station stop will be taken with black-and-white film. It is highly desirable that a second panorama or partial panorama of the sampling area be taken with at least a 20-meter base and the baseline should be oriented from East to West. To simplify crew procedures, this second panorama may be taken in color.

Partial panorama sets will be taken from the LM windows to cover the entire visible area, particularly in the immediate vicinity of the LM.

3) Flight Line Survey Photography

Flight line survey photographs will be taken along a baseline that is parallel to the boulder or other feature being photographed. The optimum spacing between camera stations is 1/4 of the distance to the object to be photographed. A spacing of 1/10 to 1/2 of the distance to the object is acceptable.

4) Close-up Stereo Pairs

Close-up stereo pairs of details of rocks and soil textures, structures, sampling sites, etc. should be taken as time permits. Tongs or scoop will be used to establish the distance from camera to object.

5) Polarimetric Photography

a) Far-field polarimetric measurement photographs will be obtained with an HEDC.
The following procedures will be used to obtain partial panoramas.

The astronaut will select a far-field area of interest, that includes the North Massif and Sculptured Hills or South Massif, and maneuver to about cross-sun. The polarizing filter will be attached to the camera lens. The camera will be focused at the far-field detent, and the shutter speed changed to 1/125 sec. C

Partial panoramas will be taken of the field of interest through the filter. The f/stop and shutter speed between photographs will not be changed during a polarization sequence. All three filter positions will be used and reported before moving to the next azimuth position (positions are approximately 20° apart). Three azimuth positions should be taken in each partial panorama (cross-sun, 20° and 40° up sun of cross-sun view).

If the astronaut cannot maneuver, then a set of 3 photographs, one at each filter position, will be taken with the camera pointing east of north (or west of south) such that the phase angle is approximately 110°.

b) Deleted.

C

6) Standard Core Tube Photography

A location photograph including the core tube and LRV or horizon will be taken from a distance of 15 feet after core tubes are emplaced.

The gnomon will be position near the core tube. The leg with attached photometric chart will be pointed up-sun.

After embedding the core tube in the lunar surface but prior to hammering the core tube, a cross-sun stereo pair of the gnomon and the core tube will be taken from a distance of 7 feet. The numbers (or other identifying marks) on the core tube will be visible.

7) LRV Sampling Photography

The crew will select points along the traverse where it is desirable to collect a soil sample with the LRV sampler device (without dismounting from the LRV). When approaching such a point, the LMP will take two photographs with the HEDC of the approximate sampling area. It is highly desirable that the LRV be parked cross-sun ±45 degrees prior to sampling. At the conclusion of the sampling operation, each crew member will take a straight-ahead photograph, using an HEDC, to provide data that will aid in determining the location of the sample.

8) 500 mm Photography

The HEDC with 500 mm lens may be used, if suitable targets exist, to photograph distant targets, such as: blocks and albedo contrasts in large craters; lineaments, boulders, boulder tracks, possible out crops and source areas of light mantle on South Massif; lineaments, boulders, boulder tracks, and possible out crops on North Massif and Sculptured Hills; pictures of the scarp.

9) LRV Photography C

While on route between stations, photographs should be taken at intervals (approximately 50 to 100 m apart) to document the lurain, its uniformity and/or heterogeneity.

10) Television Procedures

At each major geological site, including the LM and ALSEP sites, a television full panorama will be performed, at the earliest convenient time. The panorama should be made with pauses in the scan to permit polaroid hard copies to be obtained in the Science Support Room. Targets of opportunity for television coverage will be determined in real time. No astronaut activity is planned in support of these TV requirements.

11) General Comments C

The priority of stowage of return lunar samples in the SRC's is as follows:

1) Organic Control Sample
2) Sample stowed in the CSVC
3) Sample stowed in the SESC
4) Up to four core tubes
5) Documented samples
6) Rake/soil samples (1 kg of rocks and 1 kg of soil each)
7) Rake/soil samples (1 kg of rocks and 200 grams of soil each) C

Success Criteria

FTO 1)
FTO 2)
FTO 3)
FTO 5) Verbally and photographically documented samples shall be collected, placed in the proper containers, and returned with the film data to the LRL.

FTO 4) 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) 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)

Data Requirements

1) Experiment Support Data (ESD):

   a) Position of the landed LM as determined by the MCC and crew comments. (M)

   b) Voice Comments: (M)

      (1) Comments and identification of samples (by sample bag number and sample collection bag number) 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. (M)

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 photographic documentation as shown in Table 1. (Priorities are as shown in the table.)

e) Sequence Photographs: (HD)*

(1) Descent to touchdown.

(2) Ascent from lunar surface.

(3) All orbital photography of the landing area.

f) Lunar samples as shown in Table 1. (Priorities are as shown in the table.)

g) Lunar surface TV video tapes. (HD)

h) Copies of annotated photomaps returned from the moon. (HD)

*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.

5.6 LUNAR GEOLOGY INVESTIGATION

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 were accomplished on Apollo 11, 12, 14, 15 and 16. A

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 landing site for Apollo 15 was Hadley-Apennine. The Apenninean material may provide very ancient rocks, the origin of which predates the formation and filling of the major mare basins.

The mission to Hadley-Apennine should resolve questions concerning the chronology of major events in lunar history, the nature of these events, and the composition of deep-seated materials.

The Apollo 16 landing site was the Descartes area of the lunar highlands. In this area, a variety of highlands constructional units were within range of the landing point. A

The Taurus-Littrow area is in the mountainous region of the southeastern rim of the Serenitatis basin, approximately 750 km east of the Apollo 15 site. Steep-sided massifs, accessible on LRV traverses, provide an opportunity to obtain old highlands material from an unsampled quadrant of the Moon. The landing point itself is on the floor of a graben-like trough whose subsurface is thought to consist of down-faulted uplands material that may be partially buried by younger basin-filling materials. The surface of the valley floor, as well as portions of the upland area, is covered by a dark mantle of probable pyroclastic origin.

Major surface features of special geologic interest include craters, shallow troughs at the bases of the massifs and sculptured hills, and the prominent east-facing fault scarp.

The larger craters (generally >100 m) on the plains surface are of three types: 1) large (.5 - 1 km) steep-sided craters that occur in a cluster near the landing point, 2) large subdued craters with barely perceptible rims, and 3) scattered clusters of smaller (<.5 km) craters. All three types are inferred to be older than the dark mantle although some could be contemporary volcanic sources. Exposures of wall and rim material are discontinuous and generally occur only on the inner wall below the rim crest. Elsewhere the ejecta are mantled except for scattered blocks large enough to project through the thin mantle. Although the larger craters are probably of impact origin, a volcanic origin for some may be considered. A

The dark mantle is excavated only by relatively small craters that are generally much less than 100 m in daimeter. The most likely vents for dark mantle material in the nearby uplands are small craters with related dark deposits of local extent. Vents in the plains area may be represented by similar small craters closely enough spaced so that the ejecta blankets overlap.

In many places the boundary between the uplands and the plains is a fairly sharp, topographic break accentuated by a shallow trough or slight depression at the edge of the plains. Although the great height and steepness of the massif faces show large-scale uplift of the mountain blocks relative to the plains, the bounding depressions suggest a final slight subsidence of the mountain blocks or uplift of the trough floor.

An apparently young, east-facing scarp, with local height of as much as 80 m, crosses the floor of the trough about 5 km west of the landing point and continues into the north massif. The scarp, which probably represents the surface trace of a complex fault, consists of alternating north and northwest-striking segments, each on the order of 5 km long. Some segments occur as single, continuous, approximately straight scarps, others as zones of discontinuous en echelon scarps. Between the light mantle unit and the north massif the scarp is covered by the dark mantle unit, which it therefore appears to antedate. However, distinctness of some segments of the scarp in the area of the light mantle and absence of dark mantle on some segments of the scarp on the north massif suggest that younger movement may have occurred.

The primary data for the Lunar Geology Investigation Experiment come from photographs, crew observations and interpretations, and returned lunar samples. Photographs taken according to specific procedures 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 filter will permit the measurement of the degree of polarization and orientation of the plane of polarization contained in C 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. A

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 gnomon with photometric chart attached will be photographed beside a representative rock and, if practical, beside any rock or fine-grained material with unusual features.

Sampling techniques vary with the nature of the area at each station stop. The basic samples at each site are the documented samples for which the standard photographic sequence is obtained. With these photographs the following basic data can be determined: the original lunar location and orientation, photometric properties of the samples and adjacent terrain on the lunar surface, the local lunar geologic environment of the sample, and photogrammetric analysis of rocks and surfaces in the stereoscopic coverage of the cross-sun pictures. Rocks and soil samples of this type can characterize the various geologic units identified at each site. A

The lunar rake is designed to collect all fragments larger than 1 cm across from an area free of rocks. This sample enhances the statistics of rock types and increases the probability of returning fragments which were thrown into the sample area from distant impact sites.

Small exploratory trenches, several centimeters deep, may be dug to determine the character of the regolith down to these depths. The trenches should be dug in the various types of terrain 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 centimeters of the regolith in terms of petrological characteristics and particle size.

A special environmental sample container (SESC) is being carried to ensure a vacuum seal on certain regolith samples. This is particularly desirable for a permanently shadowed sample which might be obtained in the shadowed side of a large boulder. A permanently shadowed locality is a cold trap and thus will preferentially precipitate and retain volatile elements. This sample when compared to an adjacent regolith sample that is exposed to the sun will permit an analysis of amounts and rates of transfer of the volatiles.

The Core Sample Vacuum Container is designed to return a single core tube of lunar material in lunar vacuum so that it can be stored and preserved for many years. This material may then be opened and analyzed by techniques as yet undeveloped.

A number of samples from boulders, soil beneath boulders, and soil in an east-west crack, will be collected as time permits if the special relationships required are found and identified.

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.

The LRV sampler is designed to permit sampling without dismounting. These samples will provide additional sampling points between major stations. This will aid in understanding the lateral variation in the surface materials C as well as providing an opportunity to sample targets of opportunity seen along the traverse route with the least time impact.

In order to more fully sample the major geological features of the Apollo Mission J-3 landing site, various groupings of sampling tasks will be combined and will be accomplished in concentrated areas. This will aid in obtaining vertical as well as lateral data in the principal geological

settings. Thus, some trench samples, core tube samples and lunar environmental soil samples will be collected in association with rake/soil samples. In addition, sampling of crater rims of widely differing sizes in a concentrated area will give a sampling of the deeper stratigraphic divisions at that site. Repeating this sampling technique at successive traverse stations will show the continuity of the main units.

Deleted A

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
S-059	Lunar Geology Investigation	15
S-059	Lunar Geology Investigation	16

A

Table 1. Experiment Activities

Tasks (Priority)*	Astronaut Activities	Photographs	Stowage	Rationale/Remarks	B
FTO 1) <u>Crater Sampling</u>					
1*. Rim sampling (soil and rocks). (M) 20 to 50 m diameter craters.	Scoop soil and collect rock samples from each crater rim. Take photographs.	Documented Sample Photography and partial panorama from each crater rim. (M)	In individual pre-numbered bags.	The material from the rims of the craters will provide samples from the deepest part of the craters.	B
2*. Radial sampling of a fresh crater (M) and diametric sampling (HD). 20 to 50 m diameter craters.	Collect 3 samples: 1 one crater diameter outward on ejecta field; 1 one-half crater diameter outward from rim; 1 on crater rim. Perform diametric sampling, time permitting: a) crater center; b) diametrically opposite crater rim; c) one-half outward from this crater rim; d) one crater diameter from this crater rim.	Documented Sample Photography. 1 stereo partial panorama after sampling along sampling direction. (M)	Loose in an SRC or collection bag.	The aim is to determine the stratigraphic history and characterize regolith structure of the area. The deepest material should be exposed at the crater rim; the material origin should get progressively shallower moving out from the crater; i.e., materials farthest away should have the shallowest origin in the crater. Photographs of the crater will record its size, type, and freshness (freshness is suggested by radiating patterns of high albedo material; i.e., "bright ray" craters, or by a large abundance of angular blocks or boulders).	B B

*Note: The numbers for each task are for reference only and do not imply priority. The word "Priority" refers only to the symbols (M) or (HD).

Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photographs	Stowage	Rationale/Remarks
2. Radial sampling of a fresh crater (M) and diametric sampling (HD). 20 to 50 m diameter craters. (Continued)	If time limited, rake/soil samples can be replaced by 2 scoops of soil and several documented rocks at each site. Take photographs.			
3. Fresh secondary crater soil and rocks. (HD) Crater with clearly associated remnants of impacting projectile (preferably 10 to 20 sq. cm, glass-coated, non-vesticular remnants)	Scoop soil and collect rocks from crater. Collect impacting projectile or chip. Take photographs.	Documented Sample Photography. (M)	In individual prenumbered bags.	Samples from crater soil and chips from rock(s) producing the crater will provide data on contemporary exposure histories. Undisturbed glass remnants (i.e., not struck by other projectiles) will provide magnetic lunar history.
FTO 2) <u>Boulder Sampling</u>				
4. Large boulders (M). Boulder >5 m diameter, most likely breccia	Collect samples. Take reference soil sample. Take photographs.	Flightline survey (3 to 5 frames). (M) Close-up stereo pair of each chip. (M) Documented Sample Photography of reference soil sample. (M)	Individual prenumbered bags.	Can be used for crater dating if boulders are unambiguously related to crater of interest. Samples will provide variation in lithology, rock structure and radiation history.

C

C

Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photographs	Stowage	Rationale/Remarks
5. Vertical split boulder chips. (HD) Boulder >1 m diameter. Split <5 cm wide. Crystalline or very hard breccia. Chips from vertical column down middle of interior surface (HD).	Pull or pry boulder apart along fracture. Collect chips from top, bottom, and interior surface. Take photographs.	Documented Sample Photography. (M) Close-up stereo pair after each chip. (M)	In pre-numbered bag in SRC.	Chips from fracture surface and boulder top/bottom will provide data on radiation history and long cosmic ray tracks.
6. Chips and soil from overturnable boulder. (HD) Chips from other sides. (HD)	Take chip from top, turn boulder over, take chip from bottom center. Collect soil from under boulder and reference soil from nearby unshielded location. Take chips from exposed sides. (HD) Crew judgment used on biggest rock which can be turned over. Overturned half should be N or E portion if split. Take photographs.	Cross-sun stereo pair before attempting to overturn the boulder. (M) Stereo pair of each of 3 other faces of the same boulder prior to overturning it. (M) Close-up stereo pair of chipped area. (M) Cross-sun stereo pair of overturned boulder. (M) Documented Sample Photography of reference soil. (M) Down-sun and location photos. (M)	In pre-numbered bag in SRC.	Chips and samples from soil underneath and adjacent to boulder will provide data on surface radiation history.

A

Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photographs	Stowage	Rationale/Remarks
7. Boulder with permanent shadow. (M, if encountered) >1 km from LM	Collect soil from permanently shadowed area beneath boulder overhang and chip from shadowed rock surface. Fill SESC to near capacity. Collect reference soil at least 1 m away in open area. Take photographs.	Adequate to permit calculation of shadow pattern on soil. (M) Documented Sample Photography of reference sample. (M)	In SESC and prenumbered bag in SRC.	SESC sample of soil under overhang will be used for analysis of volatile substances. Soil, if possible, should be from material (i.e., dark mantle cover) that was deposited after the boulder was implaced. C
8. East-West split boulder soil. (HD) >1 km from LM. Width of split <height of split; i.e., 45° shielding angle.	Collect soil sample from between split halves and reference soil sample from unshielded surface east or west of rock. Split should be narrow but wide enough to permit sample collection. Take photographs.	Flightline survey (3 to 5 frames). (M) Documented Sample Photography of reference soil sample. (M)	Individual prenumbered bags.	Soil from East-West split boulder will have been shielded from cosmic radiation. Soil, if possible, should be from material (i.e., dark mantle cover) that was deposited after the boulder was implaced. C
FTO 3) <u>Rock and Soil Sampling</u>				
9. Contingency sample. (M, if circumstances arise)	In event of actual contingency, collect loose sample of lunar material. Take photographs.	Location photo. (HD) Photo through LM window will be satisfactory if sample area is in view.	Suitable return container.	This lunar surface material will provide a lunar sample for earth return only if the lunar stay is terminated early in the first EVA period.

Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photography	Stowage	Rationale/Remarks
10. Documented Samples. (M) and (HD)	Scoop 100 to 200 gm of soil and rocks. Where rocks are too large, chips will be obtained. (M)	Documented Sample Photography. (M)	In pre-numbered bags in an SRC or sample collection bag. If too large, store in collection bag.	The intent is to obtain samples representative of the landing area.
At each major geological site on traverses and from each geological unit.				The photographs will show sample orientation, buried depth, relationship to other geologic features, and location with respect to the LM or other recognizable features. Photographs with gnomon and photometric chart will show orientation with respect to sun, lunar local vertical, and colorimetric properties; stereo-pairs will be obtained for precise photogrammetric measurements of features.
Rake/soil samples at stations representative of dark mantle, subfloor, South Massif/ light mantle, North Massif and Sculptured Hills.	Collect rake/soil sample including 1-kg rock from 1 to 4 cm diameter and samples from just outside each raked area, as described on page 5-40. (M)			
Around blocky-rimmed craters. (M)	Collect samples of local bedrock. (M)			
Within each major geological site.	Collect several roughly equidimensional rocks of 1 to 3 kg mass. (M)			
Each assessible layer.	Samples of bedrock. (M, if encountered)			
Each bedrock layer greater than 10 m in thickness. (HD)	Samples from top, middle, and bottom. Take photographs.			

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Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photographs	Stowage	Rationale/Remarks
11. LRV Sampling. (M)	Collect soil/rock samples along traverses without dismounting from LRV. Use LRV sampler device.	LRV Sampling Photography. (M)	LRV sampler bags in an SRC or a sample collection bag	Soil samples from many points along traverses provide information on transport mechanism for lunar surface materials and on lateral variation in dark mantle materials. Samples from LRV without dismounting is only manner to collect such samples in given time frame.
12. 2 lunar environment soil samples. (M) Use CSVC >1 km from LM away from flight path. Use SESC only if shadowed soil sample not previously collected in task 7. >1 km from LM away from flight path.	Collect single core tube sample and seal in CSVC. Collect soil sample from bottom of trench at least 10 cm deep, fill SESC to near capacity. Take photographs.	Documented Sample Photography. (M) Small exploratory trench photographs will suffice. (M)	CSVC in an SRC. In SESC.	These samples will be the only truly virgin vacuum samples from the moon and will provide biologically pure samples for gas analysis and for chemical and microphysical analyses.
13. 3.3-meter drill core. (M) At least 25 m from the ALSEP Central Station. (M) It is (HD) that it also be in center of largest old crater.	Obtain sample using Apollo lunar surface drill. Take photograph.	One location photograph. (M)	Stow drill stem sections in Beta cloth bag.	This core will provide the only deep sample of regolith and will help to determine stratigraphy in the sample area. The location within a crater will provide a subsurface line of sight between the RTG

Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photographs	Stowage	Rationale/Remarks
13. 3.3-meter drill core (M) (Continued)				and the Lunar Neutron Probe which will be inserted in the hole left by extracting the drill core sample.
14. 1 double core tube sample. (M) Should penetrate lower dark mantle sequence and enter subfloor materials.	Obtain core tube sample. Report number and order of multiple core tubes. Take photographs.	Standard Core Tube Photography. (M)	In an SRC or sample collection bag	This activity will provide a sample for determining stratigraphy and soil-type distribution to depths of approximately 0.6 meters in the lunar surface at selected locations (expected multiple layer areas). Thin edges of rays and ejecta blankets are preferable. The photographs will record the surface characteristics and location of the sample area.
15. 1 double core tube sample. (M) Remote from fresh craters near base of scarp. Lower tube should be placed in CSVC.	Obtain core tube sample. Report number and order of multiple core tubes. Take photographs.	Standard Core Tube Photography. (M)	In an SRC.	
16. 1 double core tube sample. (M) Remote from fresh craters near rake/soil sample. Should penetrate dark mantle sequence and enter subfloor materials at location other than task 14.	Obtain core tube sample. Report number and order of multiple core tubes. Take photographs.	Standard Core Tube Photography. (M)	In an SRC or sample collection bag.	

C

C

Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photographs	Stowage	Rationale/Remarks
17. 1 double core tube sample. (M) Remote from fresh craters near rake/ soil sample. In dark mantle. One single core tube sample. (M) Base of North Massif in massif debris, if possible.	Obtain core tube samples. Report number and order of multiple core tubes. Take photographs.	Standard Core Tube Photography. (M)	In an SRC or sample collection bag.	This activity will provide samples for determining stratigraphy and soil-type distribution to depths of approximately 0.6 meters in the lunar surface at selected locations (expected multiple layer areas). Thin edges of rays and ejecta blankets are preferable. The photographs will record the surface characteristics and location of the sample area.
18. Any remaining core tube sample. (HD) In vicinity of LM.	Obtain core tube samples. Collect at end of final EVA. Report number and order of multiple core tubes.	Standard Core Tube Photography. (M)	In an SRC or sample collection bag.	
19. Additional samples to maximize amount of material returned. (M)	Collect samples of particular interest in order of priority. In SRC's: a) small rocks; and b) soil. In SCB's: a) 15 to 20 cm equidimensional rocks; and c) soil. Collect near end of available sampling time on each EVA.	Before sampling cross-sun photograph. (M)	Loose in SRC's and SCB's.	15 to 20 cm diameter: The intent is to obtain information on the radiation history of the sun by providing a large sample with exposed and unexposed external areas. The photographs will record the exposed parts of the rock and the location of the sample area.

Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photographs	Stowage	Rationale/Remarks
19. Additional samples to maximize amount of material returned. (M) (Continued)	Take photographs.			5 to 15 cm diameter: Similar to rationale on previous page. Several small rocks may be more valuable than one large rock because of higher statistical significance of more samples.
20. 1 fillet sample - fillets around most of rock base. (HD)	Scoop fillet material before taking chip from rock. Scoop nearby typical soil sample 2 to 3 m from rock for reference. Take photographs.	Down-sun, location, and cross-sun stereo-pair before collecting fillet material. (M) Cross-sun stereo-pair after fillet material is collected. (M) Close-up stereo pair after chip. (M) Documented Sample Photography for reference soil. (M)	Chip, fillet material, and nearby reference soil will be placed in separate prenumbered bags.	The volume of the fillet may be directly proportional to the time the rock has been in position and to the rock size.

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Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photographs	Stowage	Rationale/Remarks
21. Small exploratory trenches. (HD) The following sites will be considered for trenching: a) near rim of small crater; b) in center of crater; c) in a mound; d) in an area where there is a change in surface characteristics such as color surface patterns, or mechanical properties.	Dig trenches 20° off sun line to a depth of 8 to 20 cm. Soil and rock samples will be taken at crew's discretion, except that 200 to 500 grams of soil will be taken from bottom of trenches in rake/ soil sample areas. Collect >1 buried rock, if encountered. Take photographs.	1 location photograph before or after sampling. (M) 1 stereo pair of the sunlit wall after trenching. (M) 1 after-sampling photograph. (M) Photos at crew's discretion if interesting features are observed. (HD)	In pre-numbered bag in an SRC or SCB	The intention is to determine the character of regolith and small scale stratigraphy in terms of petrologic characteristics and particle size. The photographs will record the surface characteristics and location of the trench sample area and other characteristics. Buried rock will provide an opportunity to assess effects of surface erosion when compared with exposed rocks.
21A. Fuel products contamination sample. (M)	Collect soil sample near LM descent engine skirt. Double bag. Take photographs.	1 location photograph after sampling showing sample area and part of LM.	Individual pre-numbered bags. Double bag and return in SRC.	The intention is to obtain a sample with the maximum contamination caused by the LM descent engine. Should be collected as early as practical.

C

Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photographs	Stowage	Rationale/Remarks
FTO 4) <u>Lunar Field Relationships</u>				
22. Lunar surface features and field relationships. (M)	Examine and describe following types of field relationships: a) surface patterns of linear features or other surface textures; b) rock surfaces that show textures such as layering, fracturing or color variations, and structures too large to return; c) craters that show a range of size, freshness, and degradation; d) rock-soil contacts such as fillets banked against rocks, especially those banked against rocks on one or two sides; e) boundary zone between hillside and relatively level ground at its base; f) disturbed (footprints, wheeltracks, trenches) and undisturbed surface material; g) source of light mantle (South Massif); h) out crops; i) boulders and boulder tracks; and j) scarp features.	Features and field relationships will be photographed at crew discretion using 60 mm or 500 mm lens. Short base stereo pair of targets of opportunity using 60 mm lens. (HD) Include scale (gnomon, LRV, etc.) in photo when possible. Take photographs.	N/A	Geologic feature color and texture differences infers age, origin, and composition of features.

Table 1. Experiment Activities (Continued)

Tasks (Priority)	Astronaut Activities	Photographs	Stowage	Rationale/Remarks
26. Deleted.				
27. Far-field polarimetric measurement photographs. (M)	Photos of North Massif-Sculptured Hills and South Massif.	Partial panoramas with camera cross-sun 20° and 40° upsun of cross-sun. (M)	N/A	Comparison of polarimetric signatures with those of known materials will allow classification and correlation of lunar material even though textures are not resolvable.
FTO 5) <u>Organic Control Sample</u>				
28. 2 organic control samples. (M)	Seal the organic control sample at the beginning of each EVA on which an SRC is used.	N/A	In each SRC.	These samples will permit a determination of the contamination within each SRC.

5.7 SURFACE ELECTRICAL PROPERTIES

Conduct the Surface Electrical Properties Experiment (S-204).

Purpose

The purpose is to obtain data about the electromagnetic energy transmission, absorption and reflection characteristics of the lunar surface and subsurface for use in the development of a geological model of the upper layers of the moon.

The functional test objective is as follows:

FTO 1) Obtain data on the electrical properties of the lunar subsurface as a function of depth and lateral position.

Test Conditions

FTO 1) The Surface Electrical Properties (SEP) experiment transmitter will be deployed on the lunar surface at a site at least 100 meters from the LM and 70 meters from any other metallic object.

The following astronaut activities will be accomplished:

a) The portable receiver and orthogonal-loop antenna will be mounted on the SEP brackets on the LRV. Receiver temperature will be read and reported to MCC. The receiver will be connected to the LRV to obtain range, bearing, and wheel rotation pulses from two LRV wheels.

b) Receiver thermal control will be exercised by readouts of the temperature indicator and operation of the radiator covers. If the receiver is deployed during the first EVA period, the receiver will be in the OFF position between the end of the first EVA period and the start of the second EVA period, with both flaps of the radiator covers open. In addition, the receiver temperature will be read at this time to MCC to help establish a heating gradient as a function of sun angle. C

c) Photographs of the receiver/antenna will be taken with a HEDC to show the general mounting arrangement and orientation.

d) The transmitter package will be deployed, leveled, and aligned using the bubble level and shadowgraph.

e) The transmitter antenna reels will be removed from the transmitter package and reeled out in two orthogonal directions (each antenna element within 90±10 degrees of the adjacent legs and within 180±10 degrees of the opposite leg), with one axis roughly normal to the initial traverse direction. The orientation of each antenna leg with respect to lunar north will be reported to MCC. C

f) A photograph will be taken of the deployed transmitter/ antenna with a HEDC to show orientation of transmitter and general layout of the antenna. It is highly desirable that one crew member take a HEDC photograph from the end of one of the four antenna elements to show lunar features and the other crewman standing at the far end of the opposite antenna element. Another HEDC photograph will be taken in a similar manner from the end of either of the other two antenna elements.

g) The transmitter power will be turned ON and MCC will be notified of this event.

h) Approximately twenty minutes prior to the start of the traverse during the second EVA period, receiver temperature will be read and reported to MCC. The receiver will then be switched to STANDBY and both flaps of the radiator covers will be closed. At the start of the traverse the receiver will be switched to the ON position. An HEDC photograph will be taken showing the position of the parked LRV (at the beginning of the traverse) with respect to the transmitter package. The LRV will start at a position as close as practicable but no more than 25 meters from the transmitter package and approximately 5 meters from that antenna element which points in the general direction of the subsequent traverse. The LRV will then move in a direction parallel to the same antenna element and the crew will report to MCC when the LRV passes the end of that antenna element. After reporting position and heading to MCC, the LRV will continue on the planned traverse. It is highly desirable that the LRV be driven in roughly a straight line for the first 300 meters of the traverse. The position and heading of the LRV will be reported to MCC by voice at each subsequent stop. C

i) The recorder will be powered down during the long station stops as necessary to insure recorder coverage through the end of the third EVA. Power will be applied to the recorder before proceeding and these power down and power up events will be reported to MCC as they occur. The receiver radiator will be dusted, as required.

j) It is highly desirable that prior to the end of the second EVA period the LRV return to the starting position as described in paragraph h) above, following the initial path between the end of the antenna element and the starting position. It is also highly desirable to push the NAV reset button at the end of the second EVA period prior to power down of the SEP receiver and recorder.

k) At the end of the second EVA period the receiver and recorder will be powered down. Both flaps of the radiator covers will be opened. Receiver temperature will be read and reported to MCC. C

l) Prior to beginning the third EVA traverse, power will be applied to the receiver and recorder. Both flaps of the radiator covers will be closed. Receiver temperature will be read and reported to MCC. C

m) At the beginning of the LRV traverse during the third EVA period, the LRV will be driven to a position similar to that described in paragraph h) above but near the transmitter antenna element that is in the direction of the subsequent traverse. An HEDC photograph will be taken from the transmitter package showing the LRV location. It is highly desirable that the LRV then proceed on the planned traverse as in paragraph h) above.

n) Recorder and receiver power will be applied and removed as noted in paragraph i) above.

o) At the end of traverse on the third EVA, it is highly desirable that the LRV be driven to the end of any one of the transmitter antenna elements and proceed parallel to the antenna leg to a position as close as practical to the transmitter package. It is highly desirable that the NAV reset button then be pushed. The receiver and recorder will then be powered down.

p) The SEP transmitter will be turned OFF anytime after power is removed from the receiver and recorder for the final time during the third EVA period.

q) The recorder with tape will be removed and stowed in the LM at the end of the third EVA period.

Success Criteria

FTO 1) Experiment data defined as mandatory under Data Requirements shall be provided to the Principal Investigator.

Evaluation

FTO 1) The data shall be analyzed to determine the following:

a) Changes in electrical properties due to layering in the regolith or other strata in the lunar subsurface, in the vicinity of the landing site, to a depth of one or two kilometers;

b) Electrical properties of surface lunar materials in situ;

c) Number and size of surface and subsurface scattering bodies;

d) Indications of the presence or absence of water beneath the lunar surface; and

e) Lunar thermal flux and location of zero degree isotherm. (Premission data, experiment support data and experiment evaluation data as defined under Data Requirements)

Data Requirements

1) Premission Data (PD): (M)

Premission data included in the Apollo 17 ALSEP Final Acceptance Data Package provided to NASA/MSC by the integration contractor. D

2) Experiment Support Data (ESD):

a) Position of the landed LM as determined by the MCC and crew comments. (HD)

b) Location of transmitting site with reference to LM and ALSEP and orientation of each antenna leg with respect to lunar north. (M)

c) Voice Comments: (M)

(1) Position and heading of LRV at each stop.

(2) Time of each turn-off and turn-on of receiver and recorder.

(3) Receiver temperature at deployment, at end of first EVA (if deployed during first EVA), at beginning and end of second EVA, and at beginning and end of third EVA.

(4) Mark as the LRV passes the end of the antenna elements at the start of the traverses during the second and third EVA periods.

3) Experiment Evaluation Data (EED):

a) Recorder with tape. (M)

b) Position of landed LM. (HD)

c) Astronaut Logs or Voice Records: (HD)

(1) Comments and description of deployment of SEP experiment and of transmitter site.

(2) Comments and description of traverse route and stops.

d) Astronaut Debriefings: (HD)

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

e) Still Photographs:

(1) Photographs of the receiver and antenna as mounted on the LRV. (M)

(2) A photograph of the deployed transmitter/antenna. (M)

(3) Photographs of the LRV position with respect to the transmitter packages at the start of the traverses during the second and third EVA periods. (M) B

(4) HEDC photographs from the ends of any two orthogonal antenna elements showing lunar features and a crewman at the far end of the opposite antenna element. (HD)

(5) One set of panoramic photographs per major site. (HD)*

4) Supporting Data: (M)

a) One copy of a topographic map of the traverse area with an accuracy of 10 to 15 meters in elevation. The map is to be provided by the S&AD of NASA/MSC.

b) One copy of LRV navigation data (reduced by MSC/FOD). B

*No specific crew tasks are required. Copies of the panoramas obtained at the major sites in support of the Lunar Geology Investigation experiment will be satisfactory.

5.7 SURFACE ELECTRICAL PROPERTIES

Background and Justification

This experiment will provide data on the electrical properties of the lunar subsurface as a function of depth and lateral position. The frequency range of the experiment has been selected to allow determination of layering and scattering over a range of depths from a few meters to a few kilometers. Accordingly, it may be possible to determine the thickness of the outer layer or regolith in the vicinity of the landing site. Such layering could be detected by the expected change in dielectric properties. This subsurface topographic information holds considerable implications for the history of the outer few kilometers of the moon. B

Recent seismic experiments have indicated that a large amount of scattering material may be present in the lunar subsurface. Since electromagnetic propagation in this experiment will be sensitive to these scattering bodies, and since a number of different wavelengths are being used, a measure of the size and number of scattering bodies is also possible. This would give additional information on the nature of the outer few kilometers of the moon.

Since minute amounts of water in rocks change the electrical conductivity by several orders of magnitude, any moisture present would be easily detected by this experiment. Thus, upper bounds can be set on the amount of water in the lunar subsurface to depths of a few kilometers.

Moreover, the presence of water in the moon would allow determination of the amount of heat flowing from the interior of the moon to the surface. The electrical properties experiment, under favorable conditions, could provide a determination of the depth at which any moisture present changed from the solid to liquid form. Thus the approximate depth of the zero-degree isotherm could be found. This depth, together with the knowledge of the thermal conductivity estimated from the heat flow experiment and lunar samples, could give an estimate of the lunar thermal flux.

The experiment will use a transmitting antenna set up on the lunar surface and both a receiver and recorder to be moved over the surface on the LRV. There are at least three waves which may reach the receiver: 1) a direct wave along and above the surface, 2) a direct wave along and below the surface; and 3) a reflected wave from the subsurface, if such a reflecting surface exists.

In general, these waves travel at different velocities and/or different distances, and therefore interact with each other at each point on the surface. The result is a series of peaks and nulls in the received field strength as the separation between the receiver and the transmitter is changed. It is this interference pattern of peaks and nulls which is indicative of the electrical properties of the medium and of the depth of the reflector. In actual practice, the situation is never quite so simple, due to such things as sloping interfaces, arbitrary changes in dielectric properties, more than two layers, and inhomogeneity of materials.

The usefulness of this method for depth sounding depends upon two implicit assumptions. First, the medium being probed must not be too lossy or the amplitude of the reflected wave will be too low to interfere well with the direct waves. Both the lack of moisture in the returned samples, and extensive radar data suggest that the moon will not be very lossy. Second, there must exist some strong electric contrast below the subsurface or there will be very little energy reflected. This contrast may be in the dielectric constant, as between soil ($\sim$3.0) and rock ($\sim$9.0 to 15.0), or in the conductivity, if a moist layer is present.

Interpretation of the data requires a knowledge of the location of the receiver relative to the transmitting antenna. The position of the LRV will be determined by crew reports and by traverse reconstruction from recorded LRV navigation system data (range, bearing and wheel rotation pulses from two wheels). Orientation of the LRV may be inferred from traverse leg directions and voice reports of LRV heading. B

The transmitter will produce continuous waves at 1, 2.1, 4, 8.1, 16, and 32.1 MHz successively, on each of two orthogonal transmitting antennas. The receiving antenna on the LRV will detect three orthogonal field components for each frequency and transmitting dipole combination. The field strengths, plus navigation data, will be recorded on a small analogue tape recorder which will be returned to earth.

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.8 TRAVERSE GRAVIMETER

Conduct the Traverse Gravimeter Experiment (S-199)

Purpose

The purposes are to make a relative survey of the lunar gravitational field in the lunar landing area and to make an earth-moon gravity tie.

The functional test objectives are as follows:

FTO 1) Measure the value of gravity, relative to the value at a lunar base station, at selected, known locations along the lunar traverse.

FTO 2) Measure the value of gravity, at a known point on the lunar surface (base station), relative to the value of gravity at a known point on earth.

Test Conditions

FTO 1) At each LRV scheduled science stop during each lunar geological traverse, a GRAV measurement will be made with the traverse gravimeter. In addition, it is highly desirable that a GRAV measurement be made at any unscheduled science stops.

At each scheduled science stop where gravity measurements are performed, a photographic panorama will be obtained to assist in determining the coordinates of the measurement site with respect to the base station. In addition, the panoramas should provide a permanent record of the lunar topography in the measurement location area. the HEDC will be used to obtain these photographs.

FTO 2) At the initial location (base station) from which the LRV departs for the first geological traverse, three gravity measurements will be made. Two of these measurements (one GRAV measurement followed by one BIAS measurement, in that order) will be made with the gravimeter on the lunar surface. One GRAV measurement will be made with the gravimeter mounted on the LRV.

At the end of the first traverse, and at the beginning and end of each subsequent traverse, a GRAV measurement will be made within 15 meters of the initial location (base station) where the first gravity measurement was made.

FTO 1)
FTO 2) Prior to each traverse, if the ON/STANDBY switch is in the OFF position, it will then be placed in the ON position. It is highly desirable that the READ switch then be depressed and the instrument temperature read D

by an astronaut to MCC.

Prior to any gravity measurement, at least 5 minutes of warmup time (20 minutes is highly desirable) must have elapsed with the instrument ON/STANDBY switch in the ON position. C

At the time each measurement is initiated by the astronaut actuating the appropriate switch on the traverse gravimeter, the astronaut will signal MCC, and MCC will record the time of each measurement to the nearest minute. C

The astronaut will transmit the gravity readings to MCC for each measurement. It is highly desirable that this be done prior to moving the LRV to the next stop on the traverse and preferably as soon as possible after the measurement has been completed. C

Success Criteria

FTO 1)
FTO 2) Experiment data defined as mandatory under Data Requirements shall be provided to the Principal Investigator.

Evaluation

FTO 1) The values of gravity at selected locations along the lunar traverses, with respect to the value of gravity at the lunar base station, will be determined to within ± 3 milligals (i.e., approximately 1.9 in 10^5 parts of lunar gravity). (Premission and experiment support data as defined under Data Requirements)

FTO 2) The value of gravity at the lunar base station, with respect to a selected base station on earth, will be determined to within ± 10 milligals (i.e., approximately 6.3 in 10^5 parts of lunar gravity). (Premission and experiment support data as defined under Data Requirements)

Data Requirements

1) Premission Data (PD): (M)

Calibration and Checkout Data:

Premission calibration and checkout data package provided to the Principal Investigator by the S&AD of NASA/MSC.

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

a) Voice Comments:

Gravimeter readings and time to the nearest minute for each gravimeter measurement.

b) Deleted B

3) Experiment Evaluation Data (EED):

a) Voice Records: (M)

One copy of voice records containing gravimeter readings and time to the nearest minute for each gravimeter measurement.

b) Astronaut Debriefings: (HD)

One copy of the transcript of astronaut postmission scientific and photographic debriefings pertaining to experiment operations and lunar geological characteristics of the locations where gravity measurements are performed.

c) Photographs: (M)

One copy of each of the photographs taken as described under Test Conditions.*

d) Supporting Data:

(1) A topographic relief map of the Apollo landing area covering a radius of 30 km around the landed LM and B encompassing all gravity measurement sites, with each measurement site identified. The map should include elevation contour intervals of 100 meters B or less, with elevations accurate to within ±15 meters, and with horizontal distances accurate to within ±25 meters. This map will be provided by B the S&AD of NASA/MSC. (HD)

(2) One copy of a tabulation of the coordinates of each traverse measurement site with respect to the lunar base station. Horizontal distances must be accurate to ±25 meters; elevations must be accurate to less B than ±15 meters, with ±2 meters preferred. These data will be derived with the aid of the panoramic photographs described under Test Conditions, and will be provided by the S&AD of NASA/MSC. (M)

*Panoramas obtained in support of detailed objectives or other experiments, such as Lunar Geology Investigation, will be satisfactory.

5.8 TRAVERSE GRAVIMETER

Background and Justification

Gravimetry is a major tool of geophysical exploration on earth. The interpretation of gravity anomalies on earth has led to major discoveries such as isostasy, tectogenes, lateral density variations in crust and mantle, strength of the mantle, geometry of geosynclines, margins, batholiths and figure of the earth. The first application of gravimetry to the moon, satellite tracking, provided an important contribution to lunar tectonics, the discovery of positive gravity anomalies correlated with ringed maria. Future satellite gravity studies of the moon will probably contribute to further understanding of large scale structures (>50 km). However, only lunar surface gravimetry can lead to the finer resolution required for exploring such features as mare ridges, edge effects of mascons, craters, rilles, scarps, thickness variations in the regolith and lava flows, density variations in the basement, and maria-highland interfaces.

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.9 LUNAR SOUNDER

Conduct the Lunar Sounder Experiment (S-209).

Purpose

The purposes are to obtain stratigraphic, structural, tectonic and topographic data, via electromagnetic soundings, of the lunar surface and subsurface; to obtain measurements of ambient electromagnetic noise levels in the lunar environment; and to measure lunar occultation of electromagnetic waves.

The functional test objectives are:

FTO 1) Obtain data in HF-1 and HF-2 bands to allow determination of lunar subsurface stratigraphic, structural and tectonic characteristics; and to construct a topographic profile along the great circles defined by the spacecraft lunar track.

FTO 2) Obtain data in VHF band to allow determination of near lunar surface stratigraphic, structural, and tectonic characteristics, and to construct a topographic profile along the great circles defined by the spacecraft lunar track.

FTO 3) Obtain data in HF-1 and HF-2 bands to measure cosmic, solar and Jovian noise; to measure solar wind electromagnetic noise; and to determine lunar occultation of the electromagnetic waves emanating from earth.

FTO 4) Obtain data in HF-1 and HF-2 bands to determine lunar occultation of electromagnetic waves emanating from the Lunar Surface Electrical Properties Experiment (S-204) equipment.

FTO 5) Obtain data in VHF and HF bands to allow determination of stratigraphic, structural, and tectonic characteristics of individual sounding targets.

Test Conditions

FTO 1) HF sounding data will be collected for two continuous orbits. HBR (high bit rate) telemetry is preferred during HF sounding; however, LBR (low bit rate) telemetry is acceptable. The CSM high gain antenna will not be used when performing HF soundings. While in the LBR mode, measurements SL 1250 E, SL 1251 E, SL 1255 E, SL 1276 V, SL 1277 V, SL 1278 V and SL 1279 Q will not be telemetered. The HF-1 and HF-2 transceivers will be operated continuously in the operate mode with the HF antennas fully extended during this period. Preceding and following B B the above data collection period, lunar sounder systems status data will be collected for at least 1 minute (but not more than 2 minutes) with the telemetry in HBR. It is preferred that the lunar sounder systems status (HF mode) data be received in real time; however, it is acceptable if it is delayed. The CSM high gain antenna will not be used when the lunar sounder system status (HF mode) data are being taken. The Surface Electrical Properties Experiment (SEP) will be in the OFF mode during the HF sounding period.

The VHF transceiver and all SIM bay equipment (i.e., experiments, cameras and laser altimeter) will be in the OFF mode during these two orbits of data collection and experiment calibration.

FTO 2) VHF sounding data will be collected for two continuous orbits with the experiment in the VHF mode and the telemetry in HBR (except that LBR data are acceptable during one overfly from longitude 150°W to 180°W and from 140°E to 110°E). The HF transceiver and other SIM bay equipment (i.e., experiments, cameras, and laser altimeter) will be in the OFF mode. The VHF sounding will be done as close to the HF sounding ground track of FTO 1) as is possible. C

FTO 1) FTO 2) The sounding data will be collected during lunar orbits in which the spacecraft altitude is continuously within the limits of 52 to 68 nautical miles with respect to the mean lunar surface. It is highly desirable that the HF and VHF data collection periods begin on the lunar nearside, at least 25 minutes before LOS, and that at least 5 minutes of sounder telemetry data (preferably at HBR) be downlinked in real time at the start of each data collection period. It is highly desirable that during two additional lunar orbits the remaining SIM bay equipment (such as the IR scanning radiometer, far UV spectrometer, laser altimeter, panoramic camera and mapping camera) be operated, with the HF and VHF transceiver in the OFF mode. The ground track of these two additional orbits will be as close as possible to the ground track for those orbits when sounding data are collected during FTO 1) and FTO 2). Minimum lunar sounder equipment cooldown requirements between data collection periods will be as specified in paragraph 3.13.3.4.2 of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027, Volume VI, CSM Experiments Data Book for J-Type Missions.

FTO 3) Test data will be collected in lunar orbit in the receive only mode. The telemetry will be in the HBR mode and the SEP will be OFF.

FTO 4) Test data will be collected in lunar orbit in the receive only mode. The telemetry will be in the HBR mode and the SEP will be ON. The test data will be collected during those orbits which come closest to overflying the landing site in order to obtain SEP signal occultation.

FTO 3)
FTO 4) FTO 3) and FTO 4) will provide a rising and setting occultation of the Sun, Jupiter, and the Earth. The coverage for each of these two FTO's will be equivalent to that for data collection over an arc beginning at least 45° east of the landing site, then passing completely around the moon, past the starting longitude and ending at least 45° west of the landing site. The coverage may be broken into two or more segments. Individual target soundings may be performed within ±45° of longitude from the landing site, providing that the ground tracks for individual sounding targets do not overlap. There is no restriction as to the ellipticity of the orbits. The HF transceivers will be in receive only mode with the antennas fully extended. The other SIM bay equipment (i.e., experiments, cameras and laser altimeter) will be OFF during these orbits of lunar sounder operation in the receive only mode.

FTO 5) Test data will be collected for short data sequences in VHF mode and HF-1, HF-2 operational modes for selected individual sounding targets. The data will be collected during orbits within that defined by the extreme parameters 68 x 52 NM. The targets, transmission time and mode are as defined by Table 1.

The recorder film remaining after completion of FTO 1) and FTO 2) shall be utilized to the fullest extent possible for FTO 5) individual sounding targets. The other SIM bay equipment (i.e., experiments, cameras and laser altimeter) will be OFF whenever the lunar sounder is used to obtain data from individual sounding targets. The SEP will be OFF during HF sounding of individual targets within ±45° of longitude from the SEP. HBR telemetry is required for VHF soundings and is preferred for HF soundings; however, LBR is acceptable for HF soundings. The CSM high gain antenna will not be used when performing HF soundings of selected targets. Preceding the data collection for the priority number 1 individual sounding target (see Table 1), lunar sounder systems status (HF mode) data will be collected for at least 1 minute (but not more than 2 minutes) with telemetry in the HBR mode. Lunar sounder systems status (HF mode) data will be obtained for another 1 to 2 minutes following the last sounding of an individual target in the same revolution that includes the priority number 1 individual target. It is preferred that the lunar sounder systems status (HF mode) data be received at MCC in real time; however, it is acceptable if it is delayed. D

FTO 1) FTO 2) FTO 5) The CSM attitude during the data acquisition will be CSM +X axis or -X axis pointed along velocity vector and SIM bay centerline aligned to nadir to an accuracy of ±1.4 degrees (not including the CSM attitude deadband contribution). The CSM attitude deadband will be ±0.5 degrees in all axes during VHF and HF operate modes. C

The lunar sounder HF and VHF operate mode science data will be stored on the instrument optical recorder located in the SIM bay. The film from the optical recorder will be retrieved during an EVA.

It is mandatory that FTO 1) be planned to occur prior to the other four FTO's. It is mandatory that FTO 1) and FTO 2) be planned to be completed prior to starting the remaining FTO's. The number of targets and duration of transmission for FTO 5) will be limited by the amount of film available on the optical recorder.

FTO 3) FTO 4) The CSM will be in inertial hold with the HF antenna horizontal to the ground. Attitude deadband will be ±5.0 degrees. The lunar sounder science data obtained during the HF receive mode will be recorded on the spacecraft data recorder reproducer for playback to the MSFN and/or transmitted to MSFN on downlink telemetry. C

FTO 5) When the receive only mode is interrupted for individual sounding target data collection, it is permissible to stay in inertial hold.

Success Criteria

FTO 1) FTO 2) FTO 3) FTO 4) FTO 5) Spacecraft attitude and trajectory data, astronaut logs and voice records for the Lunar Sounder Experiment periods shall be provided to the Principal Investigator.

FTO 1) FTO 2) FTO 5) The HF and VHF sounding experiment data shall be obtained and recorded on the optical recorder during the CSM lunar orbits specified, and during individual sounding target activities. The optical recorder film magazine shall be recovered during EVA activities. The experiment data shall be processed and delivered to the Principal Investigator. C

FTO 3) FTO 4) The HF experiment data (receive only mode) shall be obtained as requested during lunar orbits and provided to the Principal Investigator. C

Evaluation

FTO 1) FTO 2) The Principal Investigator Team will develop three-dimensional distributions of scattering centers by comparing the parameters of detected pulses (such as shape, amplitude, time and spectrum) to the parameters of the transmitted pulses. The scattering center distribution, together with calculated electromagnetic parameters will be used to produce a circumlunar geological model of the lunar interior to a depth of approximately 1.3 kilometers along the great circle paths over which the experiment is conducted. (Telemetry measurement tapes, astronaut records, astronaut debriefing data, trajectory data, optical recorder film, photographs and ground track supporting data)

FTO 3) FTO 4) The Principal Investigator Team will determine the occultation by the moon of electromagnetic waves emanating from the earth and from the Surface Electrical Properties Experiment. The deep lunar probing via occultation by the moon will be demonstrated, studied and evaluated. (Telemetry measurement tapes, astronaut records, trajectory data, and SEP supporting data)

The Principal Investigator Team will analyze the data to measure the solar wind electromagnetic noise, cosmic, solar and Jovian noise in the lunar environment and the occultation of these noise sources by the moon. (Telemetry measurement tapes, astronaut records and trajectory data)

FTO 5) The Principal Investigator Team will develop analytical studies of individual sounding targets such as mascons, ridges, and craters, to delineate their size, depth, and electromagnetic properties in order to permit the composition or mode of origin of the targets to be determined. (Telemetry measurement tapes, astronaut records, astronaut debriefing data, trajectory data, optical recorder film and photographs)

Data Requirements

1) Premission Data (PD):

a) Telemetry Measurements:

Telemetry measurements listed under 3)a).

b) Calibration and Checkout Data:

Calibration and checkout data in accordance with KSC procedure TCP-K-0005. (M) B

2) Experiment Support Data (ESD):

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

b) Voice Comments:

(1) Description and GET of changes to Lunar Sounder Experiment control during periods of experiment operation. (Mandatory only if telemetry measurements SL 1250 E, SL 1251 E, SL 1257 V and SL 1258 V are not available.)

(2) GET of operating SIM bay equipment (i.e., IR scanning radiometer, far UV spectrometer, laser altimeter, panoramic camera and mapping camera) when the lunar sounder equipment is in the OFF mode as specified in the Test Conditions for FTO 1) and FTO 2). (HD)

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority PD	ESD	EED
SL 1250 E	CSAR RF Power Output HF1	PCM	1	M	M	M
SL 1251 E	CSAR RF Power Output HF2 & VHF	PCM	1	M	M	M
SL 1255 F	CSAR Oscillator Frequency	PCM	1	M	HD(D)	M
SL 1256 T	CSAR Internal Temperature	PCM+	2	M	HD(D)	M
SL 1257 V	CSAR Receiver Gain HF1	PCM+	2	M	M	M
SL 1258 V	CSAR Receiver Gain HF2 & VHF	PCM+	2	M	M	M
SL 1261 E	CSAR Noise Pwr and Spec Pwr HF1	PCM+	2	M	M	M
SL 1262 E	CSAR Noise Pwr and Spec Pwr HF2/ Specular Power VHF	PCM+	2	M	M	M
SL 1275 T	Optical Rec Film Cassette Temp	PCM+	2	M	M(D)	M
SL 1276 V	Optical Rec Control Mode Status	PCM	1	M	M(D)	M
SL 1277 V	Optical Rec Echo Status	PCM	1	M	M(D)	M
SL 1278 V	Optical Rec Video Status	PCM	1	M	M(D)	M
SL 1279 Q	Optical Recorder Film Remaining	PCM	1	M	M(D)	N/A

b) Telemetry Measurement Tapes: (M)

Four copies of tapes** containing EED telemetered measurements listed under 3)a) recorded and correlated with GMT during periods of experiment operation. C

c) Astronaut Logs or Voice Records:

One copy each of astronaut logs or voice records containing:

(1) Description and GET of changes to Lunar Sounder Experiment control modes during periods of experiment operation. (Mandatory only if telemetry

measurements SL 1250 E, SL 1251 E, SL 1257 V and SL 1258 V are not available.)

(2) GET of operating SIM bay equipment (i.e., IR scanning radiometer, far UV spectrometer, laser altimeter, panoramic camera and mapping camera) when the lunar sounder equipment is in the OFF mode as specified in the Test Conditions for FTO 1) and FTO 2). (HD)

d) Astronaut Debriefings: (M)

One copy of each astronaut postmission scientific and photographic debriefing transcript pertaining to the period of experiment operation.

e) Trajectory: (M)

Four copies of tapes** containing best estimate of trajectory (BET) including spacecraft attitude for the CSM during periods of experiment operation. C

f) Optical Recorder Film: (M)

The original film from the optical recorder cassette and nine copies of all imagery developed from film exposed during experiment operation.

g) Photographs: (M)

One copy of each appropriate Mapping and/or Panoramic Camera photograph that has been taken of the lunar surface over which the lunar sounder has operated. Photographs are to be identified by GET and selenographic coordinates.

h) Supporting Data:

The following scientific data will not be provided by MSC but will be obtained through arrangement of the S-209 Principal Investigator Team with other principal investigators and with the Photo Team.

(1) Reduced and interpreted S-Band Transponder (CSM/LM), Far UV Spectrometer, IR Scanning Radiometer, Mapping Camera, and Laser Altimeter data over the lunar ground track scanned by the Lunar Sounder Experiment. (HD)

(2) Reduced and interpreted data from the Surface Electrical Properties Experiment. (M)

**Magnetic tapes produced are to be as follows: C

- One tape Univac 1108 computer-compatible digital, 7 track, 800 BPI (for JPL)
- One tape Univac 1108 computer-compatible digital, 7 track, 800 BPI (for U. of Utah) D
- One tape IBM 360/67 computer-compatible digital, 7 track, 800 BPI (for U. of Michigan) D
- One tape PDP 11 computer-compatible digital, 7 track, 800 BPI (for USGS)

5.9 LUNAR SOUNDER

Background and Justification

This experiment will provide fundamental new scientific data of the stratigraphic, structural, and tectonic composition of the lunar surface to a depth of 1.3 kilometers on a global basis.

The experiment will require the transmission of electromagnetic pulses from the spacecraft in lunar orbit, reflection of these pulses from the lunar subsurface and surface, then the subsequent detection and recording of the reflected pulses at the spacecraft. The data will permit the development of a circumlunar geological model of the lunar interior to a depth of 1.3 kilometers. The geological model will be developed from the electromagnetic sounding of the moon which will yield a cross sectional physical model of scattering centers derived from contrast in lunar electrical conductivity, dielectric constant, and the magnetic permeability. The model will then be interpreted in terms of the surface and depth distributions of lunar parameters.

The time delay of subsurface reflections with a given velocity profile will yield the thicknesses of various layers. Calculations of the apparent conductivity, reflection coefficient and apparent dielectric constant may delineate lunar electromagnetic parameters and enable detection of the regolith layer, the postulated ice layer and other possible differentiated layers within the lunar interior.

Mare-terra and other geological contacts, igneous intrusions, meteorite impact and permafrost accumulations may be evident from sounder data, as lateral changes in lunar properties are detectable through lateral variations in electromagnetic parameters.

Variations of radar return time will be used to denote depth variations of various lunar interfaces such as mare-terra contacts, changes in regolith depth, differentiated layers, and igneous intrusions.

The presence of subsurface water in pore liquid or permafrost form is evident in characteristic electromagnetic response. Total or regional absence of this characteristic response will imply a dry (less than 1%

pore liquid) lunar interior within the depth of penetration of the experiment.

The lunar sounder data will be studied at all spatial points where ground tracks cross the vicinity of known mascons. Variations in radar time returns and electromagnetic properties will delineate the electromagnetic properties of the mascons. The electromagnetic response may be sufficient to determine the mascon composition, geometry and/or mode of origin.

Lunar surface features such as surface roughness patterns, buried ejecta blankets, lava deltas, rille structures, and patterns of buried scatterers will be located and studied using the off-vertical sounding data. This surface areal information will be used to locate features completely around the great circle trajectory to an accuracy of 0.0007 radians of longitude or approximately 20 meters along the subtrajectory path.

The relative elevation between points separated by a few kilometers will be measured to a maximum accuracy of 1/10 of the wavelength of the center of each frequency band (i.e., an accuracy of 0.2 meters VHF, 2 meters at HF-2 and 6 meters at HF-1). These data in conjunction with data from the laser altimeter, cameras, accelerometers, spacecraft orientation, etc., will yield an absolute topographic profile. The lunar surface profile, along the great circles covered during the Lunar Sounder Experiment, will be developed with greater accuracy than was possible previously.

The electromagnetic waves from the earth and those emanating from the Surface Electrical Properties Experiment on the lunar surface will be monitored and studied with respect to lunar probing via occultation by the moon.

The VHF radar data and possibly some of the HF data are capable of providing coverage of the lunar surface on a complete great circle path. These data may be used as a base of reference (not provided by photography on the darkside of the moon) for laser and IR scanner selenographic mapping investigation.

The experience gained in technology and analyses from the sounder experiment will be invaluable in designing electromagnetic experiments for future space missions such as detection of surface or near surface water on Mars, and mapping major geologic units on Mars and Venus, and topside sounding of Jupiter.

Previous Mission Experiments

Experiment Number	Title	Mission
None		

Table 1. Individual Sounding Targets for FTO 5)

Priority	Target Description	Start Longitude	Stop Longitude	Transceiver Mode VHF	Transceiver Mode HF
1	Crisium, Serenitatis, Fra Mauro Apennine Bench and Euler Hills	99° E	36° W		X
2	Tsiolkovsky, Fermi	135° E	117° E		X
3	Tranquilitatis-Serenitatis Boundary	49° E	08° W		X
	Deleted				
4	Marius Hills	45° W	60° W		X
5	Apollonius Volcanics, Rima Cauchy I, and Tranquilitatis-Serenitatis Boundary	58° E	8° W	X	
	Deleted				
6A*	Reiner & Mare Ridge	49° W	64° W		X
6B*	Reiner & Mare Ridge	49° W	64° W	X	
7A*	Pasteur	110° E	98° E		X
	Deleted				
8	Hertesprung	117° W	144° W		X
	Deleted				

*The letters A and B mean that the priority of this target is based upon obtaining data in both the HF and VHF modes. If data cannot be obtained in one of these two modes, then a reordering of priorities may occur.

5.10 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 59 x 15 NM lunar orbit. B

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 circular 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.

Translational motion resulting from unbalanced RCS thruster firing when maintaining SIM bay attitude will slightly degrade the data but is permissible. 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.

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 four operational modes in which translational motion due to effluent dumps and fuel cell purges may take place. A

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. Deleted	
6. Deleted	

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 ground tracks. One ground track is gravitationally equivalent to another if it lies within a specific altitude-dependent band about that ground track. The size of such a band may be defined as follows:

$$BW = \frac{\text{Altitude}}{40 \sin i} = \frac{\text{Altitude}}{13.81}$$

where

BW = width of band in terms of degrees of longitude at the lunar equator.

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 20.2 degrees for FTO 1). [Not applicable to FTO 2) or FTO 3) due to the short tracking period.]

FTO 1)
FTO 4)
FTO 5) The CSM S-band transponder system will be operated during experiment periods while the CSM is in the circular, 59 x 15 NM elliptical, and 170 x 60 NM elliptical lunar orbits. B

FTO 2)
FTO 3) The LM S-band transponder system will be operated during the experiment period.

FTO 4) During the circular lunar orbit, the MSFN will track the CSM during a number of experiment data collection periods. It is highly desirable that each data colleciton period consist of two consecutive frontside passes. As a minimum, each data collection period will consist of one frontside pass. The total number of collection periods will be a function of the inclination of the CSM orbit. For an inclination of 20.2 degrees prior to LOPC, 4 revolutions must elapse between data collection periods before new unique gravitational data will be obtained. With an inclination of 23.25 degrees after LOPC, 3 revolutions must elapse.

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 test periods and delivered to the Principal Investigator.

FTO 2) 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 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

Measurement Number	Description	TM	Mode	Priority PD*	ESD*	EED
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
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

*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 59 x 15 NM lunar orbits. B

(2) The periods between AOS and LOS of the LM during descent.

(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.

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

d) MSFN Data:

(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)

(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)

(9) Identification of any USB ground station anomalies as shown in GSFC document DSS-670, "USB Mission Log." (HD)

e) Trajectory Data: (M)

Best estimate of trajectory (BET) of CSM/LM, CSM, LM, and LM ascent stage, on microfilm with only spacecraft state vector (time, position, and velocity) required during experiment data collection periods.

f) Supporting Data: (HD)

Reduced Laser Altimeter data for same time periods of S-band Transponder Experiment operation.

5.10 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, 15, and 16. These data will provide a factor of 10 improvement in spatial resolution over pre-Apollo experiments.

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 circular 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 for future lunar missions with an improved lunar gravity model.

Previous Mission Experiments

Experiment Number	Title	Mission
S-164	S-band Transponder (CSM/LM)	14
S-164	S-band Transponder (CSM/LM)	15
S-164	S-band Transponder (Subsatellite)	15
S-164	S-band Transponder (CSM/LM)	16
S-164	S-band Transponder (Subsatellite)	16

A

5.11 FAR UV SPECTROMETER

Conduct the Far UV Spectrometer Experiment (S-169).

Purpose

The purposes are to obtain data to determine the atomic composition, density, and scale height for each constituent in the lunar atmosphere and to investigate far ultraviolet (UV) radiation from the lunar surface and galactic sources.

The functional test objective is as follows:

FTO 1) Obtain data on spectral emissions in the spectral range from 1175 Å to 1675 Å.

Test Conditions

FTO 1) The Far UV spectrometer (UVS) will be operated and data collected while the CSM is in lunar orbit and transearth coast, under the following six conditions (arbitrarily identified as Modes I through VI). Modes I and II are of equal importance and are of higher priority than the remaining four modes. The UVS instrument cover will be closed during effluent dumps through the first two days in circular lunar orbit but not during subsequent dumps. The cover will also be closed during all operation of RCS jets A2, A4, B1, and B4, and whenever the spacecraft/sun line is within 20 degrees of the spectrometer optical axis.
Data collection periods will begin no sooner than 15 minutes after effluent dumps through the first two days in circular lunar orbit. It is highly desirable that data collection periods for inertial hold targets begin no sooner than two hours after effluent dumps. It is highly desirable that the UVS be operated whenever possible throughout the SIM equipment operating period. For all spectrometer operation except Mode VI, the CSM attitude deadbands will be ±0.5 degrees for inertial attitude hold targets and ±3.0 degrees for other targets.

Mode 1 (Nearside Terminator Mode). Data will be collected with the CSM +X axis aligned to the velocity vector and the SIM bay centerline aligned to the nadir.

C

Data in Mode I will also be acquired during crew rest periods in lunar orbit, and it is highly desirable that these be alternate rest periods (with remaining rest periods to be used for Mode II). Mode I data will be collected during a four-hour period from 1200 to 1600 hours CST on at least two days in lunar orbit. (Note: This is to ensure coordination with a rocket launch, at White Sands Missile Range, which will be scheduled for the first day in lunar orbit, with succeeding days as alternate launch dates.) The final period of Mode I data collection will be as late as practicable in lunar orbit.

Mode II (Farside Terminator Mode). Data will be collected with the CSM -X axis aligned to the velocity vector and the SIM bay centerline aligned to the nadir. Data will be collected during one 59 x 15 NM orbit from at least five minutes before terminator crossing (lightside) to at least 10 minutes after terminator crossing (darkside). Data in Mode II will be acquired during those crew rest periods in lunar orbit which are not used for Mode I data collection. C

Mode III (Lunar Grazing Mode). Data will be collected during two light side passes, once in a 59 x 15 NM orbit and once in an approximately circular orbit. The CSM will be maintained in inertial attitude hold such that the UVS optical axis will point at 6^h28^m right ascension, and -74 degrees declination while in the 59 x 15 NM orbit, and at 4^h32^m right ascension and -72 degrees inclination while in the circular orbit. The UVS cover will be opened 5 minutes prior to tangency of the instrument optical axis with the lunar surface. C

Mode IV (Solar Atmosphere Mode). During lunar orbit, data will be collected when the spacecraft is on the dark side of the moon. Before entering the shadow on one revolution, the UVS cover will be closed and the CSM will be placed in orbital attitude rate. The CSM attitude at the time of initiation of orbital rate will be such that the UVS optical axis will point at the receding lunar horizon in the ecliptic plane with the longer dimension of the field of view parallel to the horizon. The UVS cover will be opened as soon as practical after entry into the shadow, and orbital rate will be maintained for approximately 10 minutes after the cover is opened. The CSM will then be maneuvered at a rate of -0.2 degrees per second in the orbit plane to a point such that the UVS optical axis will point at the approaching lunar horizon with the longer dimension of the field of view parallel to the horizon. The CSM will then be placed in orbital attitude rate and maintained in orbital rate for the remainder of the darkside pass. The UVS cover will be closed as late as practical prior to entry into sunlight. C

Deleted

Mode V (Stellar Target Mode). During transearth coast, data will be collected with the CSM maintained in inertial attitude hold such that the UVS optical axis will point at celestial coordinate positions as specified below. C

Mode	Name	Right Ascension	Declination	Duration of Observation
V-1	Lyman Alpha Minimum*	$4^h\ 35^m$	+30°	1 hr.
V-2	Mode III Calibration	$6^h\ 28^m$	-74°	15 min.
V-3	Mode III Calibration	$4^h 32^m$	-72°	15 min.
V-4	Coma Cluster	$12^h\ 58^m$	+26°	1 hr.
V-5	Dark North	$14^h\ 00^m$	+22°	1 hr.
V-6	Virgo Cluster	$12^h\ 30^m$	+12°	50 min.
V-7	Spica	$13^h\ 24^m$	-11°	10 min.
V-8	North Ecliptic Pole	$19^h\ 00^m$	+78°	1 hr.
V-9	Dark South	$1^h\ 05^m$	-10°	1 hr.
V-10	Alpha Eridani	$1^h\ 39^m$	-58°	10 min.
V-11	Current position of moon			10 min.
V-12	Current position of earth			10 min.
V-13	Mode IV Calibration**			30 min.

C

* The smaller dimension of the 12° x 20° field of view will be oriented in the celestial east-west direction such that the CSM +X axis will point generally away from the sun.

**The Mode IV calibration data will include the same celestial scan as the Mode IV data obtained in lunar orbit (as limited by sun line constraints). C

Mode VI (PTC Galactic Scan Mode). Data will be collected during transearth coast while the CSM is in PTC. UVS operation will be as specified in the table below.

Mode	CSM +X Axis Right Ascension	Declination	Duration of Observation
VI-1	$10^h\ 25^m$	+07°	9 hr.
VI-2	$20^h\ 20^m$	+88°	8 hr.
VI-3	$5^h\ 45^m$	-47°	8 hr.
VI-4	$17^h\ 40^m$	+05°	45 min.
VI-5	$4^h\ 55^m$	+46°	1 hr.
Deleted			
VI-7	$0^h\ 55^m$	+08°	1 hr.

C

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 study and evaluate the data obtained from the MSFN receiving stations. Data obtained from this experiment will be in the form of pulse counts in each of 115 divisions of the spectral region from 1175 Å to 1675 Å. The position within this spectral range will determine the atmospheric (or other) species from which the radiation comes. Magnitudes of the counts at different positions in the spectral region will give information on densities of the corresponding species. The data collected in Modes I, II and III will also be correlated with lunar coordinates and with time during the mission to provide atmospheric composition and density as a function of altitude. (Premission, experiment support, and experiment evaluation data listed under Data Requirements)

Data collected in Mode IV and during transearth coast in Modes V and VI will be evaluated to determine the presence and distribution of atomic hydrogen between the earth and moon, to determine the ultraviolet emission of the earth, and to determine the emission of solar system, galactic, and extragalactic sources. (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). (HD)

b) Pre-installation Checkout Data:

Pre-installation checkout data in accordance with KSC procedure TCP KE-8003. (M) C

2) Experiment Support Data (ESD):

a) Telemetry Measurements:

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

3) Experiment Evaluation Data (EED):

a) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority PD	ESD	EED
SL 1100 K	UVS Spectrum Count - 16 bit Ser	PCMD	N/A	HD	M*(D)	M
SL 1101 T	UVS Housing Temp	PCM	N/A	HD	HD(A)	HD
SL 1102 T	UVS Motor Temp	PCM	N/A	HD	HD(A)	HD
SL 1103 V	UVS Input Voltage	PCM	N/A	HD	HD(A)	HD
SL 1104 C	UVS Input Current	PCM	N/A	HD	HD(A)	HD
SL 1105 V	UVS Photomultiplier Tube Hi Volt	PCM	N/A	HD	HD(A)	HD
SL 1106 V	UVS Regulated Voltage	PCM	N/A	HD	HD(A)	HD
SL 1109 T	UVS Electronics Temp	PCM	N/A	HD	HD(A)	HD

*This measurement is M during periods of mandatory experiment operation and HD during highly desirable periods of experiment operation.

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 Debriefings:

One copy each of astronaut postmission scientific and photographic debriefing transcript pertaining to both mandatory and highly desirable periods of experiment operation. (HD)

d) Photographs:

One copy each of appropriate Mapping and/or Panoramic Camera photographs that have been taken of the lunar surface over which the UV spectrometer has operated. Photographs are to be identified by BET and selenographic coordinates. (HD)

e) 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)

**Magnetic tapes produced are to be IBM 7094 computer-compatible digital 7-track, 800-BPI tapes.

5.11 FAR UV SPECTROMETER

Background and Justification

There is an important experimental fact about the lunar atmosphere, namely that the total density of the light atmospheric constituents (atomic hydrogen, oxygen, nitrogen) is less than 10^6 atoms per cubic centimeter. This conclusion is based on the absence of radiation scattering loss from a star near occultation by the dark limb of the moon.

This experimental fact leads to one simple conclusion. The base of the lunar exosphere is the lunar surface itself. Any quantitative analysis leading to values for equilibrium concentration of atmospheric constituents at the lunar surface requires a knowledge of the lunar degassing rate, which is unknown. Quantitative calculation of thermal escape or of escape by collisions with solar wind particles is therefore inconclusive. Consequently, the following qualitative analysis is presented, based on the known scale heights and average lunar velocities of candidate atomic species, together with the corresponding terrestrial parameters.

1) Solar wind protons cannot provide a high hydrogen atom concentration by picking up an electron at the surface because the escape velocity is less than the average thermal velocity of such atoms and the solar wind density is very low.

2) Nitrogen and oxygen molecules will be lost by escape. Because of their large scale height, these constituents will also escape as a result of collisions with solar wind protons. Those atoms which survive a ballistic excursion are probably tightly held by the lunar surface when they return, which would further reduce the equilibrium concentration.

3) The noble gases argon, krypton, and xenon would be expected to enjoy a longer lifetime. Their loss rate from direct escape is very small; their shorter time of flight per orbit reduces the probability of a collision with a solar proton and increases the chance that such collisions will drive them to the lunar surface, and their greater mass decreases the velocity imparted by a collision with a solar proton. Furthermore, these atmospheric components will not bind at the lunar surface and can quickly

recycle to the atmosphere after a ballistic impact. At each impact, the atoms should thermally equilibrate with the surface and neutralize if ionization occurred during flight.

4) The conclusions of paragraph 3) above are particularly true for the heaviest of the noble gases - xenon, mass 131, scale height 21 km, and mean velocity of 2.6 x 10^4 cm/sec. In fact, xenon could very possibly be the predominant species of the lunar atmosphere. If so, the stellar radiation scattering experiment would have had an upper limit of 10^7 atoms per cubic centimeter for the atmospheric density at the lunar surface (because of the reduced scale height).

5) If we assume that the total xenon content of the earth's atmosphere (10^{12} atoms per cubic centimeter at the surface, 10^{36} atoms total) can be scaled for the lunar atmosphere in proportion to the moon/earth mass ratio, the total number of xenon atoms in the moon's atmosphere is about 10^{34} and the surface density is 10^{11} atoms per cubic centimeter. The above calculation assumes that all of the earth's xenon is in its atmosphere and therefore provides a lower limit for the original lunar supply. Clearly, either the moon has lost most of its xenon or some remains trapped beneath the lunar surface. Although the above numerical exercises are inconclusive, they emphasize two key points:

a) Xenon may exist in the lunar atmosphere in densities as great as 10^7 atoms per cubic centimeter.

b) If the moon has an atmosphere, xenon is a prime candidate for the title of major constituent.

Since most atomic species that may be present in the lunar atmosphere are very sparse, it is necessary to maximize the sensitivity of the spectro-photometer. Accordingly, the largest and most sensitive system developed for studying planetary atmospheres is planned for lunar studies: a 1/2-meter focal length Ebert spectrometer with 6 cm long slits, 1/2 cm wide, a 100 cm^2 grating with 3600 grooves/mm, used in the second order, and collecting optics to direct the dispersed radiation to a solar-blind low dark current photomultiplier tube which employs pulse counting circuitry (dynamic range of 10^6) to measure the light intensity. The instrument is similar in design to the Mariner VI and VII UV spectrometer, but the increased dimensions provide almost an order of magnitude increase in sensitivity. The Ebert spectrometer will give an output of about 200 photoelectrons per Rayleigh.* With an observation time of the order of tens of seconds the limit of detection will be about .05 Rayleighs. However, stellar and galactic background, the magnitude of which is unknown, will probably limit the detectability to a higher value, particularly for hydrogen, where the known galactic background is a few hundred Rayleighs.

In the spectral range 1100 to 1700 Å several neutral atomic constituents have ground state resonance lines, and may exist in concentrations which are detectable by this experiment. These are hydrogen (1216 Å), carbon (1657 Å), nitrogen (1200 Å), oxygen (1304 Å), krypton (1236 Å), and xenon (1470 Å). In particular, there is a high probability that xenon will be detected. It is believed unlikely that any other constituent except hydrogen will be detected. It is important to know whether the lighter species exist in the virgin lunar atmosphere before man adds much more contamination. For example, the minimum amount of oxygen, nitrogen and carbon which can be detected represents only about 25 to 50 tons of each of these constituents in the lunar atmosphere.

Operation in Modes I and II will permit observation of the lunar atmosphere during predawn and post-sunset periods. During these periods the lunar surface is not illuminated but the atmosphere is illuminated, and resonantly scattered radiation can be observed. The instrument can be operated throughout the orbit, providing a measure of the lunar albedo and possible lunar phosphorescence. The operation in the above two modes has the advantage (as compared to operation in Mode III) that the lunar background is possibly lower than the galactic background, and measurements made at different solar depression angles provide scale height information. Surface scattering is not normally encountered in the far UV spectrum in planetary atmospheres because molecular species absorb the spectrum above the surface and above the level at which Rayleigh scattering becomes significant, whereas the full solar UV spectrum reaches the lunar surface

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*The Rayleigh is a unit of radiation brightness defined as 10^6 photons per cm^2 per sec per 4π steradians, and is equivalent to a variable energy per unit area per unit time per unit solid angle depending on the wavelength of radiation.

where a portion of the spectrum is diffusely scattered. This experiment will not be able to spectrally distinguish between the very weak resonance scattering and the diffuse surface scattering of the solar spectrum. Because of the possibility of contamination of the spectral measurement by surface scattering, no horizontal scanning mode will be employed. The instrumented rocket to be launched at White Sands Missile Range in coordination with Mode I operation will provide a calibration for UVS data acquired in lunar orbit.

Operation in Mode III will be at such an attitude that the spectrometer looks through a long atmospheric path against the galactic background. Mode III operation in a 59 x 15 NM orbit will maximize the atmospheric path and therefore the signal strength at the instrument. C

Operation in Mode IV will permit two important observations:

1. A search for ultraviolet zodiacal light.
   This light is very faint, but increases strongly in the direction of the sun. Normally the UVS cannot be pointed near the sun. The operation discussed here, however, makes use of the moon's limb as a shield to allow collection of data from only 7.5 degrees away from the sun's position in the sky. Data acquired from previous experiments (OAO) indicate a rapid increase in the zodiacal light toward the wavelengths sensed by the UVS. Apollo Mission J-3 provides a unique opportunity to verify and extend these observations. Separation of the zodiacal light from the general galactic light should be possible from the spectral character of the signal.

2. A map of the ultraviolet brightness of the available sections of the sky.
   This ultraviolet light is emitted by solar system hydrogen and by stars; the latter portion comes mostly from the galactic plane. The emission at high galactic latitudes is also of great interest as part of the radiation might be due to quasars or hot gas in clusters of galaxies.

Mode V and Mode VI operation of the spectrometer will view the galactic background while the CSM is in cislunar space. The instrument may determine the presence of an earth geomagnetic tail by detection of Lyman alpha radiation from hydrogen. One of the Mode V targets is the earth, which emits ultraviolet light through two basic processes, both solar in ultimate origin. Solar Lyman alpha radiation is resonantly scattered by hydrogen atoms in the outer part of the earth's atmosphere, and particles impinging on the earth's atmosphere cause atoms to be excited and subsequently emit ultraviolet photons. The experiment will measure the total airglow and aurora spectrum of the earth. A A

In summary, this experiment will provide data on spectral emissions from lunar atmospheric species by resonance re-radiation of adsorbed solar flux in the spectral range of 1100 to 1700 Å. It is predicted that the lunar atmosphere is composed predominantly of xenon, in concentrations perhaps as great as 10^7 atoms per cubic centimeter at the lunar surface. The measurement technique is potentially capable of measuring a density of 10^2 xenon atoms per cubic centimeter; it is also capable of detecting other atmospheric constituents which are not expected to be present in concentrations above 10^5 atoms per cubic centimeter and which probably are below the detectable limit of the experiment, i.e., 10^2 atoms per cubic centimeter.

Previous Flight Objectives

Objective Number	Title	Mission
None		

5.12 IR SCANNING RADIOMETER

Conduct the IR Scanning Radiometer Experiment (S-171).

Purpose

The purpose is to measure the thermal emission from the lunar surface beneath the orbiting spacecraft by scanning traversely to the ground track.

The functional test objective is as follows:

FTO 1) While the CSM is in lunar orbit, measure the thermal emission at the CSM from the lunar surface to obtain a high resolution surface temperature map.

Test Conditions

FTO 1) The mandatory portion of the experiment will be performed after the CSM circularization burn at lunar altitudes no lower than 40 NM. In addition, it is highly desirable that data be acquired in the 59 x 15 NM lunar orbit. Data from this orbit can be approximately corrected for analysis by estimating the effect of the deep space calibration scan from previous and/or succeeding operation periods. As a minimum, mandatory data will be collected in segments of four hours duration, spaced 24±2 hours apart, throughout the mission period when the CSM is above the required altitude specification. It is highly desirable to operate the experiment in more frequent, equally-spaced periods of length equal to two or more complete revolutions. Concurrent operation of the IR Scanning Radiometer during periods of laser altimeter operation is highly desirable. It is highly desirable to maximize common surface area coverage between this experiment and the Lunar Sounder Experiment (to provide complementary data to aid in interpretation of the IR sensor results). C

During lunar orbit experiment operation, the CSM will be maneuvered such that the SIM bay centerline points toward the lunar surface along the local vertical to an accuracy of ±1.4 degrees (not including the CSM attitude deadband contribution). The CSM attitude deadband will not exceed ±3.5 degrees in all axes during experiment operation. It is highly desirable that at least one experiment operation segment be performed using CSM attitude deadband of ±0.5 degrees. The SIM centerline direction must be known to within ±1.4 degrees (not including the CSM attitude deadband contribution) to satisfy postmission pointing knowledge requirements. Data will be collected with the CSM +X axis or -X axis aligned along its velocity vector.

The crew will set the IR sensor operation switch to the ON position for 10 minutes prior to SIM door jettison. Initial and subsequent data collection periods will be preceded by a warm-up period in accordance with paragraph 3.11.3.4.1 of the CSM/LM Spacecraft Operational Data Book, SNA-8-D-027(VI), Volume VI, CSM Experiments Data Book for J-Missions.

RCS jets A2, A4, B1 and B4 will be inhibited and liquid dumps (urine and waste water) and fuel cell purges will be prohibited during periods of experiment operation. It is highly desirable that all RCS firings and effluent dumps and purges be minimized from the time of SIM door jettison until all planned experiment data collection segments have been completed. The IR sensor protective cover will be in the CLOSE position when these jets are enabled and effluent dumps and SPS burns are performed. When an effluent dump is necessary, the protective cover will remain in the CLOSE position for at least 30 minutes after the dump is terminated.

All CSM maneuvers will be performed with the sensor protective cover in the CLOSE position.

The Scientific Data System must be operating prior to applying power (switch ON position) to the sensor.

Deleted D

Success Criteria

FTO 1) Mandatory experiment data defined under Data Requirements shall be obtained and provided to the Principal Investigator.

Evaluation

FTO 1) The data analysis and evaluation will be conducted postflight by the Principal Investigator. A lunar surface temperature map will be generated directly from the gathered data which will lead to the calculation of cooling curves for various lunar regions. These curves will enable the characterization of such physical parameters as the lunar surface thermal conductivity, the bulk density, and the specific heat. Lunar surface thermal anomalies at high resolution will also be identified. (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).

b) Calibration and Checkout Data:

(1) Calibration Data:

Magnetic tapes** containing analog signals from the Infrared Scanning Radiometer (ISR) scientific data channels, recorded during calibration operations by the instrument contractor. (M)

(2) Checkout Data:

Calibration and checkout data in accordance with KSC procedure TCP-K-8004. (M) B

2) Experiment Support Data (ESD):

a) Telemetry Measurements

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

b) Voice Comments:

(1) Description and GET of changes to experiment control and protective cover settings during mandatory periods of experiment operation. (M)

(2) Description and GET of changes to experiment control and protective cover 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 1126 K	ISR Data Channel No 1	PCM	N/A	M	M*(A)	M*
SL 1127 K	ISR Data Channel No 2	PCM	N/A	M	M*(A)	M*
SL 1128 K	ISR Data Channel No 3	PCM	N/A	M	M*(A)	M*
SL 1129 T	ISR Prim Mirror Temp	PCM	N/A	HD	HD(D)	HD
SL 1131 T	ISR Calibration Patch Temp	PCM	N/A	M	M*(D)	M*
SL 1132 T	ISR Detector Temp	PCM	N/A	M	M*(D)	M*
SL 1134 V	ISR Bias Voltage Mon	PCM	N/A	HD	HD(D)	HD
SL 1135 V Deleted	ISR Circuit Voltage Sum	PCM	N/A	HD	HD(D)	HD
SL 1202 T	Temp Thrm Envir-BM1 XS221,R62	PCM	1	N/A	N/A	HD
SL 1221 T	Temp Thrm Envir Shelf XS236.5, R70	PCM	1	N/A	N/A	HD

B

B

Measurement Number	Description	TM	Mode	Priority PD	ESD	EED
Deleted						
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 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 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

B

b) Telemetry Measurement Tapes: (M)

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 and protective cover settings during mandatory periods of experiment operation. (M)

(2) Description and GET of changes to experiment control and protective cover settings during highly desirable periods of experiment operation. (HD)

d) Astronaut Debriefings:

One copy of each astronaut postmission scientific and photographic debriefing transcript pertaining to both mandatory and highly deisrable periods of experiment operation. (HD)

e) Photographs:

One copy of each appropriate Mapping and/or Panoramic Camera photograph that has been taken of the lunar surface over which the IR Scanning Radiometer has operated. Photographs are to be identified by GET and selenographic coordinates. (HD)

f) Trajectory:

One copy of tape** containing:

(1) Output of the Apollo Photographic Evaluation (APE) program, modified for the IR scanning Radiometer, during mandatory periods of experiment operation. (M) C

(2) Output of the Apollo Photographic Evaluation (APE) program, modified for the IR Scanning Radiometer, during highly desirable periods of experiment operation. (HD) C

g) Supporting Data:

The following scientific data will not be provided by MSC but will be obtained through arrangement between responsible Principal Investigators:

(1) Reduced and interpreted Lunar Sounder Experiment data gathered over lunar surface scanned by the IR Scanning Radiometer experiment. (HD)

(2) Precision spacecraft altitude and IR sensor pointing information obtained during periods of IR sensor operation as derived from reduced laser altimeter data and stellar camera photographs***, respectively. (HD)

*This measurement is M during mandatory experiment operation and HD during highly desirable experiment operation.

**Magnetic tapes produced are to be IBM 7094 computer-compatible digital 7-track, 556 - BPI tapes.

***There is no requirement for stellar camera photographs to support this experiment. If, however, these photographs are obtained on the lunar dark side in support of other objectives (such as SM Orbital Photographic Tasks), then they will provide useful data.

5.12 IR SCANNING RADIOMETER

Background and Justification

The IR (infrared) Scanning Radiometer Experiment is intended to obtain a surface temperature map of the lunar surface at a higher resolution than has been possible before. The data for the unilluminated portion of the front side of the moon will be improved. The back side of the moon has not previously been surveyed in the infrared spectrum. This resulting temperature map will permit the calculation of cooling curves for various lunar regions and, hence, to the characterization of such lunar surface physical parameters as the thermal conductivity, the bulk density, and the specific heat.

The data from this experiment will be used to locate, identify, and study anomalously hot or cold regions at a high spatial resolution over relatively long term surface cooling periods. Previous earth-based IR searches for thermal anomalies have been limited to spatial rather than localized temporal scans across the lunar sunset terminator and from localized temporal studies conducted for a few hours while the lunar surface was darkened by an earth eclipse. Other relatively recent earth-based observations in the IR have been concerned with the detection of the low predawn lunar surface temperatures acquired during lunar phases near the new moon. These observations have served to identify thermal differences between maria and highland regions, apparent differences between the number of eclipse and night-time anomalies, and the presence of lunar material with unusual thermal properties.

The identification of such thermal anomalies at high resolution will aid in the understanding of the problem concerning the origin of surface features exhibiting previously unexplained anomalous thermal "signatures." Typical of such features would be surface rock fields, crustal structural differences, volcanic activity, fissures emitting "hot" gases, and the like. This experiment can conceivably provide sufficient information to answer the following questions related to some of the thermal puzzles noted from earth-based observations:

a) Why have certain small craters exhibited intense anomalies while some large craters have shown practically no anomalies at all?

b) Why do certain maria contain a high concentration of anomalies while other maria have only a few anomalies?

c) Why cannot some anomalies be readily identified with a particular surface feature?

Lunar dark side thermal studies will be enhanced by the ability of the IR sensor to detect variations in the rate at which dark side cooling is taking place which, in turn, is related to subsurface structure composition by inference of exhibited thermal and other physical properties. An additional benefit to be derived from this experiment would be the resolution of whether or not the moon is an inert body (possessing no internal heat sources). If it were discovered that the moon has internal heat sources, a scientific discovery of immense significance would be realized. Contemporary scientific hypotheses presume the moon to be an inert body. In this respect there is now known to be a significant tie-in of the ISR experiment with preliminary results currently being formulated from the Apollo 15 Heat Flow Experiment (HFE). The extensive spatial mapping of lunar cooling curves to be obtained with the ISR experiment in conjunction with additional data now being received and analyzed from the Apollo 15 HFE and that expected to be obtained from temperature probes to be emplaced at the planned Apollo Mission J-3 HFE site may add a significant dimension to the history of lunar thermal evolution, its present thermal state, and clues to the origin and makeup of surface and subsurface structure. A

Finally, hardware and operational experience obtained from this experiment will serve as a basis for the development of an advanced IR spectrometer capable of performing a compositional characterization of planetary surfaces for advanced lunar and planetary missions.

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.13 LUNAR NEUTRON PROBE

Conduct the Lunar Neutron Probe Experiment (S-229).

Purpose

The purpose is to measure the neutron capture rates of lunar materials as a function of depth in the lunar regolith.

The functional test objectives are as follows:

FTO 1) Determine the average mixing depth for lunar soil.

FTO 2) Determine the degree of stratification and mixing history of lunar soil cores.

FTO 3) Determine the average irradiation depth for lunar rocks.

FTO 4) Obtain information on the lunar neutron energy spectrum.

Test Conditions

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

The Lunar Neutron Probe experiment will be unstowed, activated, assembled, and inserted approximately two meters deep into the lunar soil in the hole left by extracting the deep core sample (part of experiment Lunar Geology Investigation S-059). The probe will remain in the lunar soil for at least 24 hours and will then be extracted, deactivated, stowed, and returned to earth for analysis. It is highly desirable that the probe be emplaced during the first EVA period and that it remain emplaced until the third EVA period.

The astronaut will photograph the deployed probe using a HEDC from a distance of approximately 7 feet to provide a permanent record of the depth of penetration into the lunar soil. D

It is highly desirable that a photograph of the deployed probe and the RTG be obtained which shows the approximate separation distance between the probe and RTG.*

The astronaut will notify MCC when the upper probe section is activated, when the lower probe section is activated, when the assembled probe is inserted, when the probe is extracted, when the upper probe section is deactivated and when the lower probe section is deactivated.

*TV or photographs obtained in support of other lunar surface activities which show the separation distance between the deployed neutron probe and the RTG will be acceptable.

The deployed probe will be at least 25 meters from the RTG. Probe temperature must not exceed 70°C at any time during the mission or prior to analysis of the exposed probe. The probe sections should not be activated until the RTG has been deployed in order to minimize the effect of this neutron source.

Success Criteria

FTO 1)
FTO 2)
FTO 3)
FTO 4) The probe shall be returned to earth and provided to the Principal Investigator after having been deployed in the activated condition in the lunar soil to a depth of at least 1.5 meters for a minimum time of 24 hours. A copy of the mandatory photograph defined under Test Conditions and a record of the activation, insertion, extraction and deactivation times shall be provided to the Principal Investigator.

Evaluation

FTO 1)
FTO 2)
FTO 3)
FTO 4) Evaluation will consist of analysis of the track detector materials contained within the probe and the data described under Data Requirements. (Experiment support and experiment evaluation data)

FTO 1) The average mixing depth for lunar soil in the experiment deployment area will be determined by analysis of the returned probe materials and other data. (Experiment support and experiment evaluation data as defined under Data Requirements) A

FTO 2) The degree of stratification and mixing history of lunar soil cores will be determined by analysis of the returned probe materials and other data. (Experiment support and experiment evaluation data as defined under Data Requirements)

FTO 3) The average irradiation depth for lunar rocks will be determined by analysis of the returned probe materials and other data. (Experiment support and experiment evaluation data as defined under Data Requirements).

FTO 4) Information on the lunar neutron energy spectrum will be derived by analysis of the returned probe materials and other data. (Experiment support and experiment evaluation data as defined under Data Requirements)

Data Requirements

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

Voice Comments:

Comments indicating the times of probe activation (each probe section), insertion, extraction, and deactivation (each probe section) described under Test Conditions.

2) Experiment Evaluation Data (EED):

a) Lunar neutron probe. (M)

b) Astronaut Logs or Voice Records: (M)

One copy each of astronaut logs or voice records pertaining to the experiment including the times of probe activation, insertion, extraction, and deactivation.

c) Astronaut Debriefings: (HD) A

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

d) Photographs:

(1) One copy of the mandatory photograph described under Test Conditions. (M)

(2) One copy of the highly desirable photograph(s) or TV coverage described under Test Conditions. (HD)

5.13 LUNAR NEUTRON PROBE

Background and Justification

Previous research on both Apollo 11 and Apollo 12 lunar samples has demonstrated that there are Gd isotopic variations which can be ascribed to neutron capture by Gd^{157} and Gd^{155}. From the Gd isotopic variations, low energy neutron exposures for lunar samples can be calculated. Because the lunar neutron probe data is a very sensitive function of depth, the measured exposures are a useful tool in interpreting the mixing history of lunar rocks, and particularly, the lunar soil. However, a thorough interpretation of the Gd isotopic data has been hindered by a lack of knowledge of the gradient of the Gd capture rate. Theoretical calculations of the neutron capture rates are being carried out and will be very useful and necessary in any case. However, there are enough uncertainties involved that a direct measurement of neutron capture rates will provide more useful information. The Lunar Neutron Probe experiment is based on the $^{10}B(n, \alpha)^7$ Li reaction utilizing a plastic track detector to detect the recoil alpha particles from this reaction. The inclusion of cadmium and potassium bromide strips on the detector material within the probe will allow data to be obtained on the energy distribution of lunar neutrons. Mica/U^{235} is included as part of the detector material to increase the reliability of the instrument in low count rate areas such as near the lunar surface. The mica detects fission products from the neutron/U^{235} reaction. A trace amount of U^{238} is included within the probe for calibration purposes. B B

Previous Mission Experiments

Experiment Number	Title	Mission
None		

5.14 COSMIC RAY DETECTOR (SHEETS)

Conduct the Cosmic Ray Detector (Sheets) Experiment (S-152).

Purpose

The purposes are to measure the mass and energy distribution of solar wind and cosmic ray particles in the energy range 1 Kev/amu to 25 Mev/amu, to determine the quiet-time energy spectrum and composition of particles with $Z \geq 6$ in interplanetary space, and to determine the Rn^{222} flux at the lunar surface.

The functional test objectives are as follows:

FTO 1) Obtain data on cosmic ray and solar wind particles at the lunar surface.

FTO 2) Determine the Rn^{222} flux at the lunar surface.

Test Conditions

FTO 1)
FTO 2) Platinum, aluminum, mica, glass and lexan nuclear particle track detectors mounted within a thin aluminum box (approximately 6 cm by 10 cm by 0.9 cm) and its sliding cover (approximately 5 cm by 10 cm by 0.3 cm) will be deployed for a minimum of one sleep period and one EVA period. It is highly desirable that the box and cover be deployed as long as practicable during the lunar stay. The astronaut will slide the cover from the box by pulling in opposite directions on two rings mounted on opposite ends of the box and sliding cover. The sliding cover will be immediately placed in a shaded location such that the exposed detector materials mounted inside it face away from the sun with a view of the dark sky and with minimum obstructions in its approximately hemispherical field of view during the entire exposure period. The detector materials on the cover will not be exposed to direct sunlight for more than 60 seconds. The box will be placed in a location such that the exposed detector materials mounted on its inside surface face directly into the sun during the entire exposure period with minimum obstructions in its approximately hemispherical field of view. The deployment locations will be such as to minimize the possibility of contaminating the exposed detector surfaces with lunar soil or other debris. B

After the box and cover are retrieved, the box and cover will be mated together and stowed in a single bag for return to earth. The mated box and sliding cover will not be exposed to direct sunlight for more than approximately 20 minutes.

It is highly desirable that the detector box and cover remain in their closed bag(s) until they have been provided to the Principal Investigator, at which time the bags will be examined and opened under clean room conditions and the contents photographically documented.

The astronaut will notify MCC at the time the detector materials are exposed and at the time the materials are stowed for earth return so that MCC can record the times.

It is highly desirable that if a solar flare warning is received by MCC during the mission, the experiment will be terminated as early as practicable by stowing the box and cover for earth return.

Success Criteria

FTO 1) FTO 2) The detector materials shall be returned to earth after having been exposed on the lunar surface in accordance with the Test Conditions and shall be provided to the Principal Investigator. (Mandatory experiment evaluation data defined under Data Requirements)

Evaluation

FTO 1) Data will be obtained on cosmic ray and solar wind particles at the lunar surface by examination and analysis of the experiment detector materials, platinum, aluminum, mica, glass and lexan. (Astronaut records and detector materials) B

FTO 2) The Rn^{222} flux at the lunar surface will be determined by examination and analysis of the mica detector material. (Astronaut records and detector material)

Data Requirements

1) Experiment Support Data: (ESD) (HD)

a) Astronaut Voice Records:

The times of the beginning and end of the detector material exposure interval.

2) Experiment Evaluation Data: (EED)

a) Astronaut Logs or Voice Records: (M)

Six copies of astronaut logs or voice records containing the times of the beginning and end of the detector material exposure periods.

b) Astronaut Debriefings: (HD)

Six copies of astronaut postflight scientific and photographic debriefing transcripts pertaining to the experiment. B

c) Detector Materials: (M)

Detector materials which have been exposed on the lunar surface in accordance with the Test Conditions.

5.14 COSMIC RAY DETECTOR (SHEETS)

Background and Justification

The Cosmic Ray Detector (Sheets) experiment will provide data on charged particles in interplanetary space in an interval of energy and atomic number that is at best only sketchily known. The results will be of direct relevance to lunar surface processes, to processes in the solar atmosphere, to interplanetary processes, and to processes occurring in the earth's magnetosphere. Collectively, the detectors will span the energy interval from 1 Kev/amu to 25 Mev/amu. At solar wind energies and up to 100 Kev/amu the mica will cover the unknown 3/4 of the Periodic Table beyond Fe; at higher energies lexan and glass will be used to identify light ($Z = 2$ to 14) and heavy ($Z > 10$) ions respectively.

The distribution in mass and energy of solar wind ions (as well as suprathermal ions up to ∿100 Kev/amu) can be determined by measuring the diameters and depths of pits produced by controlled etching of mica. A solar flare that occurred during Apollo 16 produced such a high density of particles of various energies in interplanetary space that is was not possible unambiguously to distinguish solar wind ions from flare ions. From observations presented in the NASA Apollo 16 Preliminary Science Report, it appears highly likely that the heavy solar wind ion composition can be successfully determined in this experiment, assuming no solar flare occurs during Apollo Mission J-3. B

Because radon in the lunar atmosphere produces pits in mica that can be mistaken for pits produced by solar wind ions with $Z > 200$, it is necessary to do a control experiment with mica facing away from the sun. To check on the radon contribution, lexan subsequently exposed to ultraviolet irradiation and chemically etched will give the alpha particle flux from radon decay.

The platinum and aluminum foils are doubly useful. When analyzed mass spectrometerically they will give the solar wind helium flux to which the mica data on heavy ions can be compared. In addition, the helium flux can be compared with helium data obtained on all previous missions to permit inferences to be drawn about spatial and temporal variations in solar wind flux.

The origin and nature of interplanetary ions with energies between that of the solar wind and that of cosmic rays are unknown. Only when a solar flare occurs does the flux of these ions reach a level that has been investigated by detectors on satellites and rockets. The composition of ions present during a time when the sun is quiet will permit a determination of their origin, i.e., whether they originated from the sun or whether they originated as cosmic rays but managed to penetrate into the solar system.

The track densities in the plastic and glass detectors on the Apollo 16 Cosmic Ray Detector (Sheets) experiment were extremely high, perhaps as much as six orders of magnitude higher than will be observed in the absence of a flare. In the Apollo Mission J-3 experiment, data should be obtained on the more abundant elements (He, C, N, O, Ne, Mg, Si and Fe) even if the flux is 10^{-6} to 10^{-5} of that found during Apollo 16. Having glass in the shade as well as in the sun should give directional information on the heavier ions. The abundances of heavy ions such as Fe relative to helium are enhanced during solar flares. The experiment will also determine if the quiet-time abundances show a similar heavy element enhancement. B

Previous Mission Experiments

Experiment Number	Title	Mission
S-151	Cosmic Ray Detector (Helmets)	8
S-151	Cosmic Ray Detector (Helmets)	12
S-152	Cosmic Ray Detector (Sheets)	16

6.0 OPERATIONAL TESTS AND IN-FLIGHT DEMONSTRATIONS

6.1 No operational tests have been assigned to this mission.

6.2 A Heat Flow and Convection in-flight demonstration will be accomplished to utilize the unique conditions of space flight environment. See paragraph 6.2.1 for details. A

6.2.1 HEAT FLOW AND CONVECTION

Perform the heat flow and convection demonstration.

Purpose

The purpose is to obtain data on the types and amount of convection that occur in the near weightless environment of space flight.

The functional test objectives are as follows:

FTO 1) Obtain data on temperature distribution patterns in heated fluids.

FTO 2) Obtain data on the flow patterns caused by surface tension gradients in heated fluids.

Test Conditions

FTO 1)
FTO 2) The demonstration will be performed in translunar coast with the FDAI in the 5/1 scale setting and the telemetry in the HBR mode. The three test cells and related equipment will be mounted in a fixed position such that the full face of the apparatus can be photographed by the DAC at one frame per second. A

The spacecraft rates will be nulled in all three axes (i.e., $\leq$0.005 degrees per second) in the manner normally accomplished prior to setting up PTC. Liquid dumps will be inhibited where possible, RCS jets will be inhibited, and crew motion will be minimized, until completion of that portion of the demonstration which requires nulled spacecraft rates. At least one minute will be allowed for the fluid in the test cells to come to rest after the test cells are mounted and the spacecraft rates are nulled. Sequence photographs will be obtained for ten minutes with power applied to the radial and lineal test cells [for FTO 1)], and for a separate 15-minute period with power applied to the flow pattern test cell [for FTO 2)]. It is highly desirable that the crew provide comments during the above two test periods regarding the appearance of the temperature distribution patterns and the manner in which the patterns develop and change.

It is highly desirable that the demonstration be repeated after PTC has been initiated. At least one hour must elapse after termination of the above test (i.e., the test when the spacecraft rates are nulled) before starting the test in PTC to allow the three test cells to return to ambient temperature. It is highly desirable that sequence photographs be obtained for ten minutes with power applied to the radial and lineal test cells and for a separate 15-minute period with power applied to the flow pattern test cell. It is highly desirable that the crew provide comments during these final two test periods regarding the appearance of the flow patterns and the manner in which the patterns develop and change.

Upon completion of the demonstration, the small reference tab of liquid crystals will be removed from the face of the demonstration equipment and returned to earth. B
There is no requirement to return the remainder of the demonstration equipment.

Success Criteria

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

Evaluation

FTO 1) FTO 2) The data will be analyzed to determine the convective behavior of heated fluids in the space flight environment. (All data listed under Data Requirements)

Data Requirements

1) Telemetry Measurements:

Measurement Number	Description	TM	Mode	Priority
CC 0206 V	DC Voltage Main Bus A	PCM+	2	M
CF 0001 P	Pressure Cabin	PCM+	2	M*
CF 0002 T	Temp Cabin	PCM	1	M*
CG 0001 V	Computer Digital Data 40 Bits	PCMD+	2	M
CH 3503 R	FDAI SCS Body Rate Pitch	PCM	1	M**
CH 3504 R	FDAI SCS Body Rate Yaw	PCM	1	M**
CH 3505 R	FDAI SCS Body Rate Roll	PCM	1	M**

B

*It is highly desirable that cabin pressure and temperature telemetry data be obtained continuously during all operations. It is mandatory that cabin temperature data be recorded at least once at or just prior to the start, and at or just prior to the end of each use of the flow pattern test cell[i.e., FTO 2)]. Astronaut logs or voice records of cabin pressure and cabin temperature data are suitable substitutes for cabin pressure and cabin temperature telemetry data. B

**It is mandatory that telemetry data be obtained for at least one continuous minute any time during the use of the radial and lineal test cells [i.e., FTO 1)]. Crew readouts of the three corresponding body rate meters are not suitable substitutes for telemetry data. Body rate data are not required whenever the flow pattern test cell is used [i.e., FTO 2)].

2) Astronaut Logs or Voice Records: (HD)

Comments by the crew on the appearance of the flow patterns and the temperature distribution patterns and on the manner in which they develop and change.

3) Photographs:

(a) Sequence photographs of the demonstration equipment during the test periods with the spacecraft rates nulled. (M)

(b) Sequence photographs of the demonstration equipment during the test periods when the spacecraft is in PTC. (HD)

4) Trajectory:

One copy of tab listing containing:

(a) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during the test periods with the spacecraft rates nulled. (M)

(b) Best estimate of trajectory (BET) including spacecraft attitude for the CSM during the test periods with the spacecraft in PTC. (HD)

5) The reference tab of liquid crystals which was removed from the face of the demonstration equipment upon completion of the test periods. (M)

6.2.1 HEAT FLOW AND CONVECTION

Background and Justification

One of the major factors considered in planning for science experiments and manufacturing processes in space is the fact that gravity driven convection is suppressed to a very low level. In space, fluid flows are induced primarily from surface tension, artificial gravity, expansion, and possibly interfacial tension. On earth, fluid flow is usually dominated by gravity effects, making experimental observation of flows caused by these other forces very difficult. Consequently, laboratory data have been primarily oriented toward the study of gravity induced flow. Theoretical analyses have been made on natural fluid flows caused by surface tension gradients, interfacial tension and expansion, but experimental confirmation must be obtained in space flight.

The demonstration on Apollo Mission J-3 will provide data on the thermal and fluid flow behavior of fluids in a specially selected "cell" configuration in low gravity. The three cells contained in this demonstration are as follows: A

1) Radial test cell. The radial test cell is a circular cell with a small electric heater in the center. It will be used to test radial heat flow. The cell is filled with argon gas and is covered with a liquid crystal material which changes color when it is heated. The flow of heat will be indicated by the changing color patterns, which will be recorded by the DAC.

2) Lineal test cell. The lineal test cell is a transparent cylinder with a small electric heater at one end. It will be used to test lineal heat flow. The cylinder is filled with Krytox (a heavy oil) and strips coated with liquid crystals are located along the walls. The flow of heat will be indicated by changing color patterns which will be recorded by the DAC.

3) Flow pattern test cell. The flow pattern test cell consists of a shallow aluminum dish with a heated bottom into which thin layers of Krytox are introduced. The Krytox contains a suspension of aluminum flakes which will enable the oil flow patterns

to be photographed by the DAC. The window to this cell will be opened during the test so that the heat can be dissipated into the spacecraft atmosphere.

The Apollo 14 Heat Flow and Convection demonstration provided evidence of significant surface tension flows in the flow pattern cell and showed unexpected trends in the heat flow cells. Additional data and greater sensitivity are required to assess the importance of these trends. It is most important to define the magnitude of these effects and the conditions required for their existence so that they may be considered for future science experiments and manufacturing processes in space. It is also of scientific and technical interest to determine the cause of the unexpected trends. A

Previous Mission Demonstrations

Demonstration Number	Title	Mission
2.6.2	Heat Flow and Convection	14

7.0 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.

7.1 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-3 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) It is highly desirable that all large SPS maneuvers in earth orbit be positioned so that MSFN coverage is available. A

9) An RCS deorbit capability will be maintained at all times when in earth orbit.

7.2 Contingency plans will be available for the following modes as directed by Reference 8.

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) Launch vehicle backup guidance.

6) Launch vehicle target update.

7) Alternate orbit injection.

8) LM entry targeting.

9) Circumlunar return.

10) Alternate transearth injection using LM DPS.

11) Alternate lunar stay times.

12) LM ascent.

13) LM rescue.

14) Alternate transearth return times.

15) Alternate crew transfer.

16) Changed recovery area.

7.3 Launch aborts will be planned in accordance with MSC/MPAD document, 72-FM-231 "Operational Abort Plan for Apollo 17, Volume I, Launch Phase," of September 21, 1972. Aborts after TLI will be planned in accordance with MSC/MPAD document 72-FM-231, "Operational Abort Plan for Apollo 17, Volume II, Translunar, Lunar Orbit and Transearth Aborts," of November 2, 1972. C

7.4 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 6-1/2 days. An orbit of approximately 240 by 115 NM with a 45° inclination will be established. The apogee will be at 30 degrees South latitude (on the ascending leg). Prior to establishing the above orbit with a 45° inclination, there will be intermediate orbits of up to approximately 700 by 115 NM. The lunar sounder will be used during portions of approximately four intermediate orbits to obtain HF data. The Far UV Spectrometer will be operated during the intermediate orbits as well as during the 240 by 115 NM orbit to obtain data at high and low altitudes. The IR Scanning Radiometer will be pointed at the moon and operated for up to approximately 30 minutes in either orbit. The lunar sounder will be used in the 240 by 115 NM orbit to obtain VHF data. The

SIM cameras will be used in the 240 by 115 NM orbit. RCS deorbit capability will be maintained throughout the earth orbital period. An EVA will be planned for cassette retrieval during the last day.

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 period will be approximately 6 days. The LOI burn will shift the node approximately 55 degrees to the east for optimum coverage by SIM cameras. The lunar orbit will be circularized at approximately 60 NM with a 20 degree inclination. An EVA will be planned for cassette retrieval during TEC. B

3) In case the LM is taken into lunar orbit but a decision is made not to land, the mission will be planned to have a duration of approximately 6 days in lunar orbit. There will be no plane change and no shift of the node. The lunar orbit will be circularized at approximately 60 NM with a 20 degree inclination. The SIM cameras and experiments will be operated whenever feasible. The LM will remain docked with the CSM as long as possible, consistent with SHe limitations. A real time decision will then be made to continue the mission or utilize the DPS for TEI based on CSM systems status. If the DPS is not used for TEI, the LM will be jettisoned from the CSM. An EVA will be planned for cassette retrieval during TEC.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

Å	Angstrom Unit
A	Analog
α	Alpha Particle
ALFMED	Apollo Light Flash Moving Emulsion Detector
ALSD	Apollo Lunar Surface Drill
ALSEP	Apollo Lunar Surface Experiments Package
AM	Amplitude Modulation
amu	Atomic Mass Unit
AOS	Acquisition of Signal
APE	Apollo Photographic Evaluation
APS	Ascent Propulsion System
AS	Apollo Saturn
B	Boron
BET	Best Estimate of Trajectory
BPI	Bits per Inch
BW	Band Width
C	Carbon
CDR	Commander
CM	Command Module
cm	Centimeter
CMP	Command Module Pilot
CSM	Command and Service Module
D	Digital
DAC	Data Acquisition Camera
db	Decibel

DOI	Descent Orbit Insertion
DPS	Descent Propulsion System
E	East
EED	Experiment Evaluation Data
ESD	Experiment Support Data
EVA	Extravehicular Activity
Fe	Iron B
FM	Frequency Modulation
FOV	Field-of-View
fps	Feet per Second
FTO	Functional Test Objective
g	Gravity
GCTA	Ground Commanded Television Assembly
Gd	Gadolinium
GSFC	Goddard Space Flight Center
GET	Ground Elapsed Time
GMT	Greenwich Mean Time
HBR	High Bit Rate (51.2 kilobits per second)
HD	Highly Desirable
He	Helium B
HEC	Hasselblad Electric Camera
HEDC	Hasselblad Electric Data Camera
HF	High Frequency
HFE	Heat Flow Experiment
HOPE	Houston Operations Predictor-Estimator
HZE	High-Z Energy
hr	Hour
Hz	Hertz

IMU	Inertial Measurement Unit
in	Inch
IR	Infrared
ISR	Infrared Scanning Radiometer
JPL	Jet Propulsion Laboratory
KC	Kilocycle
Kev	Kilo-Electron Volts
kg	Kilogram
km	Kilometers
KSC	Kennedy Spacecraft Center
λ	Lambda (Wavelength)
LBR	Low Bit Rate (1.6 kilobits per second)
LDAC	Lunar Surface Data Acquisition Camera
LGC	Lunar Module Guidance Computer
Li	Lithium
LM	Lunar Module
LO	Lunar Orbit
LOI	Lunar Orbit Insertion
LOPC	Lunar Orbit Plane Change
LOS	Loss of Signal
LRL	Lunar Receiving Laboratory
LRV	Lunar Rover Vehicle
LSPE	Lunar Seismic Profiling Experiment
LSPET	Lunar Samples Preliminary Examination Team
M	Mandatory
Mev	Mega-Electron Volts
Mg	Magnesium
MHz	Megahertz

B

B

min	Minute
mm	Millimeter
MCC	Mission Control Center
MPAD	Mission Planning and Analysis Division
MSC	Manned Spacecraft Center
MSFN	Manned Space Flight Network
N	Nitrogen B
N	North
n	neutron
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
Ne	Neon B
NM	Nautical Mile
O	Oxygen B
OAO	Orbiting Astronomical Observatory
OMSF	Office of Manned Space Flight
PCM	Pulse Code Modulation
PCMD	Pulse Code Modulation Digital
PCME	Pulse Code Modulation Event
PD	Premission Data
PGNS	Primary Guidance and Navigation Subsystem
PI	Principal Investigator
PLSS	Portable Life Support System
PM	Phase Modulation
PRN	Pseudo-Random Noise
psia	Pounds per Square Inch Absolute
PTC	Passive Thermal Control
Quad	Quadrant

RCS	Reaction Control Subsystem
Rn	Radon ▮B
RTCC	Real Time Computation Center
RTG	Radioisotope Thermoelectric Generator
S	South
SA	Saturn Apollo
S&AD	Science and Applications Directorate
SEA	Sun Elevation Angle
Sec	Second
SEP	Surface Electrical Properties
SESC	Special Environmental Sample Container
Si	Silicon ▮B
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
SXT	Sextant
S-IC	Saturn IC
S-II	Saturn II
S-IVB	Saturn IVB
T	Time (of lift-off)
TBD	To be determined
TEI	Transearth Injection
TLI	Translunar Injection
TM	Telemetry

TPI	Terminal Phase Initiation
TV	Television
U	Uranium
U	Unclassified
USB	Unified S-Band
USSR	Union of Soviet Socialist Republics
UV	Ultraviolet
VHF	Very High Frequency
ΔV	Delta Velocity
W	West
Z	Atomic Number of an Element

B

GLOSSARY

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.
ANGSTROM UNIT	A unit of length equal to 10^{-10} meters or 10^{-4} microns commonly used in specifying wavelengths of electromagnetic radiation.
ANISOTROPIC	Exhibition of different properties when tested along axes in different directions.
BASEMENT	A compact, firm rock underlying less firmly consolidated earth (or lunar) materials.
BATHOLITH	A great mass of intruded igneous rock that for the most part stopped in its rise a considerable distance below the surface and that extends downward to unknown depth.
COSMIC RAYS	Very high energy nuclear particles, commonly protons, that bombard the earth (or moon) from all directions.
COSMOLOGICAL	Concerned with the investigation of the character and origin of the universe.
CRUST	The outer part of the earth composed essentially of crystalline rocks and varying in thickness from place to place but probably nowhere more than a few score miles thick as distinguished from the underlying zones composed of denser but less rigid matter.
FIGURE OF THE EARTH	The precise geometric shape of the planet.
GALACTIC	Pertaining to a galaxy in the universe such as the Milky Way.
GEOSYNCLINE	A great downward flexure of the earth's crust.
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.
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).

ISOSTASY	General equilibrium in the earth's crust maintained by a yielding flow of rock material beneath the surface under gravitative stress and by the approximate equality in mass of each unit column of the earth from the surface to a depth of about 70 miles.
LITHIFIED	Evidence of having been changed into stone.
MANTLE	The part of the earth's interior beneath the lithosphere and above the central core from which it is separated by a discontinuity at a depth of about 1800 miles.
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.
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.
REGOLITH	The unconsolidated residual material that resides on the solid surface of the moon (or earth).
SCARP	A line of cliffs produced by faulting or erosion.
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.

TECTOGENE	A long narrow downward fold of the earth's crust that is postulated as an early phase in the process of the formation of a mountain range or an island arc.
TECTONICS	Geological structural features as a whole.
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.
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.

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