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APOLLO MISSION J-2

(APOLLO 16)

MISSION SCIENCE PLANNING DOCUMENT

REVISION

MARCH 15, 1972

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SCIENCE MISSIONS SUPPORT DIVISION
SCIENCE AND APPLICATIONS DIRECTORATE
MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

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Prepared by TRW Systems

for

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Contract NAS 9-12330

MISSION SCIENCE PLANNING DOCUMENT
APOLLO MISSION J-2

(Apollo 16)

REVISION

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- Section II, Experiment and Equipment Description: Apollo Lunar Surface Experiment Package (ALSEP) equipment descriptions supplied by the Bendix Aerospace Systems Group.
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- Appendix E, Film Characteristics and Processing Test Data: Photographic Technology Division/JL.

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INTRODUCTION

The Mission Science Planning Document (MSPD) is intended primarily as a science overview for use by experiment Principal Investigators, members of the scientific community, and personnel involved in planning science activities for the Apollo Mission J-2. It is also intended to provide detailed interim data for use in implementing the science requirements presented in the MSC-controlled J-2 Mission Requirements Document (MRD) until such data are published in other MSC-controlled documents. Such documents include the Apollo 16 Flight Plan, Apollo 16 Lunar Surface Procedures, Apollo 16 Flight Mission Rules, Apollo Operations Handbook, and CSM/LM Spacecraft Operational Data Book. The MRD contains the science and operational requirements for science experiments and science-related detailed objectives assigned to the mission; the other documents present detailed hardware data and procedures for implementing these requirements. In case of conflicts, the MRD and other controlled documents take precedence over the MSPD.

The MSPD is divided into eight sections: Section I, General Mission Science Planning; Section II, Experiment and Equipment Description; Section III, Photographic Plan; Section IV, Lunar Surface Science Plan; Section V, Science Activities Rationale; Section VI, Science Recovery Plan; Section VII, Lunar Receiving Laboratory Plan; and Section VIII, Science Contingency Data. These sections contain detailed data which supplement science requirements incorporated in Sections 4 and 5 of the MRD. The MSPD also contains five appendixes: Appendix A, Acronyms and Abbreviations; Appendix B, Glossary; Appendix C, References; Appendix D, Distribution; and Appendix E, Film Characteristics and Processing Test Data.

The publication schedule for the MSPD has been coordinated with other MSC organizations to optimize the availability and use of science data for preparation of MSC-controlled documents. Nominal MSPD publication dates for each mission are L-9 months (Preliminary), L-5 months (Final), and L-2 1/2 months (Revision). Schedules and contents will be changed as necessary to satisfy user needs.

All proposed changes to and requests for additional copies of the MSPD should be submitted in writing to the following representative of the Science Missions Support Division, Science and Applications Directorate, Manned Spacecraft Center, Houston, Texas:

Mr. Richard R. Baldwin/TD12
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SECTION I

GENERAL MISSION SCIENCE PLANNING

1.1 GENERAL

This section contains general information for the Apollo Mission J-2 (Apollo 16). It includes a summary of science-oriented mission characteristics; a brief description of the Descartes landing site; a listing of each assigned experiment and detailed objective (DO) that is science related, and their cognizant Principal Investigator (PI) and Point-of-Contact at the Manned Spacecraft Center (MSC); and a prioritized list of these experiments and detailed objectives.

Data presented in this section are intended primarily as general information for experiment PI's and members of the scientific community. Much of the data are subject to constant change until launch because of the dynamic nature of the Apollo Spacecraft Program. For official planning data, reference should be made to MSC-controlled documents as they become available. These documents include the J-2 Mission Requirements Document (MRD) (Reference 1), Apollo 16 Flight Plan (Reference 2), and Apollo 16 Lunar Surface Procedures (Reference 3). The J-2 MRD contains approved mission science requirements; the other documents provide detailed information for implementing these requirements. In case of conflict, data in controlled documents take precedence over data in this section.

1.2 MISSION DESCRIPTION

1.2.1 J-2 MISSION CHARACTERISTICS

The J-2 Mission is the second of three J-series missions planned for the Apollo Program. This mission series incorporates certain spacecraft hardware and crew equipment modifications as well as an enhanced science equipment complement, both command and service module (CSM) and lunar surface experiments, to provide the capabilities for a much greater mission science return than has been possible on previous Apollo missions, notably the G- and H-series missions.

The major changes in the science payload for the J-2 Mission as compared to the highly successful J-1 Mission (Apollo 15) are

a) Deletion of the Solar Wind Spectrometer (S-035) Apollo Lunar Surface Experiment Package (ALSEP) experiment

b) Deletion of the Suprathermal Ion Detector (S-036) ALSEP experiment

c) Deletion of the Cold Cathode Ion Gauge (S-058) ALSEP experiment

d) Deletion of the Lunar Dust Detector (M-515) ALSEP experiment

e) Deletion of the Laser Ranging Retro-Reflector (S-078) experiment

f) Deletion of the Contingency Sample Collection detailed objective (Requirement is preserved, however, in the Lunar Geology Investigation Experiment (S-059))

g) Addition of the Active Seismic (S-033) ALSEP experiment

h) Addition of the Cosmic Ray Detector (Sheets) (S-152) lunar surface experiment

i) Addition of the Portable Magnetometer (S-198) lunar surface experiment

j) Addition of the Far UV Camera/Spectroscope (S-201) lunar surface experiment

The Scientific Instrument Module (SIM) payload configuration is to be the same as for the J-1 Mission.

The nominal launch date for the J-2 Mission is April 16, 1972, with a lunar landing to be performed in the Descartes region of the moon. The Descartes landing area will provide access to material for crew sampling that is representative of two major volcanic morphologic units of the lunar highlands, the Cayley formation and Kant Plateau (Descartes formation). The particular and detailed geological features of interest as well as the current detailed lunar surface exploration activities are described in Section IV.

1.2.2 LANDING SITE DESCRIPTION

Descartes, the J-2 Mission landing area (Reference 4), is located in a highlands region lying in the southeastern portion of the moon. The landing area of interest lies to the southwest of the Mare Tranquillitatis, north of the Descartes Crater, and several hundred kilometers west northwest of the Theophilus Crater. The landing coordinates are 9°00'01" S latitude, 15°30'59" E longitude (Reference 5).

The Descartes area is characterized by hilly, grooved, and furrowed terrain (Descartes formation) which appears to be morphologically similar to many terrestrial areas of volcanism. This area is also the site of an extensive development of highland plains material (Cayley formation), a geological unit of widespread occurrence in the lunar highlands.

This region is important to the lunar geologist since knowledge of the composition, age, and extent of magmatic differentiation in a highland volcanic complex is particularly important in understanding lunar volcanism and its contribution to the evolution of the lunar highlands. A comparison with similar mare complexes (the Cayley formation unit appears to be the highlands counterparts of the Apollo 11 and 12 mare basalt basin fill) provides an evaluation of a wide spectrum of lunar volcanic activity. An understanding of the composition and age of the highland plains material also adds to the knowledge of the processes which modify large areas of the lunar highlands.

1.2.3 PRIMARY MISSION SCIENCE OBJECTIVES

Primary science objectives are extracted from the official list of primary mission objectives, assigned by the Office of Manned Space Flight (OMSF), that are listed in the Apollo Flight Mission Assignments (AFMA) directive (Reference 6) and Mission Implementation Plan (MIP) (Reference 7).

These primary objectives are to

a) Perform selenological inspection, survey, and sampling of materials and surface features in a preselected area of the Descartes region

b) Emplace and activate surface experiments

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

These objectives have, in turn, been subdivided into individual experiments and detailed objectives. Experiments are those technical investigations which have been recommended and assigned a number (e.g., S-059, Lunar Geology Investigation) by the Manned Space Flight Experiments Board (MSFEB), and which have been subsequently assigned to the Apollo Program for flight by the Associate Administrator for Manned Space Flight. Detailed objectives (such as Service Module Orbital Photographic Tasks) represent scientific, engineering, medical, or operational investigations that provide important data and experience useful for the development of hardware and/or procedures for application to other Apollo missions. The Apollo Program Director approves the assignment of experiments and detailed objectives to specific Apollo missions.

Only those experiments and detailed objectives of a science nature are discussed in this document. Detailed objectives and experiments for all disciplines as well as operational tests to be performed on the J-2 Mission as authorized by the Apollo 16 MIP (Reference 7) are listed and detailed in the J-2 MRD (Reference 1) published by the Systems Engineering Division of the Apollo Spacecraft Program Office (ASPO). Changes in mission assignments of experiments, detailed objectives, and operational tests are governed by the MIP and Configuration Control Board (CCB) directives approved by the Apollo Program Director.

1.2.4 MISSION SCIENCE-ORIENTED EXPERIMENTS AND DETAILED OBJECTIVES

The science-oriented experiments and detailed objectives assigned to this mission have been divided into three groups: those to be performed from the CM; those to be performed from the SM; and those to be performed on the lunar surface. Command module experiments and objectives are listed in Table 1-1, service module experiments and objectives are listed

in Table 1-2, and lunar surface experiments are listed in Table 1-3. These tables also list the PI or Chairman of the PI Team, as applicable, and the Manned Spacecraft Center/Science and Applications Directorate (S&AD) Point-of-Contact assigned to each experiment or objective. The official CCB-controlled mission requirements (functional test objectives, test conditions, data requirements, etc.) for these experiments and objectives appear in the J-2 MRD.

Any questions that arise concerning the science or operational requirements of a particular experiment or objective should be directed to the S&AD Point-of-Contact who represents the science interface between MSC and the PI. Questions concerning integration of these experiments and objectives into mission and program planning should be referred to the Science Mission Manager for the J-2 Mission, Mr. Richard R. Baldwin/TD12. Mr. Baldwin represents the S&AD science interface with the ASPO J-2 Mission Staff Engineer, Mr. Don R. Segna/PD12, who has the overall responsibility for integration of all mission requirements.

1.3 CONDUCT OF MISSION SCIENCE ACTIVITIES

1.3.1 EARTH ORBIT SCIENCE ACTIVITIES

There will be no scientific activities conducted from earth orbit. Ultraviolet (UV) photography of terrestrial cloud and water features had previously been planned in support of the S-177 CM experiment. Recent analyses of Apollo 15 results, however, indicate that these photographs will no longer be required. The nominal 90-nautical mile earth parking orbit will be used in preparation for translunar injection (TLI). The TLI burn will occur nominally 1.5 revolutions after insertion of the Apollo spacecraft and S-IVB stage into earth orbit.

1.3.2 TRANSLUNAR COAST SCIENCE ACTIVITIES

CM UV photography activities (experiment S-177) will be conducted during translunar coast at specified earth-moon distances to provide planetary feature signature data. Also, during this coast period, the spent S-IVB stage/instrument unit (IU) assembly will be guided to impact the lunar surface (2.3°S latitude, 31.7°W longitude) (Figure 1-1) as a known seismic stimulus for sensors of the Passive Seismic Experiment (PSE) (S-031) previously emplaced on Apollo 12, 14, and 15.

1.3.3 LUNAR SCIENCE ACTIVITIES

1.3.3.1 Lunar Orbit Science Activities

The Scientific Instrument Module door is scheduled for jettison about 4.6 hours before lunar orbit insertion (LOI). This door protects the SIM bay experiment sensors and cameras from adverse mission environments (launch, service propulsion system contamination, etc.). Jettison prior to LOI keeps hazardous debris out of lunar orbit and prevents any subsequent CSM or subsatellite recontact. The service propulsion system (SPS) LOI burn will place the docked CSM/lunar module (LM) into a 170- by 60-nautical mile lunar orbit. Four hours later and following acquisition of CSM S-band experiment (S-164) data, a second SPS retrograde burn to perform descent orbit insertion (DOI) will take place. This maneuver will insert the docked CSM/LM into a 60- by 9-nautical mile orbit from which LM undocking and lunar descent will occur (LM S-band transponder experiment data will be acquired where possible during descent). LM undocking will occur at approximately 17.5 hours after this burn. During this 17.5-hour time period, the SIM bay experiment sensors (X-ray, alpha particle, gamma-ray, and mass spectrometers) and cameras will be scanning and photographing the lunar surface, respectively, and the CSM S-band transponder experiment will be performed. LM touchdown at the Descartes landing site will occur 24 hours after LOI.

Shortly before LM touchdown (1 hour), a third SPS burn (posigrade) will circularize the CSM orbit at 60 nautical miles. The SIM bay experiments and photographic activities, CM photographic activities, and CSM S-band transponder experiment will be performed. Orbital science data gathering will continue through the LM lunar surface stay period until approximately 3.5 hours prior to ascent stage lift-off. A CSM lunar orbit plane change is scheduled approximately 20 hours prior to ascent stage lift-off in readiness for CSM/LM rendezvous. LM ascent stage lift-off will occur at 97 hours* after LOI.

*Times indicated may be converted approximately to the number of CSM orbits elapsed after LOI by utilizing a period of 2 hours per orbit corresponding to the nominal 60-nautical mile CSM orbit.

After docking and completion of crew/stowables transfer activities, the LM ascent stage will be undocked and propelled/guided to impact on the lunar surface (9°29'S latitude, 14°58'E longitude) (Figure 1-1) as a known seismic stimulus for the ALSEP Passive Seismic Experiment (S-031) emplaced during the surface phase of this mission.* LM ascent stage S-band experiment data will be obtained prior to impact. The lunar surface color TV camera (GCTA) attached to the Lunar Roving Vehicle (LRV) will monitor this impact (Figure 1-6). A second plane change (3 degrees) is performed 21 hours after lift-off to increase lunar surface photographic and sensor coverage for the remainder of the mission. The SIM bay experiments and cameras are then reactivated. CM photography activities and the CSM S-band and bistatic radar experiments are also conducted. The CMP makes visual observations and accompanying narrative descriptions of designated surface features at various times during lunar orbit.

A CSM shaping maneuver is performed at 6 hours prior to transearth injection (TEI) to achieve a 76- by 56-nautical mile orbit. This orbit is designed to maximize the subsatellite orbital lifetime. The SIM bay subsatellite carrying equipment and sensors to perform the S-Band Transponder (S-164), Particle Shadows/Boundary Layer (S-173), and Magnetometer (S-174) Experiments is ejected at approximately 4 hours prior to TEI. The total time period in lunar orbit in which CSM/SIM experiments and photography can be performed is approximately 143.5 hours as measured from descent orbit insertion (DOI) to TEI. The approximate 4-hour time period between LOI and DOI is devoted to CSM/LM tracking verification to form the basis for a DOI-commit decision.

1.3.3.2 Lunar Surface Science Activities

Three extravehicular activity (EVA) traverses are to be performed. The first EVA is planned to be performed after touchdown prior to the first lunar sleep period. These EVA's are planned for a duration of 7 hours each. The total planned lunar surface stay time is 73 hours. The current status of surface science activities and traverse planning appears in Section IV of this document.

*This impact may also be recorded by seismic sensors of the PSE emplaced on the Apollo 12, 14, and 15 missions.

The following information appearing in this document is being used to develop the J-2 Mission surface science plan:

a) Lunar surface science experiments to be deployed and conducted as identified and described in Sections I and II, respectively

b) Lunar surface science photography requirements as identified in Section III

c) Lunar geological requirements as identified in Section IV

d) Lunar surface science experiment rationale as presented in Section V

1.3.4 TRANSEARTH COAST SCIENCE ACTIVITIES

Scheduled transearth coast science activities include the following: gamma-ray measurements of cislunar and cosmological space for background evaluation, cosmological spectrum determination, and to locate galactic gamma-ray sources for astronomy studies; X-ray measurements of deep space and the measurement of X-ray flux emitted from known galactic sources for background evaluation and astronomy studies, respectively; a supergalactic X-ray survey to locate new X-ray sources for astronomy investigations; alpha particle measurements made concurrently with the X-ray measurements for engineering evaluation; and additional photography activities performed from the CM and SIM. Assessments of the spatial extent and constituents of the spacecraft contamination "cloud" (including special tests to determine effects of specific contaminant sources) and the CSM/SIM radioactive background will also be performed with the mass and gamma-ray spectrometers, respectively. An EVA period lasting approximately 45 minutes is scheduled after TEI by the CM pilot to retrieve two film cassettes from the SIM cameras. Pacific Ocean splashdown will nominally occur on April 28, 1972.

1.4 PRIORITY OF SCIENCE EXPERIMENTS AND DETAILED OBJECTIVES

The specification of science priorities is subject to the approval of the Associate Administrator for the Office of Space Sciences and Application (OSSA) and the concurrence of the Apollo Program Office (APO). Recommendations for prioritization are made to OSSA by the Apollo Lunar

Exploration Office. The priorities appearing in this document are those listed in the Apollo 16 MIP (Reference 7).

Science experiments and detailed objectives to be performed on the J-2 Mission are listed in Table 1-4 in descending order of priority. The order of priority presented is based upon such considerations as: (1) the science value of the experiment or detailed objective and the corresponding science benefits expected; (2) the results obtained from previous missions; (3) unachieved science objectives from previous missions; (4) changes made in the science payload since previous missions; (5) the science opportunity for the mission such as a particular landing site or astronomical conditions; (6) hardware which is flown the first time; and (7) the role of the experiment or objective in integrated science planning for future flights and programs.

This prioritization benefits premission planning activities and is also of significance when any of the science experiments or detailed objectives cannot be accomplished as planned because some contingency or abnormal situation (excessive ALSEP setup time, difficulty in LRV negotiating terrain, etc.) occurs during the mission with a resulting impact on such major mission considerations as consumables availability, crew participation in the science activities, and the mission timeline. This priority listing is provided to facilitate the assessment of the relative importance of each experiment and objective which will, in turn, aid in real-time replanning and rescheduling of science activities. The information presented is intended to maximize science return from the mission if a contingency situation arises where tradeoffs must be made and assessed quickly and efficiently in terms of crew, spacecraft, and mission constraints.

Table 1-1. J-2 Command Module Science Experiments/Objectives and Cognizant Science Personnel

LUNAR ORBIT EXPERIMENT/OBJECTIVE		PRINCIPAL INVESTIGATOR	S&AD POINT-OF-CONTACT
NO.	TITLE		
-	CM Photographic Tasks (Detailed Objective), includes use of: • Hasselblad Electric Camera • Maurer Data Acquisition Camera • 35-mm Nikon Camera	CSM Orbital Science Photographic Team Mr. Frederick J. Doyle, Chairman Topographic Division U.S. Geological Division 1340 Old Chainbridge Road McLean, Virginia 22101 (202) 343-9445	Mr. Samuel N. Hardee, Jr./TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
-	Visual Observations from Lunar Orbit (Detailed Objective)	Dr. Farouk El-Baz Lunar Exploration Department Bellcomm, Inc. 955 L'Enfant Plaza North, SW Washington, D.C. 20546 (202) 484-7636	Mr. Samuel N. Hardee, Jr./TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-176	Apollo Window Meteoroid	Mr. B. G. Cour-Palais/TN61 Geology Branch Planetary and Earth Sciences Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-4757	Mr. Samuel N. Hardee, Jr./TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666

Table 1-1. J-2 Command Module Science Experiments/Objectives and Cognizant Science Personnel (Continued)

LUNAR ORBIT EXPERIMENT/OBJECTIVE		PRINCIPAL INVESTIGATOR	S&AD POINT-OF-CONTACT
NO.	TITLE		
S-177	UV Photography-Earth and Moon	Dr. Tobias C. Owen Department of Earth and Space Sciences The State University of New York Stoney Brook, L.I., New York 11790 (516) 246-5000	Mr. Samuel N. Hardee, Jr./TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-178	Gegenschein from Lunar Orbit	Mr. Lawrence Dunkelman, Code 673 Goddard Space Flight Center Greenbelt, Maryland 20771 (201) 982-4988	Mr. Samuel N. Hardee, Jr./TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666

Table 1-2. J-2 Service Module Science Experiments/Objectives and Cognizant Science Personnel

LUNAR ORBIT EXPERIMENT/OBJECTIVE		PRINCIPAL INVESTIGATOR	S&AD POINT-OF-CONTACT
NO.	TITLE		
-	SM Orbital Photographic Tasks (Detailed Objective), includes use of: • 24-Inch Panoramic Camera • 3-Inch Mapping Camera • 3-Inch Stellar Camera • Laser Altimeter	CSM Orbital Science Photographic Team Mr. Frederick J. Doyle, Chairman Topographic Division U.S. Geological Survey 1340 Old Chainbridge Road McLean, Virginia 22101 (202) 343-9445 Laser Altimeter Data Analysis Dr. William M. Kaula Institute of Geophysics and Planetary Physics University of California at Los Angeles Los Angeles, California 90024 (203) 825-4363	Mr. Samuel N. Hardee, Jr./TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666

Table 1-2. J-2 Service Module Science Experiments/Objectives and Cognizant Science Personnel (Continued)

LUNAR ORBIT EXPERIMENT/OBJECTIVE		PRINCIPAL INVESTIGATOR	S&AD POINT-OF-CONTACT
NO.	TITLE		
S-160	Gamma-Ray Spectrometer	Dr. James R. Arnold Chemistry Department University of California at San Diego La Jolla, California 92037 (714) 453-2000 Ext. 1453	Mr. Vernon M. Dauphin/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-161	X-Ray Fluorescence	Dr. Isidore Adler, Code 641 Theoretical Studies Branch NASA Goddard Space Flight Center Greenbelt, Maryland 20771 (301) 982-5759	Mr. Vernon M. Dauphin/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-162	Alpha Particle Spectrometer	Mr. Paul Gorenstein American Science and Engineering, Inc. 955 Massachusetts Avenue Cambridge, Massachusetts 02139 (617) 868-1600 Ext. 260	Mr. Vernon M. Dauphin/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666

Table 1-2. J-2 Service Module Science Experiments/Objectives and Cognizant Science Personnel (Continued)

LUNAR ORBIT EXPERIMENT/OBJECTIVE		PRINCIPAL INVESTIGATOR	S&AD POINT-OF-CONTACT
NO.	TITLE		
S-164	S-Band Transponder • Subsatellite • CSM • LM	Mr. William L. Sjogren Mail Code 156-251 Jet Propulsion Laboratory 4800 Oak Grove Drive Pasadena, California 91103 (213) 354-4868	Mr. Patrick E. Lafferty/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-165	Mass Spectrometer	Dr. John H. Hoffman Atmospheric and Space Sciences University of Texas at Dallas Dallas, Texas 75230 (214) 231-1471 Ext. 322	Mr. Martin L. Miller/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-170	Bistatic Radar	Mr. H. Taylor Howard Stanford Electronics Laboratory Stanford University Stanford, California 94305 (415) 321-2300 Ext. 3537	Mr. Patrick E. Lafferty/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666

Table 1-2. J-2 Service Module Science Experiments/Objectives and Cognizant Science Personnel (Continued)

LUNAR ORBIT EXPERIMENT/OBJECTIVE		PRINCIPAL INVESTIGATOR	S&AD POINT-OF-CONTACT
NO.	TITLE		
S-173	Particle Shadows/Boundary Layer (Subsatellite)	Dr. Kinsey A. Anderson Space Science Laboratory University of California at Berkeley Berkeley, California 94726 (415) 642-1313	Mr. Patrick E. Lafferty/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-174	Magnetometer (Subsatellite)	Dr. Paul J. Coleman, Jr. Department of Planetary and Space Science University of California at Los Angeles Los Angeles, California 90024 (213) 825-1776	Mr. Patrick E. Lafferty/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666

Table 1-3. J-2 Lunar Surface Science Experiments and Cognizant Science Personnel

LUNAR SURFACE EXPERIMENT		PRINCIPAL INVESTIGATOR	S&AD POINT-OF-CONTACT
NO.	TITLE		
S-031	Passive Seismic (Apollo 16 ALSEP Experiment)	Dr. Gary V. Latham Lamont-Doherty Geological Observatory Columbia University Palisades, New York 10964 (914) 359-2900 Ext. 258	Mr. Wilbert F. Eichelman/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-033	Active Seismic (Apollo 16 ALSEP Experiment)	Dr. Robert L. Kovach Department of Geophysics Stanford University Stanford, California 94305 (415) 321-2300 Ext. 4827	Mr. Wilbert F. Eichelman/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-034	Lunar Surface Magnetometer (Apollo 16 ALSEP Experiment)	Dr. Palmer Dyal, Code N204-4 Space Science Division/ Electrodynamics Branch NASA Ames Research Center Moffett Field, California 94034 (415) 961-1111 Ext. 2706	Mr. Timothy T. White/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666

Table 1-3. J-2 Lunar Surface Science Experiments and Cognizant Science Personnel (Continued)

LUNAR SURFACE EXPERIMENT		PRINCIPAL INVESTIGATOR	S&AD POINT-OF-CONTACT
NO.	TITLE		
S-037	Heat Flow (Apollo 16 ALSEP Experiment)	Dr. Marcus E. Langseth Lamont-Doherty Geological Observatory Columbia University Palisades, New York 10964 (914) 359-2900 Ext. 335	Mr. Wilbert F. Eichelman/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-059	Lunar Geology Investigation	Dr. William R. Muehlberger Geology Department University of Texas at Austin Austin, Texas 78712 (512) 471-5172	Mr. Martin L. Miller/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-080	Solar Wind Composition	Dr. Johannes Geiss University of Berne Berne, Switzerland	Mr. Timothy T. White/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666

Table 1-3. J-2 Lunar Surface Science Experiments and Cognizant Science Personnel (Continued)

LUNAR SURFACE EXPERIMENT		PRINCIPAL INVESTIGATOR	S&AD POINT-OF-CONTACT
NO.	TITLE		
S-152	Cosmic Ray Detector (Sheets)	Dr. R. L. Fleischer PI Team Chairman General Physics Laboratory General Electric Research and Development Center Schenectady, New York 12301 (518) 346-8771 Ext. 6469 Dr. R. M. Walker, Co-PI Washington University Dr. P. B. Price, Co-PI University of California at Berkeley	Mr. Timothy T. White/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-198	Portable Magnetometer	Dr. Palmer Dyal Code N204-4 Space Science Division/ Electrodynamics Branch NASA Ames Research Center Moffett Field, California 94034 (415) 961-1111 Ext. 2706	Mr. Timothy T. White/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666

Table 1-3. J-2 Lunar Surface Science Experiments and Cognizant Science Personnel (Continued)

LUNAR SURFACE EXPERIMENTS		PRINCIPAL INVESTIGATOR	S&AD POINT-OF-CONTACT
NO.	TITLE		
S-200	Soil Mechanics	Dr. James K. Mitchell Department of Civil Engineering 440 Davis Hall University of California at Berkeley Berkeley, California 94726 (415) 642-1262	Mr. Martin L. Miller/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666
S-201	Far UV Camera/Spectroscope	Dr. George R. Carruthers Code 7124.3 E. O. Hurlburt Center for Space Research Naval Research Laboratory Washington, D.C. 20390 (202) 767-2764 Co-PI: Dr. Thornton L. Page*/TN1 Planetary and Earth Sciences Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-3589	Mr. Timothy T. White/TD4 Experiment Development and Integration Branch Science Missions Support Division NASA Manned Spacecraft Center Houston, Texas 77058 (713) 483-2666

*NRL Representative at MSC for S-201 Experiment.

Table 1-4. J-2 Mission Science Experiments/Objectives Priority*

LUNAR SURFACE EXPERIMENTS	PRIORITY
Documented Samples at Highest Priority Traverse Station (Part of Lunar Geology Investigation/ S-059)	1
Apollo 16 ALSEP	2
• Heat Flow (S-037)	2.1
• Lunar Surface Magnetometer (S-034)	2.2
• Passive Seismic (S-031)	2.3
• Active Seismic (S-033)	2.4
Drill Core Sample (Part of Lunar Geology Investigation/S-059)	3
Lunar Geology Investigation (S-059)	4
Far UV Camera/Spectroscope (S-201)	5
Solar Wind Composition (S-080)	6
Soil Mechanics (S-200)	7
Portable Magnetometer (S-198)	8
Cosmic Ray Detector (Sheets) (S-152)	9

LUNAR ORBIT EXPERIMENT/OBJECTIVE	PRIORITY
Gamma-Ray Spectrometer (S-160)	1
X-Ray Fluorescence (S-161)	2
SM Orbital Photographic Tasks (DO)	3
Subsatellite	4
• Particle Shadows/Boundary Layer (S-173)	4.1
• Magnetometer (S-174)	4.2
• S-Band Transponder (S-164)	4.3
Bistatic Radar (S-170)	5
S-Band Transponder (CSM/LM) (S-164)	6
Alpha Particle Spectrometer (S-162)	7
Mass Spectrometer (S-165)	8
UV Photography - Earth and Moon (S-177)	9
Gegenschein from Lunar Orbit (S-178)	10
CM Photographic Tasks (DO)	11
Visual Observations from Lunar Orbit(DO)	12
Note: The Apollo Window Meteoroid Experiment (S-176) is not prioritized since it is passive and does not impact mission planning, crew activity, or spacecraft operations.	

*Priorities as presented in the Apollo 16 MIP (Reference 7)

Figure 1-1. Lunar Impact Points of Spent S-IVB and LM Ascent Stages - In Situ Calibrations of Seismic Experiment Response

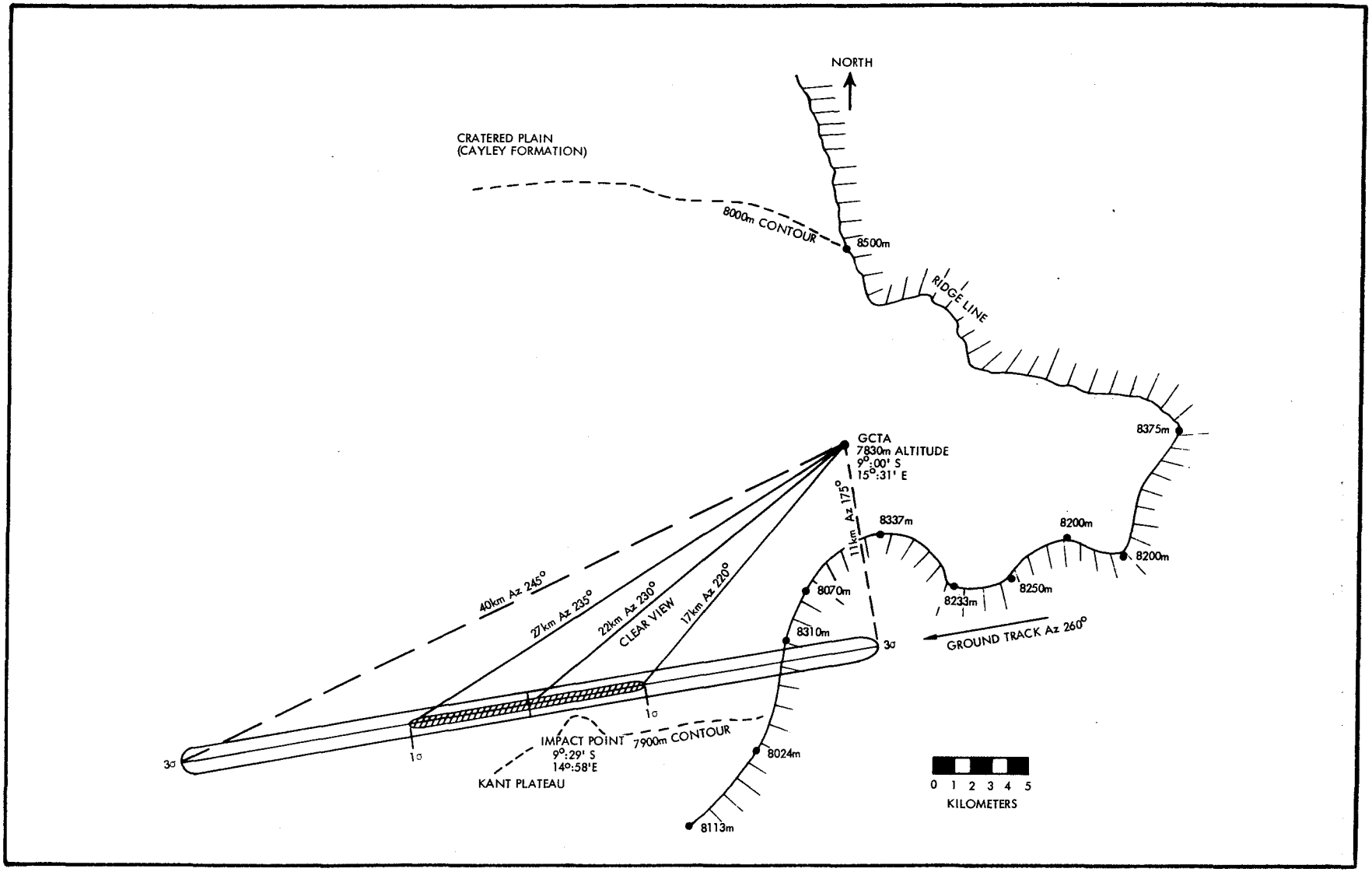


Figure 1-2(a). GCTA Coverage of LM Ascent Stage Impact at Descartes - Vertical View Perspective

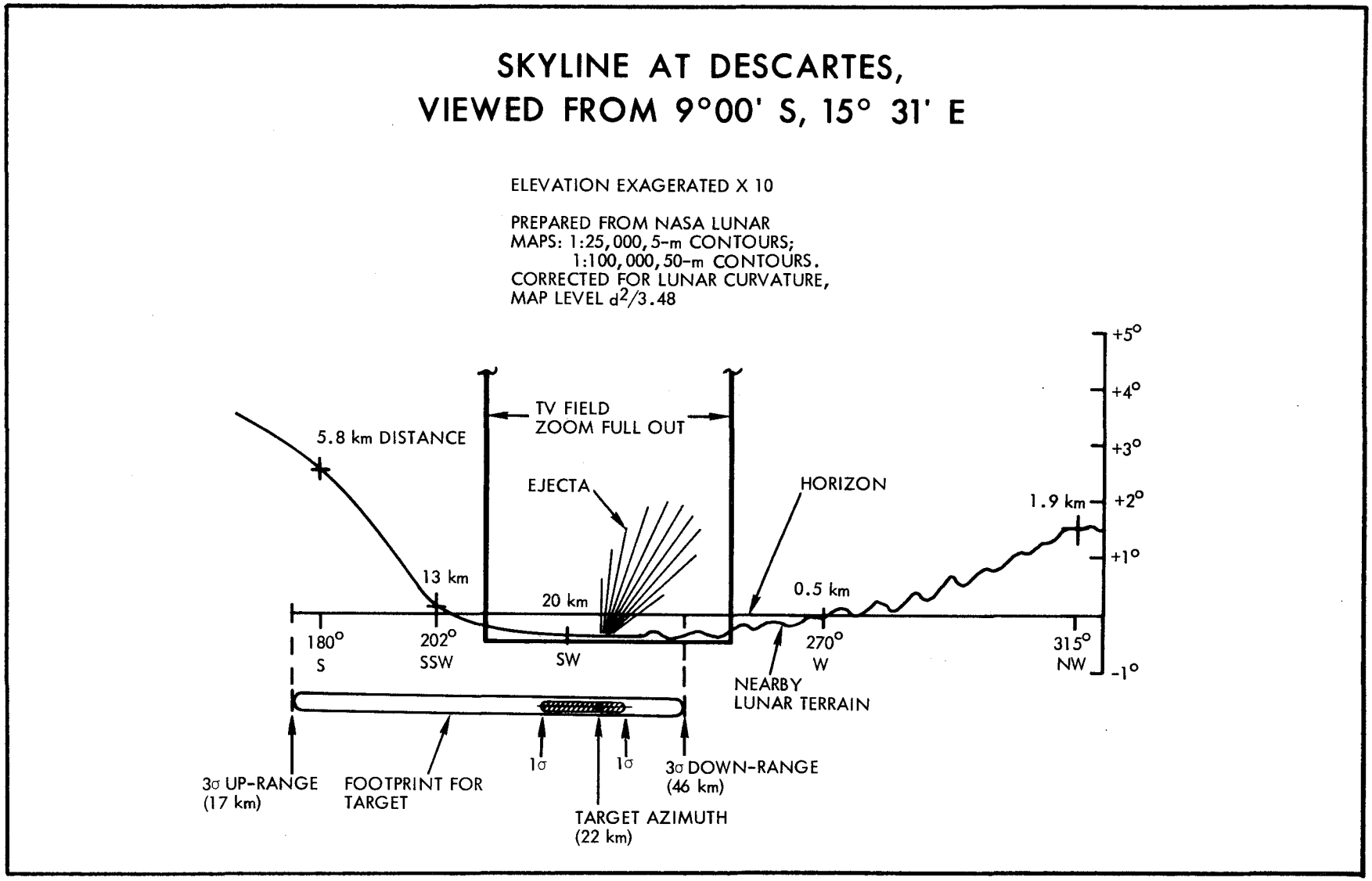


Figure 1-2(b). GCTA Coverage of LM Ascent Stage Impact at Descartes - Surface View Perspective From Landing Point

SECTION II

EXPERIMENT AND EQUIPMENT DESCRIPTION

2.1 GENERAL

This section contains brief physical and functional descriptions of each science-related experiment and detailed objective (DO) assigned to Apollo Mission J-2; it also identifies deployment interfaces and major support hardware for these experiments and DO's. Science equipment and sensors for lunar orbit activities are summarized in Table 2-1; those for lunar surface activities are summarized in Table 2-2. Science experiments and DO equipment, deployment interface details, and support hardware are illustrated in Figures 2-1 through 2-35. Standard facility equipment, such as cameras used to satisfy the photographic requirements of these experiments and DO's, is identified but not described.

Information presented in this section is general in nature and covers science hardware data most of which are available or proposed for inclusion in a number of other documents. This information is intended as an overview to familiarize each Principal Investigator (PI) and members of the scientific community with the science hardware planned for use during the mission. Personnel responsible for detailed hardware planning should use data published in MSC-controlled documents as they become available. These documents include the CSM/LM Spacecraft Operational Data Book, Volume V, ALSEP Data Book (Reference 9); and Volume VI, CSM Experiments Data Book for J-Missions (Reference 10). Noncontrolled documents which contain detailed hardware information include the Apollo Operations Handbook, Block II Spacecraft, Volume I, Spacecraft Description (Reference 11); Apollo 16 ALSEP Array D, Flight System Familiarization Manual (Reference 12); and Photo Equipment for Manned Space Flight Handbook (Reference 13).

2.2 LUNAR ORBIT SCIENCE EXPERIMENTS AND DETAILED OBJECTIVES

2.2.1 COMMAND MODULE SCIENCE EXPERIMENTS AND DETAILED OBJECTIVES

2.2.1.1 Command Module Photographic Tasks

The purposes of the Command Module (CM) Photographic Tasks detailed objective are to obtain photographs of lunar surface features of scientific interest from lunar orbit and transearth coast, and to obtain photographs of low brightness astronomical and terrestrial sources.

Photographic activities in the following categories will be conducted:

a) Lunar surface photography in lunar orbit:

Photographs are to be obtained of lunar surface areas of high scientific interest, and of specific segments of the lunar surface in earthshine and in low light levels near the terminator. This photography will complement that accomplished by the panoramic and mapping cameras installed in the Scientific Instrument Module (SIM) bay.

b) Dim light photography:

Photographs are to be obtained of diffuse galactic light from selected celestial subjects, the solar corona, and the zodiacal light while in lunar orbit.

In addition to these photography activities, comet photographs will be obtained if the appropriate combination of trajectory and celestial conditions exist. Such conditions have not yet been identified.

These tasks involve the use of the following operational CM photography equipment: the 16-mm data acquisition camera with 18-mm lens (CM sextant is used with the data acquisition camera (DAC) for possible comet photography); the 70-mm Hasselblad electric camera with 80-mm and 250-mm lenses; a 35-mm Nikon camera with 55-mm lens; camera mounting brackets; and camera hoods or spacecraft window shades for dim light photography tasks. Crew participation is required to operate the cameras and to change lenses and camera settings; to record such specific photograph identification items as ground elapsed time (GET), frame number, magazine number, and exposure time; and to control the reaction control system (RCS) jet firings to achieve and maintain the specified spacecraft attitude and attitude rates. The RCS jets will be inhibited during dim light photographic sequences to eliminate undesired illumination from the RCS.

2.2.1.2 Apollo Window Meteoroid (S-176)

The purpose of this experiment is to obtain data pertaining to the meteoroid cratering flux for masses of 10^{-12} grams and larger. This particle flux is the predominant mechanism for the degradation of surfaces exposed to the space environment.

This experiment is completely passive. The CM windows, composed of fused silica, are used as the meteoroid detecting surfaces. High magnification scanning studies of these windows conducted before and after flight will yield the data desired.

2.2.1.3 UV Photography - Earth and Moon (S-177)

The purpose of this experiment is to obtain ultraviolet (UV) photographs of sunlit areas of the earth and moon for use in the study of planetary atmospheres, and for the investigation of short wavelength fluorescence from the lunar surface. It is planned to obtain color photographs in the visible spectrum of the objects photographed in the UV and visible spectra (except lunar terra and maria) to aid in photography interpretation. The short wavelength studies of the lunar surface will detect lunar surface color differences and fluorescence, if present.

Photography is performed with the 70-mm Hasselblad electric camera mounted in a special bracket installed beside the right hand (RH) side window of the CM. This window has been designed to transmit a larger fraction of the incident UV radiation than the standard CM window. For UV photography on black and white film, a 105-mm lens and a ring slide assembly containing four band-pass filters are used with the camera. Three of the filters admit electromagnetic radiation in different regions of the UV spectrum, and one filter admits electromagnetic radiation in the visible region of the spectrum. Color photography is performed with the same camera and lens using the visible spectrum filter. Crew participation is required to install the special bracket, remove the UV window cover and install the special window shade, mount and operate the camera, attach the filter slide, change filters, and record the beginning and ending times of the photographic sequences. The crew is also required to achieve and maintain the proper spacecraft attitude and attitude rates for each photographic sequence.

2.2.1.4 Gegenschein from Lunar Orbit (S-178)

The purpose of this experiment is to make photographic observations to determine if, and to what extent, reflection from dust particles at the Moulton point contributes to the gegenschein. Photographs will be taken in the direction of the antisolar vector, in the direction of the Moulton point, and midway between the antisolar and Moulton point directions.

Photography is to be performed by means of the 35-mm Nikon camera with its 55-mm lens while the command service module (CSM) is in total darkness in lunar orbit. Window shades and a darkened spacecraft will be required to minimize the effects of stray light in the spacecraft. The crew is required to maneuver the spacecraft to the proper attitude, inhibit RCS jets after the spacecraft attitude rates have damped below a specified level, operate the camera, and record the start and stop times of each of the required photographic exposures.

2.2.1.5 Visual Observations From Lunar Orbit

The purpose of the Visual Observations from Lunar Orbit detailed objective is to make and record visual observations of particular lunar surface features and processes to complement photographic and other remote sensed data. Observations on far side passes will be recorded on the onboard tape recorder, near side passes observations will be recorded by real-time voice communications with the Mission Control Center (MCC).

Flight hardware is not required; the observations will be made by the command module pilot (CMP) from the available CSM windows without disturbing SIM operations. When appropriate, the visual observations will be recorded by marking onboard graphics and charts.

2.2.2 SERVICE MODULE SCIENCE EXPERIMENTS AND DETAILED OBJECTIVES

2.2.2.1 SM Orbital Photographic Tasks

The purpose of the SM Orbital Photographic Tasks detailed objective 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. Metric photographs of the lunar surface will also be taken during TEC. This detailed objective makes use of two camera assemblies, the 24-Inch Panoramic Camera and the 3-Inch Mapping Camera

(with 3-inch stellar camera and laser altimeter), mounted in the service module (SM) SIM bay to obtain the required imagery and altitude data.

a) 24-Inch Panoramic Camera. The purpose of the SIM 24-Inch Panoramic Camera (Figures 2-1 through 2-3) is to obtain high-resolution panoramic photographs with stereoscopic and monoscopic coverage of the lunar surface. Panoramic camera photographs taken of the lunar surface overflown by the CSM will aid the principal investigators of the other SIM experiments to correlate their sensor data with lunar surface terrain features. The camera will provide 1- to 2-meter resolution photography from an orbital altitude of 60 nautical miles.

The panoramic camera is composed of four main components: (1) a roll frame assembly that rotates continuously in the cross-track scan direction during camera operation (panoramic scanning); (2) a gimbal assembly which tilts fore and aft to provide stereo coverage as well as forward motion compensation (FMC); (3) the main frame; and (4) a gaseous nitrogen (GN_2) pressure vessel assembly (provides GN_2 for certain film roller gas bearings). This pressure vessel assembly also provides a GN_2 source for the 3-Inch Mapping Camera. The camera optics system, camera/film drive and control system, and film cassette complete the camera system. The film cassette will be retrieved by a crewman extravehicular activity (EVA) during the transearth portion of the mission.

The panoramic camera is mounted in the CSM SIM bay between the two SIM shelves. It is designed to operate in its SIM-installed position without the use of a deployment subsystem. Protection of the camera lens from CSM contamination sources such as effluent dumps and RCS/Service Propulsion System (SPS) firings is provided by stowing the lens face-inward to the SIM. This stowage position is automatically achieved when off-nominal lens and/or outside thermal control surface temperature conditions are experienced and the camera control is set to STANDBY. Thermal conditions to achieve lens stowage are preflight predicted and verified by inflight monitoring of temperature telemetry channels. Operational precautions must also be observed to protect the camera's velocity-to-height* (V/h) and automatic

*A J-2 Mission design change will provide the capability to manually override the camera automatic V/h selection system (45- to 80-nautical mile attitude range) with two manually selected rates corresponding to altitudes of 55 and 60 nautical miles.

exposure control (AEC) sensors from excessive exposure to direct solar radiation since these sensors have neither a face-inward stowage capability nor a protective cover.

CM camera controls are available for the crew to activate/deactivate camera heaters; supply/remove primary camera power; select operate/standby operational modes; supply film roller torque to prevent film slack during launch, translunar injection (TLI), and SPS-powered flight phases; activate the five-film frame advance cycle required daily (if camera is not operated in that 24-hour period) to prevent film "set" after film loading; increase/decrease the width of the camera exposure slit; and select the stereoscopic or monoscopic mode of operation. One CM crew display of the "barber pole"/gray talkback type is provided to verify camera operational status.

b) 3-Inch Mapping Camera. The purpose of the 3-Inch Mapping Camera (Figures 2-1, 2-2, and 2-4) is to obtain high-quality metric photographs of the lunar surface and stellar photographs exposed simultaneously with the metric photographs. Metric photographs will be obtained using the 3-inch cartographic lens, and star-field photographs will be obtained using the 3-inch stellar camera lens. The mapping camera provides concurrent supporting photography for the SIM panoramic camera. Mapping camera photographs taken of the lunar surface overflown by the CSM will also aid the PI's of the other SIM experiments to correlate their sensor data with lunar surface terrain features. In addition, the stellar camera is operated*, if the laser altimeter is not operating in the decoupled mode, on the lunar dark side in conjunction with laser altimeter operation as film budgets permit. These time-correlated stellar photographs are used to provide a reference for the determination of the pointing vector for both the metric camera and laser altimeter. The metric camera will provide 20-meter resolution photography from an orbital altitude of 60 nautical miles. Although prime mission photography is to be performed in lunar orbit, it is also planned to obtain wide-area photographs of the lunar surface during transearth coast to extend selenodetic control and mapping.

*The metric camera also operates during this dark side period of altimeter operation since there is no way to decouple the operation of the stellar camera from the metric camera. The metric imagery obtained is, of course, useless due to the absence of sunlight for terrain feature illumination.

The mapping camera system is composed of two individual camera subsystems: the metric (terrain mapping) camera, which performs the cartographic function, and the stellar camera. These subsystems have been integrated into a single unit that has the optical axis relationship necessary to satisfy the precision mapping camera and laser altimeter postmission attitude (pointing) determination requirements. This system also uses the GN_2 pressure vessel assembly, shared with the SIM panoramic camera, as a source of GN_2 to provide an inert and pressurized atmosphere within the camera to minimize potential static electrical corona discharge which could expose areas on the film. The camera optics system, film drive/exposure/takeup system, and a removable cassette (containing both metric and stellar camera film) complete the camera system. The film cassette is retrieved by a crewman EVA during TEC after photography operations are complete.

The mapping camera system is mounted on the top shelf in the CSM SIM bay, and is deployed on a rail-type mechanism when acquiring photography data in order to provide an unobstructed field-of-view for the stellar camera (ensures that the star field photographed is not obscured by either the lunar horizon or the SM mold line). A protective cover attached to the SIM shelf protects the metric camera lens and laser altimeter optics from spacecraft contaminants produced during RCS/SPS firings and effluent dumps as well as from direct sunlight impingement. This cover* has provisions for multiple opening and closing cycles. A multiple-opening protective cover that opens and closes automatically by mapping camera deployment and retraction, respectively, is also provided to protect the lens of the stellar camera.

CM camera controls are furnished for the crew to activate/deactivate camera heaters and camera functions; to activate/deactivate the image motion compensation (IMC) switch and increment the camera V/h control signal (five incremental steps are possible before recycling); and to activate and extend/retract the camera system on its deployment rails. Controls are also supplied to actuate the metric camera lens/altimeter optics protective

*Cover also contains a tungsten shield to reduce the gamma radiation background at the deployed gamma-ray detector produced from radioactive sources present in the metric camera lens. Cover is to be closed during primary gamma-ray detector operation.

cover when required. Two CM crew displays of the barber pole/gray talkback type are provided to verify camera operational status and to indicate the mapping camera system deployment status (fully extended/retracted). A third CM talkback display indicates the deployment status of the metric camera lens/altimeter optics protective cover.

c) Laser Altimeter. The purpose of the Laser Altimeter (Figures 2-1, 2-2, and 2-4) is to obtain ranging data to determine the altitude of the CSM above the lunar surface. These ranging data, acquired with 1-meter resolution, are used to support mapping and panoramic camera photography, to provide precision altitude data for other orbital experiments, and to relate and define lunar topographical features for a better definition of lunar shape.

The laser altimeter is hard-mounted and aligned to the mapping camera subsystem mounted on the top shelf in the CSM SIM bay, and shares with the metric camera a SIM-shelf mounted optics protective cover. The altimeter/camera system is deployed on a rail-type mechanism when operating. The altimeter can operate in either of two modes as follows: When the metric camera is operating, the altimeter automatically emits a laser pulse to correspond to a midframe ranging for each film frame exposed by the metric camera (approximately 1 ranging pulse every 24 seconds). The altimeter is also capable of operating in a decoupled mode (from the metric camera) which allows for independent ranging measurements (one every 20 seconds) when the metric camera is inoperative. Stellar camera photography to provide a precise spacecraft attitude reference is not obtained when the altimeter operates in the decoupled mode.

CM controls are provided to activate/deactivate the altimeter. No CM displays are supplied specifically for the laser altimeter although they are furnished for the mapping camera subsystem.

2.2.2.2 Gamma-Ray Spectrometer (S-160)

The purpose of the Gamma-Ray Spectrometer Experiment assembly (Figures 2-1, 2-2, and 2-5) is to obtain data relating to the origin and evolution of the moon by determining the degree of chemical differentiation the moon has undergone during its development and to determine the composition of the

lunar surface. Lunar surface gamma-rays are produced from the decay of natural radioactive isotopes such as uranium and thorium and the bombardment of nuclei of chemical elements making up the lunar surface by cosmic ray particles. Cosmological gamma-ray flux (to determine effect of lunar occultation on galactic flux change), cislunar space radiation flux, and the CSM/SIM radioactivity background* flux measurements will be made during transearth coast to determine the contribution of these sources to spectrometer data acquired in lunar orbit. In addition, a gamma-ray astronomy survey at partial boom extensions using the CSM as an occulting body will be performed during TEC to obtain emission patterns from known galactic sources and to locate new sources for further astronomy studies. This instrument is capable of measuring gamma radiation in the energy range from 0.2 to 10 million electron volts.

The experiment sensing assembly is composed of three major subassemblies: (1) the gamma-ray detector; (2) the gamma-ray electronics; and (3) the thermal shield and experiment support bracketry. Prior to gathering prime data, the detector is deployed from the SIM bay on a boom to remove the sensor from the influence of CSM/SIM radiation sources. The fully deployed distance is 7.6 meters beyond the SM mold line and represents the primary operation mode of the detector. The metric camera/laser altimeter protective cover is to be closed on a metric camera/laser altimeter operation noninterference basis to the maximum extent possible during primary gamma-ray detector operation periods. It will also be closed during TEC data-gathering periods except for a brief period. This cover shields the detector from metric camera lens radioactive sources. During transearth coast, the boom will be extended to intermediate distances of 2.4 meters and 1.2 meters, and retracted to the fully stowed position to obtain measurements required to assess the background* gradient contributed by CSM/SIM radiation sources. The experiment assembly (including the boom deployment mechanism) is suspended from the bottom of the first shelf in the SIM bay. A protective box-like cover has been mounted to the SIM shelf and completely encloses the detector when it is fully retracted. The cover door opens automatically when the boom is

*Radiation background is primarily secondary gamma-rays produced by cosmic ray interactions with atomic structure of exposed spacecraft surfaces.

extended and closes when it is retracted. This cover shields the instrument from the thermal environment produced by RCS engines that fire over the SIM bay.

CM controls are available for the crew to extend, retract, and jettison the boom. The crew may approximately select any intermediate boom position for the detector by monitoring the elapsed time* of boom extension or retraction. CM controls are provided for the crew to activate/deactivate the detector, incrementally alter the sensitivity (gain) of the detector, and select one of two detector counting modes. Two CM crew displays of the barber pole/gray talkback type are associated with boom status. They indicate the state of boom deployment (fully extended/retracted or not) and jettison (jettison complete or not).

2.2.2.3 X-Ray Fluorescence (S-161)

The purposes of the X-Ray Fluorescence Experiment assembly (Figures 2-1, 2-2, and 2-6) are to measure the instantaneous fluorescent X-ray flux from the lunar surface; to monitor both the direct solar X-ray flux which produces this fluorescence and the background galactic X-ray flux in order to obtain a gross analysis of the elemental composition of the lunar surface materials; and to measure the X-ray flux of selected galactic objects for X-ray astronomy investigations. In addition, an X-ray survey of the supergalactic plane will be performed to locate new X-ray galactic sources. All X-ray astronomy activities will be performed during TEC. A separate assembly (Figure 2-7) termed the Solar Monitor, mounted in the SIM bay (Bay IV) opposite the SIM bay (Bay I), measures the solar X-ray flux. Background galactic X-ray flux is monitored by the fluorescence X-ray sensor at selected intervals both in lunar orbit and during transearth coast. This instrument is capable of detecting X-rays in the energy range from 0.75 to 6 kiloelectron volts.

*Boom extension and retraction rates are determined in real time by the crew through a combination of ground tests conducted on flight hardware and inflight operational tests.

The X-ray fluorescence sensing assembly consists of three gas-filled (P-10) proportional counter detectors, mechanical collimators, calibration sources for in-flight calibration, a temperature monitor, and associated electronics. A magnesium passive filter covers one detector and an aluminum passive filter covers a second detector; no filter is provided for the third or bare detector. These filters increase detector sensitivity at the selected wavelength. This assembly is mounted in the same enclosure that houses the Alpha Particle Spectrometer Experiment. The combined package is mounted on the shelf forming the bottom of the CSM SIM bay. A protective cover (shared with the Alpha Particle Spectrometer Experiment) shields sensitive detector elements from spacecraft contamination sources and direct sunlight impingement. The cover mechanism provides multiple opening and closing cycles.

The solar monitor sensor has a view direction 180 degrees displaced from that of the X-ray fluorescence sensor. The solar monitor is provided with a door to shield its detector elements from adverse thermal, contamination, and launch environments encountered prior to lunar orbit insertion (LOI). This door, provided with only a one-time opening capability, is deployed early in lunar orbit.

The X-Ray Fluorescence Experiment is designed to acquire data in its SIM-installed position. CM controls are available for the crew to activate/deactivate the experiment (including heaters) and to deploy (open) the solar monitor door. Additional controls are provided to open and close the experiment detector's protective cover (shared with the Alpha Particle Spectrometer Experiment) when required. There are no CM displays for crew monitoring of the experiment itself. There is, however, one CM display of the barber pole/gray talkback type to indicate the deployment status of the protective cover.

2.2.2.4 Alpha Particle Spectrometer (S-162)

The purpose of the Alpha Particle Spectrometer Experiment assembly (Figures 2-1, 2-2, and 2-6) is to obtain data on the gross rate of lunar surface radon evolution and on localized sources of enhanced radon emission for use in constructing a radiation map showing lunar surface inhomogeneities. Alpha particles to be detected are those emitted from radon gas isotopes (Rn^{220} and Rn^{222}) and their daughter products. Measurements of deep space

background alpha particles will also be made during lunar orbit and transearth coast concurrent with X-ray experiment operation. The experiment is capable of detecting alpha particles in the energy range from 3.5 to 7.5 million electron volts.

The alpha particle sensing assembly is composed of an array of 10 silicon barrier detectors, supporting electronics, and temperature monitors housed in the same enclosure as the X-ray fluorescence experiment assembly. The detector assembly is shielded from spacecraft contamination sources and direct solar illumination by the cover that also shields the X-ray fluorescence detectors.

The Alpha Particle Spectrometer Experiment is designed to acquire data in its SIM-installed position. CM controls are provided for the crew to activate/deactivate the experiment. As for the X-ray experiment, a CM control is furnished for the deployment of the detector assembly protective cover when required. There are no CM displays for crew monitoring of the experiment itself. The protective cover deployment status is indicated on the same talkback display shared with the X-ray experiment.

2.2.2.5 Mass Spectrometer (S-165)

The purposes of the Mass Spectrometer Experiment (Figures 2-1, 2-2, and 2-8) are to obtain data on the composition of the lunar ambient atmosphere, to locate areas of lunar volcanism, and to determine the amount of lunar atmospheric contamination due to rocket firing near the lunar surface and from the spacecraft. During transearth coast, the mass spectrometer will obtain data on the amount of local contamination contributed by spacecraft effluents and RCS firings. This instrument has the capability of identifying species with atomic masses from 12 to 28 atomic mass units (AMU) with its Number 1 ion counter and from 28 to 66 AMU's with its Number 2 ion counter.

The spectrometer experiment assembly consists of the mass spectrometer itself with ion scoop,* its associated electronic components, and a boom

*A design change to the ion scoop for the J-2 Mission adds an inner plenum with heater attached to the ion source. This change in conjunction with baffling of the outgassing ports to obviate sunlight activation of sensitive electronics provides more effective scoop temperature and outgassing control.

deployment mechanism. A SIM shelf-mounted shield, to protect the spectrometer ion scoop inlet and outgassing ports from spacecraft contamination sources when in its SIM-stowed position, opens and closes automatically when the boom is extended and retracted, respectively.

When gathering prime data, the spectrometer assembly is fully deployed on a boom to remove the mass spectrometer from the influence of CSM contaminant sources. This fully deployed distance is 7.3 meters beyond the SM mold line. The spectrometer is deployed at least 1.2 meters for periods of ion source heater operation. The spectrometer is to be operated at various intermediate boom positions for specified periods during the latter portion of the lunar orbit science period to determine the gradient and abundances of constituents forming the CSM contamination cloud accumulated in lunar orbit. Photographs of the deployed spectrometer are to be taken by the crew at specified periods with the CM 16-mm DAC camera and its 18-mm lens to determine the boom twist characteristics* and, correspondingly, ion scoop orientation.

Operation of the mass spectrometer during TEC is devoted exclusively to the separate determination of the degree of contamination that various spacecraft contamination sources contribute to the composition of the characteristic CSM contamination cloud. Defining the composition, characteristics, and spatial extent of this cloud plays a major role in properly interpreting the mass spectrometer orbital data. Specific data to be acquired in TEC include: mass spectrometer operation at various boom extension distances shortly after TEI to establish a CSM "clean" cloud baseline for the ensuing tests; mass spectrometer operation with boom fully extended during a water dump and fuel cell purge, respectively; mass spectrometer operation with full and partial boom extensions for oxygen only purges; and mass spectrometer operation at full boom extension after a series of short RCS firing and outgassing periods.

The mass spectrometer's lunar orbit data gathering and outgassing attitude requirements are unique with respect to those of the other SIM bay experiment sensors and cameras in that its scoop is designed to acquire

*It is also desirable to observe and define any boom vibration characteristics that may be evident.

atmospheric constituents for sampling when the CSM's aft end is aligned along the positive direction of orbital motion (i.e., the CSM's nose aligned approximately in the direction of the negative spacecraft velocity vector). This operational attitude is termed -X direction operation and is the normal spacecraft attitude mode for crew sleep periods. The spacecraft attitude to be used for operation of the other SIM bay experiment sensors and cameras is with the CSM's nose aligned in the direction of the positive spacecraft velocity vector and is termed +X direction operation. For both +X and -X direction operation, the SIM bay centerline is to be aligned along the nadir.

The prime periods to acquire mass spectrometer data and to provide for instrument outgassing is during the first revolutions in each new lunar orbit. This would be the 60- by 8-nautical mile elliptical orbit and after the circularization and each plane change of the 60- by 60-nautical mile circular orbit. This will allow relatively uncontaminated atmospheric data to be acquired before the orbital path in the vicinity of the spacecraft becomes increasingly more polluted from spacecraft contaminant sources.

About half of the scheduled orbital operation of the mass spectrometer is planned to be in the +X direction attitude. Data acquired in this orientation is indicative of orbital contamination in the vicinity of the spacecraft. This will allow a correction to be applied to data acquired in the -X direction attitude since it is possible to measure species in the latter orientation from both the lunar atmosphere and locally of spacecraft origin.

The experiment assembly (including the deployment mechanism) is suspended from the bottom of the first shelf of the SIM bay. The gamma-ray and mass spectrometers are separated by approximately 4.6 meters if both are in the fully deployed position simultaneously.

CM controls are provided to extend, retract, and jettison the boom. The crew may approximately select any intermediate boom position for the spectrometer by monitoring the elapsed time* of boom extension or

*Boom extension and retraction rates are determined in real time by the crew through a combination of ground tests conducted on flight hardware and inflight operational tests.

retraction. CM controls are provided for the crew to activate/deactivate the spectrometer ion source heaters. Two CM crew displays of the barber pole/gray talkback type are associated with boom status. They indicate the state of boom deployment (fully extended/retracted or not) and jettison (jettison complete or not).

2.2.2.6 Subsatellite (S-164, S-173, S-174)

The subsatellite (Figures 2-1, 2-2, and 2-9), deployed from the CSM SIM bay while in lunar orbit, is the host carrier for three experiments to be conducted over a planned 1-year period. These experiments are the S-Band Transponder Experiment (S-164), Particle Shadows/Boundary Layer Experiment (S-173), and the Magnetometer Experiment (S-174).

The basic subsatellite elements are the subsatellite, a launch platform, and a mechanism to deploy the subsatellite and launch platform from the CSM SIM bay. The deployment mechanism provides for a subsatellite launch position that is clear of the SM mold line. The launch platform is retracted after launch. A box-like container similar to a rural mail box completely encloses the subsatellite, launch platform, and deployment mechanism within the SIM bay. This container protects the subsatellite from spacecraft contamination sources prior to deployment. A door at the outboard end of the container automatically opens when the launch platform is extended and closes when it is retracted.

After the proper SIM bay launch attitude and attitude rates are achieved, the subsatellite launch platform then deploys and launches the subsatellite in such a manner that its spin axis is approximately perpendicular to the ecliptic plane. Launch is performed on the lunar dark side in a northern direction. Deployment and launch operations are automatic and continuous processes upon initiation of the subsatellite launch command from the CM. The nominal linear launch velocity of the subsatellite is approximately 1.22 meters per second relative to the CSM to achieve the desired launch clearance. The subsatellite is provided an initial spin rate of 140 revolutions per minute for attitude stabilization by the launch platform. After complete satellite boom deployment, this spin rate is expected to stabilize at approximately 12 revolutions per minute. The subsatellite has three equally-spaced, folded booms mounted around the base of the

subsatellite which deploy automatically after launch to a length of 1.52 meters. The subsatellite magnetometer is mounted at the end of one boom, whereas the other two booms are provided with a proper mass balance relationship to achieve the desired subsatellite spin-stabilization characteristics.

The subsatellite itself consists of charged particle detectors (two types), a biaxial flux gate magnetometer, an optical solar aspect system (for subsatellite attitude determination), data storage unit, power system, command decoder, and an S-band communications system. Details of the subsatellite particle detectors are presented in Figure 2-10. CM controls are provided to deploy/launch the subsatellite as well as to retract the deployment mechanism into the SIM bay after subsatellite launch. One multipurpose CM display of the barber pole/gray talkback type for the crew verifies launch of the subsatellite and full retraction of the deployment mechanism.

In addition to operation of the CM subsatellite launch controls, the crew is required to achieve and maintain the proper CSM attitude and attitude rates necessary for subsatellite launch.

a) S-Band Transponder (S-164). The purpose of the subsatellite S-Band Transponder Experiment is to obtain data to study the lunar gravitational field. The location of regions possessing gravitational anomalies (e.g., mascons) is of paramount interest. The data obtained will consist of S-band doppler tracking measurements of the subsatellite in lunar orbit. Low altitude data to be acquired is of special value since they produce a higher precision gravitational field determination.

This experiment requires no flight hardware other than the subsatellite S-band transponder communications subsystem.

b) Particle Shadows/Boundary Layer (S-173). The purpose of the Particle Shadows/Boundary Layer Experiment (Figure 2-11) is to obtain data to study the plasma flow and electric fields associated with the solar wind and magnetotail, and the physics of solar flares. The data will consist of charged particle (electrons and protons) measurements made by the subsatellite in lunar orbit.

The subsatellite charged particle detectors and corresponding subsatellite support systems are used to conduct this experiment. Two types of particle detectors are used: telescope detectors and spherical electrostatic detectors.

The two silicon nuclear particle telescope detectors ("A" and "B") are capable of detecting both protons and electrons. Each telescope detector is composed of two subdetectors in series. The second subdetector in each series performs the anticoincidence function of counting particles that pass through the first subdetector. Both telescope detectors have the same number of electron counting channels (4) and proton counting channels (6). Telescope detector "A" detects electrons in the energy range from 20 to 320 kiloelectron volts and protons in the energy range from 50 kiloelectron volts to 2.0 million electron volts. Telescope detector "B" has foil covering its entrance aperture. This increases the detector's ability to count electrons and protons in the lower energy regions of an electron energy spectrum from 20 to 130 kiloelectron volts and a proton energy spectrum from 320 kiloelectron volts to 2.3 million electron volts.

Four spherical electrostatic analyzer detectors are used by the subsatellite to detect electrons. The A1 analyzer has one electron counting channel to detect electrons in the energy range from 0.58 to 0.65 kiloelectron volts. The A2 analyzer, also with one electron counting channel, detects electrons in the energy range from 1.93 to 2.17 kiloelectron volts. Analyzer A3 has two electron counting channels that detect electrons in the energy range from 5.72 to 6.40 kiloelectron volts and from 5.65 to 6.55 kiloelectron volts, respectively. Analyzer A4 has five parallel funnel channeltrons that detect electrons in the energy range from 13.6 to 15.0 kiloelectron volts.

c) Subsatellite Magnetometer (S-174). The purpose of the Subsatellite Magnetometer Experiment (Figure 2-11) is to obtain data on the electrical and magnetic properties of the moon, the interaction of the solar wind plasma with the moon, and the physical processes in the solar wind plasma. The data will consist of magnetic field measurements made by the subsatellite in lunar orbit.

The subsatellite magnetometer, magnetic sector generator, and subsatellite support subsystems are used for this experiment. The magnetometer

that acquires the prime data for this experiment is a biaxial, flux gate type and is boom-deployed from the subsatellite. This magnetometer measures the magnitude and polarity of two mutually orthogonal vector components: one parallel and the other perpendicular to the spin axis of the subsatellite. Rotation of the subsatellite in conjunction with the magnetic sector generator (generates 8 pulses every other revolution which divides the rotation time period into equal time increments over a rotational rate range from 7 to 14 revolutions per minute) provides the third vector component. The magnetometer acquires magnetic field data over a dynamic range of $\pm$50γ (gamma) in the low operating mode range and $\pm$200γ in the high operating mode range.

2.2.2.7 S-Band Transponder (CSM/LM) (S-164)

This S-Band Transponder Experiment, to be conducted with the CSM and LM S-band transponders, is very similar to the experiment to be conducted with the subsatellite. Its purpose is to obtain S-band doppler resolver tracking data to determine the distribution of mass along the lunar surface ground track. The main difference of this experiment as compared to the subsatellite S-Band Transponder Experiment is that the total tracking period available is short-term.

This experiment is to acquire unperturbed (by nongravitational forces) doppler S-band resolver tracking data from the CSM and LM during the unpowered portions of lunar flight. Tracking data are to be obtained from the docked CSM/LM while in the 170- by 60-nautical mile elliptical orbit, the 60-nautical mile circular orbit, and the lower altitude portion of the 60- by 9-nautical mile elliptical orbit; from the undocked CSM during the unpowered portions of the 60-nautical mile circular orbit; from the undocked LM during the unpowered portions of lunar descent; and from the LM ascent stage during the unpowered portion of its descent trajectory to lunar surface impact. The low altitude (<16 kilometers) doppler data obtained from the docked CSM/LM in the 60- by 9-nautical mile elliptical orbit (provides a complete front-side tracking pass), the LM during lunar descent, and the LM ascent stage along its impact trajectory are especially valuable data sources.

Flight hardware is not required to conduct this experiment other than the use of the CSM and LM S-band communications system transponder.

2.2.2.8 Bistatic Radar (S-170)

The purpose of the Bistatic Radar Experiment (Downlink Bistatic Radar Observations of the Moon) is to obtain S-band and very high frequency (VHF) radar signals that have been transmitted from the CSM and reflected from the lunar surface. These reflected signals are detected and recorded at specially equipped, earth-based antenna locations. These data will be used to provide information relative to lunar surface roughness, shape, regolith thickness, subsurface layering to a depth of approximately 20 meters, and the dielectric constant of the upper few meters of the lunar crust (by the Brewster angle method).

This experiment requires no flight hardware other than the use of the CSM high gain S-band antenna, VHF scimitar antenna, and other elements of the CSM S-band and VHF communications subsystems. The crew is required to maintain specific spacecraft and antenna pointing attitudes during the conduct of the experiment such that the axis of each antenna points toward the specular point (instantaneous point on the lunar surface from which maximum reflective power is directed toward the earth) during the conduct of S-band and VHF transmissions, respectively.

2.3 LUNAR SURFACE SCIENCE EXPERIMENTS

2.3.1 ALSEP EXPERIMENTS

2.3.1.1 ALSEP Central Station

Although not an experiment, the ALSEP Central Station (Figures 2-12 and 2-13), in conjunction with the SNAP 27 nuclear power source, interfaces functionally with the array of Apollo 16 ALSEP surface experiments and supports all of their subsystems requirements. The experiments which it supports are the Passive Seismic Experiment (S-031), Active Seismic Experiment (S-033), Lunar Surface Magnetometer Experiment (S-034), and Heat Flow Experiment (S-037).

The central station consists of the communication subsystem transmitters and receivers (including antenna), the data subsystem, the electronics subsystems for the passive and active seismic experiments, thermal control provisions, shielding and housing for these subsystems, and a

switch panel by which the astronaut can activate the central station if activation cannot be accomplished by ground commands. Electrical power (direct current) for the data and experiment subsystems is provided by the SNAP 27 radioisotope thermoelectric generator (RTG), and a power conditioning unit. Each ALSEP experiment interfaces electrically with the central station by means of flat, ribbon-like conductor cabling.

The ALSEP central station and experiments in the undeployed and unassembled configuration (Figures 2-14 and 2-15) are stored in the LM Scientific Equipment (SEQ) Bay (Figure 2-16*); the RTG fuel capsule is attached to the outside of the LM descent stage (Figures 2-17 and 2-18).

Special tools used in assembly of the central station and RTG include the fuel transfer tool, the universal handling tool, and the dome removal tool (Figures 2-19 and 2-20).

Photographic requirements of the deployed central station and ALSEP experiments (Figure 2-21) are accomplished with the 70-mm Hasselblad electric data camera and its 60-mm lens, except as noted.

The astronauts assemble, deploy, level, align, and activate these experiments and the central station. Other activities such as central station antenna leveling and pointing are also performed.

2.3.1.2 Passive Seismic (S-031)

The purpose of the Passive Seismic Experiment (PSE) is to measure seismic signals from all external and internal sources of seismic energy released on and within the moon, respectively. These data will be used to determine the internal structure of the moon, the rate of energy release, and the numbers and masses of meteoroids impacting the lunar surface. This experiment uses the lunar surface impacts of the spent S-IVB and LM ascent stages as external calibration sources for the emplaced seismometers. Seismometer response to the known mass and velocity of the spent stages at surface impact as well as time of impact and the impact point lunar coordinates enables the computation of energy generated at impact, the point of energy application, and the corresponding seismic wave velocity.

*Figure 2-16 depicts LM descent stage storage of other lunar surface science equipment as well.

Seismic data collected at several different locations on the lunar surface by more than one simultaneously active and widely dispersed instruments increase the statistical significance of the data and improve the directional information obtained (i.e., be able to locate where the seismic disturbance or meteoroid impact occurred). The PSE to be deployed on the J-2 Mission is a component of this network concept. The network is also composed of those PSE's previously emplaced and active on the moon.

The Passive Seismic Experiment (Figure 2-22*) consists of two seismic assemblies: a long-period (LP) seismometer (triaxial, orthogonal) with a seismic frequency response from 0.004 to 3 Hertz (80-decibel dynamic range); and a short-period (SP) seismometer (uniaxial, vertical motion) with a seismic frequency response from 0.05 to 20 Hertz (80-decibel dynamic range). The minimum detectable signal of the PSE seismometers is 0.3 nm at a frequency of 1 Hertz. These seismometers are housed in a drum-shaped enclosure rounded on the bottom which rests on a support structure (stool) covered by a thermal shroud after deployment. The PSE electronics package located in the central station is cable-connected to the sensor assembly.

2.3.1.3 Active Seismic (S-033)

The purpose of the Active Seismic Experiment (ASE) is to acquire data to determine the physical properties of lunar surface and subsurface materials. Both naturally-occurring and artificially-produced seismic waves are to be monitored. The artificial seismic waves are to be produced by "shotgun-like" charges fired by a "thumper" device and explosive grenade charges fired from a mortar box assembly. The surface-induced seismic waves produced by LM ascent stage lift-off are also to be monitored.

The ASE Experiment (Figure 2-23) consists of a thumper/geophone assembly; a mortar package assembly (MPA) with folding platform and emplacement anchors; interconnecting cables; and an electronics assembly housed in the central station. The ASE can generate and monitor artificial seismic waves in the range from 3 to 250 Hertz with a frequency response of ± 3 decibels in the frequency range from 3 to 100 Hertz. Naturally-occurring seismic waves are monitored, if in this frequency range, when the

*Sun alignment and leveling information for the Apollo 16 ALSEP central station and experiments are extracted from Reference 14.

ALSEP central station is operating in the ASE (high bit rate) "listening" mode. The data gathering interval for monitoring naturally-occurring seismic waves is relatively small, however, since the central station operates in the ASE mode on the average of only 30 minutes every week.

The thumper contains 19 Apollo standard initiators (ASI), similar to "shotgun" charges, mounted perpendicular to its base plate that are selected, armed, and fired* by the crewman. A flat cable, stowed on a split spoon on the upper end of the thumper handle and unwound/deployed by the crewman, connects the thumper to the central station. The geophones and connecting cable to the central station are mounted on a reel at the lower end of the thumper and are likewise deployed by the crewman. The thumper is fired by the crewman when returning along the deployed geophone line at marked intervals of 4.6 meters. Knowledge of charge firing energy, firing location, firing time, and the time of wave detection provides data to determine the seismic wave velocity.

The three identical geophones deployed from the thumper are electromagnetic listening devices whose analog outputs are transmitted through connecting cables to the central station where they are amplified, digitized, and transmitted to earth. The geophones are emplaced by means of spike-like appendages at distances of 3, 49, and 95 meters from the central station. The two emplaced geophones closest to the C/S are each marked with a stake-mounted "flag" as a surface orientation and photography reference.

The MPA consists of a mortar box assembly, a grenade launch tube assembly (GLA), and an interconnecting cable to the central station. The mortar box, mounted to a folding platform that is spike-stabilized on the lunar surface, is tilted at 45 degrees with respect to the lunar surface to provide for optimum grenade launch angles for vacuum conditions and is emplaced 16.8 meters from the central station. The mortar box contains electronics for arming and firing the four rocket grenades, safety switches, a receiving antenna deployed by the crewman, and thermal protection devices. The crewman aligns the MPA such that the grenades will launch parallel to the deployed geophone line (Figure 2-21), and then levels the MPA.

*Two of the 21 original ASI charges are fired at KSC as part of the preflight ASE checkout.

The GLA consists of a fiberglass launch tube assembly including the four rocket-launched grenades, a grenade safety pin assembly, microswitches, temperature sensors, and a two-axis inclinometer which senses pitch and roll angle deviations of the mortar package from the local vertical. These deviations are transmitted in analog form to the ASE data system. The launch tubes are 7.6 centimeters in cross section; two tubes are 22.9 centimeters long and the other two are 15.2 centimeters long. Each of the launch tubes for the grenades numbered 2, 3, and 4 contains a microswitch that closes after grenade launch to connect a sequential firing circuit for the next grenade to be launched. The grenades are similar, each differing only in the amount of their encased propellant and high explosive material. Each grenade contains a rocket motor, safe slide plate, high explosive charge, ignition and detonation devices, thermal battery, range line, and a 30-megahertz transmitter that provides time of flight and impact data. The range line connected to the transmitter and launch tube provides an antenna capability. Two copper loops are attached to the range line. The first loop breaks when the grenade is 40.6 centimeters from the launch tube. The second breaks when the grenade has traveled an additional 7.6 meters. Electronic determination of the time elapsed between breakage of these two loops establishes the launch velocity of the grenade.

The grenades are rocket-launched by earth command within three lunations (lunar months) after ALSEP deployment. They are designed to impact at ranges of approximately 153, 305, 915, and 1525 meters from the MPA, these ranges being selected in proportion to the high explosive charge contained in each grenade. Grenade detonation energy and the timing of grenade launch and detonation in conjunction with the measurement of grenade launch velocity provide data to determine the seismic wave velocity.

Photography requirements for this experiment are satisfied by both the 70-mm Hasselblad electric data camera (60-mm lens) and the lunar surface color TV camera (GCTA) mounted on the LRV.

2.3.1.4 Lunar Surface Magnetometer (S-034)

The purpose of the Lunar Surface Magnetometer (LSM) is to measure the lunar surface magnetic field vector and its temporal variations in order to determine the magnetic and electrical properties of the moon.

The LSM equipment (Figure 2-24) consists of three boom-mounted flux gate magnetometers deployed from an electronics package emplaced on the lunar surface. These sensors are capable of full-scale measurement ranges of $\pm 50\gamma$, $\pm 100\gamma$, or $\pm 200\gamma$ (range to be used is selected by earth commands) with a resolution and accuracy of 0.2 and 0.5 percent of full scale, respectively. The boom-mounted sensors are rotated by small, automatically-programmed electric motors to perform a magnetic field site survey (determines the presence of local magnetic sources). This survey is done only once during the lunar surface experiment period. The electronics package is cable-connected to the central station. A tent-shaped mylar shroud that attaches to each of the boom arms is deployed by the crewman after LSM leveling and alignment to shade the LSM electronics package.

2.3.1.5 Heat Flow (S-037)

The purpose of the Heat Flow Experiment (HFE) is to determine the rate of heat loss from the lunar interior. To perform this function, two holes are drilled in the lunar surface by a crewman to a depth of about 2.6 meters by means of the Apollo lunar surface drill (ALSD) for emplacement of heat flow instrumentation (probes). This experiment can detect lunar temperatures in the following ranges with corresponding accuracies noted in parentheses: high sensitivity measurements of $\pm 2°C$ (0.003°C) temperature difference; low sensitivity measurements of $\pm 20°C$ (0.03°C) temperature difference; probe ambient temperatures in the range from 200°K to 250°K (0.1°K); thermocouple reference temperatures from -20°C to 60°C (0.1°C); and probe cable ambient temperatures from 90°K to 350°K (0.3°K).

The Heat Flow Experiment equipment (Figure 2-25) consists of two probes, each about 1.2 meters in length, for insertion into each of the drilled holes (the bore stem assembly used in drilling remains in the hole to provide a casing to prevent hole wall collapse during probe insertion), a special tool for probe insertion which also indicates exact depth to which hole was drilled, radiation shields for each probe, and an electronics package that is cable-connected to the probes and the central station. The ALSD (Figure 2-26) is composed of the following equipment applicable to the HFE. They include the power head and spindle, six bore stems, and a bore stem wrench. Each nominal bore stem when emplaced is composed of one 1.37-meter section (with attached closed drill bit) and two 0.71-meter sections.

Relative placement of the drilled holes with respect to the HFE electronics package, central station, and other ALSEP experiments is shown in Figure 4-7. It is highly desirable that the deep core sample (2.6 meters) obtained with the ALSD as part of the lunar geology activities be taken within 10 meters of the deployed HFE. This returned core sample will supply additional information for postmission HFE data interpretation.

2.3.2 OTHER SURFACE EXPERIMENTS

2.3.2.1 Lunar Geology Investigation (S-059)

The purposes of the Lunar Geology Investigation Experiment are to obtain a better understanding of the Descartes highlands area and the processes which have modified the highland surface through the study of documented lunar geological features and returned lunar samples. This experiment will be conducted by the Apollo Lunar Geology Experiment Team (Experiment S-059) for J-2, in consultation with the MSC Science Working Panel representing the requirements of principal investigators for sample analyses.

The major equipment used for this experiment are: hammer; tongs; extension handle; large sampling scoop; rake; gnomon/photometric chart; sample scale (located in the LM ascent stage); core tubes*/caps with follower tool; special surface sampler; documented sample bags; padded sample bags; sample collection bags; special sample containers (a nominal SESC and a core sample vacuum container); sample containment bags; sample return bag; and sample return containers (Figure 2-27). A deep (2.6-meter) core sample is obtained with the use of the ALSD. ALSD equipment used in acquiring the deep core sample include the power head and spindle, core stem adapter, treadle, core stem rack, core stem extractor, core stem cap dispenser, three 0.87-meter core stem sections, open core bit, a core stem wrench (same wrench as used with the bore stems of the Heat Flow Experiment), and a core stem vise mounted on the LRV aft pallet.

*Also called "drive" tubes.

The hand tools (hammer, tongs, etc.) used for this experiment are the standard Apollo lunar hand tools (ALHT) which are located on the Apollo Lunar Hand Tool Carrier (ALHTC) attached to the LRV aft pallet (Figures 2-28 and 2-29). Sample collection bags are mounted to the LRV in the manner shown in Figure 2-29. Attachment of tools and collection bags to the PLSS of the Lunar Module Pilot (LMP) and Commander (CDR) for geological activities conducted from the LRV is shown in Figure 2-30.

Photography requirements for this experiment are satisfied with the use of the 70-mm Hasselblad electric data camera (60-mm lens and 500-mm lens). A three-position polarizing filter is also used to fulfill a polarimetric photography sequence on EVA No. 3. The Ground-Commanded Television Assembly (GCTA) provides real-time ground and science support for the geology activities.

The astronauts select sites (if not previously designated) of geologic interest, obtain and document the required standard and special geologic samples, and perform the required lunar geological photography and observations.

2.3.2.2 Solar Wind Composition (S-080)

The purpose of the Solar Wind Composition (SWC) Experiment is to determine the elemental and isotopic composition of the noble gases and other selected elements in the solar wind by measurement of particle entrapment on an exposed aluminum and platinum foil sheet. Some small patches of the foil will consist of two and three sheets. These data will provide resolution of competitive theories in the field of elemental synthesis, origin of the solar system, history of planetary atmospheres, and solar wind dynamics.

The SWC experiment (Figure 2-31) consists of an expanse of foil unrolled from a reel to face the sun vector and is mounted on a support structure emplaced on the lunar surface. The experiment is deployed and emplaced on the first EVA; the foil and reel are retrieved on the last EVA by the crewman.

Photography requirements for this experiment are met with the use of the 70-mm Hasselblad electric data camera (60-mm lens).

2.3.2.3 Cosmic Ray Detector (Sheets) (S-152)

a) General Detector Assembly Description. The purposes of the Cosmic Ray Detector Experiment are to measure the charge, mass, and energy spectrum of heavy cosmic ray and solar wind particles in the energy ranges from 0.5 to 10 kiloelectron volts/nucleon and from 0.2 to 200 million electron volts/nucleon, to provide calibration data for special detectors including glass and a special tektite sample, to measure the thermal neutron flux at the lunar surface, and to assess the problem of Ar^{40} implantation.

The Cosmic Ray Detector Experiment (Figure 2-32) consists of a 4-panel foldable detector array (Reference 15). These panels, frame-mounted on the outside of the LM descent stage, are directly exposed to cosmic ray and solar wind particles during translunar coast through lunar landing. During the initial phases of the first lunar surface EVA, a crewman pulls a lanyard downward, uncovering hidden surfaces of the Number 4 detector panel so as to initially expose these surfaces to the lunar cosmic ray and solar wind experiment.

Near the end of the last EVA, a crewman will retrieve the detector panels, fold them, and stow them in a special bag equipped with temperature indicators for return to earth. When these panels are folded, half of the detector sheets composing the panels are automatically shifted relative to the other half, allowing the separate detection of cosmic ray particles which strike the panels during the remainder of the mission. Photography requirements are satisfied with the use of the 70-mm Hasselblad electric data camera (60-mm lens).

Temperature indicators on the panels in the form of color-changing decals or patches and pre-irradiated control samples located within the stacks of detector sheets composing each of the four panels are also a part of the experiment equipment. Four of the temperature indicators are read by the crew when they stow the detector panels for the earth-return portion of the mission. The other temperature indicators and control samples are used by the PI's for postflight data analysis. The temperature indicator decal associated with the detector panel stowage bag is read by

LRL technicians upon receipt of the detector panel from mission recovery personnel.

b) Detector Panel No. 1. The Number 1 detector panel is composed of 31 sheets of Lexan plastic, 0.025 centimeters thick, covered by perforated, silver-coated Teflon. Two temperature indicators of the color-changing type are within the panel. Its purpose is to study the composition of low-energy, heavy cosmic ray particles. Particle tracks made in this panel will be studied at the University of California at Berkeley.

c) Detector Panel No. 2. The Number 2 detector panel is similar to the Number 1 panel with the exception that it has within it two samples of pre-irradiated plastic for postflight data analysis. As for the Number 1 panel, this panel is also designed to study the composition of low-energy, heavy cosmic ray particles. Particle tracks made in this panel will be studied at the General Electric Research and Development Center.

d) Detector Panel No. 3. The Number 3 detector panel is composed of a stack of 39 Kodacel cellulose triacetate sheets, each 0.020 centimeters thick, with a stack of 30, 5-micron-thick Lexan plastic sheets bonded to the upper half of the panel. Five glass specimens of various sizes and shapes are placed within the lower portion of the panel and one glass specimen (tektite slab) is in the upper portion of the panel. The five glass specimens are made of silica, aluminosilicate (two specimens), phosphate, and uranium phosphate, respectively. Panel covering and temperature indicators are the same as for the Number 1 and 2 panels. This panel contains four samples of pre-irradiated plastic for postflight data analyses.

The purposes of this panel are to study low energy, light and heavy cosmic ray particles (plastic sheet detectors) and to provide calibration data (glass specimens) for designing cosmic ray experiments for longer space flight exposure. The tektite detector is an attempt to observe cosmic ray tracks so as to estimate the flight time of tektites in space and to infer their place of origin. The top portion of the Number 3 panel is to be studied by the University of California at Berkeley; the bottom portion is to be studied by the General Electric Research and Development Center.

e) Detector Panel No. 4. The Number 4 panel, the most complex panel of all, contains a variety of particle-detecting materials to produce data concerning several different kinds of atomic particles. The lower half of

the panel is a fixed assembly while the upper half of the panel has provisions for movement of the detection surface. Perforated silver-coated Teflon, used as a thermal control surface, covers the lower half of this panel in the same manner as the other panels. There are six temperature sensors located within the Number 4 panel. The returned Number 4 panel is to be studied at Washington University.

The lower quarter of the Number 4 panel contains a fixed stack (outboard side) of 22 laminated, 5-micron-thick plastic sheets. These sheets are alternating layers of Lexan polycarbonate, cellulose triacetate, and cellulose acetate butyrate. Underneath this detector stack is a moveable aluminum plate to which is attached epoxy-bonded cadmium foil covered by deposited strips of Boron-10 (B^{10}). Beneath the plate and boron strips is a thin stack of cellulose triacetate detector sheets comprising most of the areal extent of the lower panel. The moveable aluminum plate/boron strips translates when the detector panel array is folded by the crewman for LM ascent stage stowage preceding earth return. The inboard layer of the lower panel half is composed of a boron neutron "shield" (neutron decelerator). The 22 sheet detector stack is to be used to study heavy, low energy cosmic ray particles. The boron strips provide the B^{10} source which emits alpha particles when thermal neutrons produced at the lunar surface react with it. These alpha particles are recorded by the cellulose triacetate sheets (thin stack). The crewman translates the boron plate after ALSEP deployment of the LM RTG (artificial neutron source) to expose fresh areas of the cellulose triacetate to the boron to record neutron capture after RTG removal.

The remaining quarter of the lower Number 4 panel half consists of a 0.076 centimeter-thick piece of aluminum to which small pieces of mica, glass, and various naturally-occurring mineral specimens are attached to face outboard. These detectors are used to measure the abundance of solar wind particles and unusually heavy cosmic ray particles. A boron neutron shield, placed beneath some of these specimens and near the middle of the panel, partially overlaps the larger neutron shield inboard of these detecting surfaces and, also, is a portion of the lower panel half that is mentioned in the preceding paragraph.

The upper half of the Number 4 panel is referred to as a "window shade" assembly since it consists of a moveable platinum sheet outboard of a stationary platinum sheet supported by an aluminum back plate. Both sheets are covered with a thin, deposited layer of aluminum. A crewman lanyard pull at the beginning of the first EVA slides the moveable sheet inside the panel to expose the stationary sheet. These sheets are used to detect light solar wind nuclei such as neon and helium and may allow Ar^{40} to be detected. If so, it can be resolved whether the moon or the solar wind is the source of Ar^{40} found in the outer coatings of returned lunar soil grains.

Two mica samples are also located in the upper half of the Number 4 panel. One is exposed to space only before the lanyard pull, the other only after the lanyard pull. These detectors will provide data on the limit of Rn^{222} flux at the lunar surface.

2.3.2.4 Portable Magnetometer (S-198)

The purpose of the Portable Magnetometer (PM) Experiment is to obtain data on the intensity and direction of the lunar magnetic field at the landing site and at widely separated points along the traverse. This experiment will be able to measure the gradient of the magnetic field with distance (should a difference exist) and, correspondingly, to associate any gradient changes with geological features present (such as a subdued crater). The PM will also be used to measure the magnetic characteristics of an igneous rock sample in situ at the last traverse measurement station.

The equipment for the Portable Magnetometer Experiment (Figure 2-33) that is mounted to the LRV aft pallet includes a tripod with leveling/alignment mechanism; a magnetometer sensor incorporating three flux gate magnetometers mounted to this tripod*; an electronics box with a direct digital readout shaded by a sunshield indicating the X, Y, and Z components of the local magnetic field as well as controls for activating the sensor and displaying the magnetic field readout; and a 15.2-meter flat cable connecting the electronics box and sensor. The sensor is capable of measuring magnetic fields in the range of $\pm 200\gamma$ (gamma) to an accuracy of $\pm 1\gamma$.

*Sensor/tripod assembly is bag-mounted to the rear of the LRV pallet (Figure 2-33) for stowage between traverse stations.

The sensor must be deployed from the LRV on its tripod mount when measurements are taken to remove it from local EMI sources contributed by the crewman and LRV communication systems.

A crewman is required to deploy, level, and align the tripod-mounted sensor as well as to select traverse measurement sites (if not designated a priori by lunar surface planning). He also operates the controls on the electronics box which remains mounted to the LRV aft pallet when the sensor is deployed. Temperature indicators on the electronics box are monitored as well. Sensor measurements are read directly by the crewman and voice-relayed to the Mission Control Center (MCC).

Photography requirements for the experiment are accomplished with the Hasselblad electric data camera (60-mm lens).

2.3.2.5 Soil Mechanics (S-200)

The purpose of the Soil Mechanics Experiment is to obtain data on the characteristics and mechanical behavior of the lunar soil at the surface and subsurface and the variation of these properties in a lateral direction.

The primary data sources for this experiment are obtained from penetrometer measurements and the Soil Mechanics trench excavated by the astronauts. Two cones of different cross-sectional area and a load plate are separately used with the penetrometer for each test. Grain size data are obtained from returned lunar soil samples. Lunar soil bulk density estimates are derived from X-ray imagery and the geometry and weighing of the returned core stem and core tube samples. These data and in situ photographs and crew observations derived from other sources mentioned in a following paragraph are used in conjunction with tests conducted on lunar soil simulants to arrive at a consistent overall pattern and characterization of the lunar soil types and their mechanical properties encountered at the landing site.

Photography requirements for this experiment are met with the use of the 70-mm Hasselblad electric data camera (60-mm lens) and the GCTA.

The astronauts perform the required trenching activities, penetrometer load plate and cone tests, and soil behavior/characteristics observations (Figure 2-34) such as the LRV wheel/lunar soil interaction and LM footpad/soil interaction. The crewman also reads the penetration test number to MCC after each penetrometer test prior to reindexing for the next test. This number appears in a window located in the upper penetrometer assembly. After all tests are completed, a crewman removes the upper penetrometer assembly for stowage and subsequent earth return. This assembly contains a recording drum which indicates the results of all penetrometer tests.

2.3.2.6 Far UV Camera/Spectroscope (S-201)

The purpose of the Far UV Camera/Spectroscope Experiment is to obtain photographic imagery and spectroscopic data from celestial objects in the far ultraviolet region (principally at the Lyman-alpha* wavelength), while on the lunar surface, in order to map the location of interplanetary, interstellar, and intergalactic hydrogen. Photographic imagery and spectroscopic data in the far UV region are also to be acquired from the earth's upper atmosphere and geocorona. This experiment will incorporate the use of the first extraterrestial, surface-emplaced laboratory for astronomy observations. Far UV spectroscopic data will be obtained in the wavelength range from 500 to 1550 Å with a resolution of 30 Å. Imagery data will be obtained in the wavelength ranges from 1050 to 1260 Å and from 1200 to 1500 Å. Differential measurements on the imagery data will be used to identify hydrogen gas clouds. Targets of interest include the geocorona, earth's atmosphere, solar wind, various nebulae, star clouds (Milky Way), galaxy clusters and other galactic objects, intergalactic hydrogen, the solar bow cloud, lunar atmosphere, and lunar volcanic gases (if any).

The equipment (Figure 2-35) for the Far UV Camera/Spectroscope Experiment consists of a 3-inch electronographic Schmidt camera with a CsI cathode and film transport device (containing 35-mm film) that is tripod-mounted in the LM shadow. The battery pack with connecting cable for this camera is removed from its camera stowage location and placed in the sun. LiF and CaF_2 filters are provided to obtain the imagery difference necessary to

*See Glossary

identify hydrogen Lyman-alpha radiation at the 1216 Å wavelength. No filters are used to obtain the required spectroscopic data.

The crew is required to deploy the tripod-mounted camera in the LM shadow and the camera battery pack in a solar-illuminated area. The crew must also adjust the camera to the specified level and alignment tolerances, point the camera at the required targets by means of the elevation and azimuth adjustments, and activate the automatic exposure sequencer. The crew periodically checks the temperature indicators on the battery pack for excess temperatures (to determine if it should be placed in the LM shadow). At the end of the last EVA, the crew removes the film transport device from the camera, places it in a special stowage bag, and returns it to the LM ascent stage for subsequent earth return. Orientation photographs of the deployed camera assembly and azimuth circle are taken by the crew with the 70-mm Hasselblad electric data camera (60-mm lens).

Table 2-1. Lunar Orbit Science Equipment Summary

EXP. NO.	EXPERIMENT/OBJECTIVE	SPACECRAFT LOCATION	DEPLOYMENT	EQUIPMENT
----	CM Photographic Tasks (Detailed Objective)	Command Module	None	• 70-mm Electric Hasselblad Camera/80-mm Lens/250-mm Lens • 16-mm Data Acquisition Camera/18-mm Lens • 35-mm Nikon Camera/55-mm Lens • Window Mounting Bracket • Sextant Optical Adapter • Polarizing Filter • Red/Blue Filters
S-176	Apollo Window Meteoroid	Command Module	None	• CM Windows
S-177	UV Photography - Earth and Moon	Command Module	None	• Special CM RH window (high UV transmissivity) • 70-mm Electric Hasselblad Camera/105-mm Lens (UV transmitting) • Mounting Bracket • 3 Filters - UV Spectrum • 1 Filter - Visible Spectrum • Filter Ring Slide • Special Window Shade
S-178	Gegenschein From Lunar Orbit	Command Module	None	• 35-mm Nikon Camera/55-mm Lens • CM Window Shades • Window Mounting Bracket

Table 2-1. Lunar Orbit Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT/OBJECTIVE	SPACECRAFT LOCATION	DEPLOYMENT	EQUIPMENT
----	Visual Observations from Lunar Orbit (Detailed Objective)	Command Module	None	• On-board Tape Recorder • On-board Graphics and Charts
----	SM Orbital Photographic Tasks (Detailed Objective)	Service Module (SIM Bay)	None	• 24-Inch Panoramic Camera • Roll-Frame Assembly • Gimbal Assembly • Main Frame • GN_2 Pressure Vessel Assembly • Film Cassette • CM Crew-Operated Switches • CM Crew Display
			Rail-Type Mechanism	• 3-Inch Mapping Camera • Metric Camera • Stellar Camera • Glare Shield • GN_2 Pressure Vessel Assembly • Film Cassette • CM Crew-Operated Switches • CM Crew Displays • Metric Camera Optics Protective Shield (Shared with Laser Altimeter) • Stellar Camera Optics Protective Shield

Table 2-1. Lunar Orbit Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT/OBJECTIVE	SPACECRAFT LOCATION	DEPLOYMENT	EQUIPMENT

----	SM Orbital Photographic Tasks (Continued)	Service Module (SIM Bay)	Rail-Type Mechanism (Mounted to Mapping Camera)	• Laser Altimeter
				  • CM Crew-Operated Switch
				  • Optics Protective Shield (Shared with Mapping Camera)

S-160	Gamma-Ray Spectrometer	Service Module (SIM Bay)	Boom Mechanism	• Gamma-Ray Detector and Electronics
				  • Thermal Protection Shield
				  • Boom Deployment Assembly
				  • CM Crew-Operated Switches
				  • CM Crew Displays

S-161	X-Ray Fluorescence	• Fluorescence Sensor
		  • Service Module (SIM Bay)
		• Solar Monitor
		  • Service Module (Bay IV)
			None	• X-Ray Fluorescence Sensing Assembly and Supporting Electronics (In same housing as Alpha Particle Experiment)
				• Solar Monitor
				  • Solar Monitor Door
				  • CM Crew-Operated Switch
				• Sensor Protective Shield (Shared with Alpha Particle Experiment)
				• CM Crew-Operated Switches
				• CM Display (Protective Shield)

Table 2-1. Lunar Orbit Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT/OBJECTIVE	SPACECRAFT LOCATION	DEPLOYMENT	EQUIPMENT
S-162	Alpha Particle Spectrometer	Service Module (SIM Bay)	None	• Alpha Particle Sensing Assembly • Detector Array and Supporting Electronics (in same housing as X-Ray Fluorescence Sensing Assembly) • Sensor Protective Shield (Shared with X-Ray Experiment) • CM Crew-Operated Switch • CM Display (Protective Shield)
S-164	S-Band Transponder (CSM/LM)	• Command and Service Module • Lunar Module	None	• S-Band Communications Subsystem

S-165	Mass Spectrometer	Service Module (SIM Bay)	Boom Mechanism	• Mass Spectrometer Assembly
				  • Mass Spectrometer
				  • Electronics
				  • Ion Source Heaters
				  • Boom Deployment Mechanism
				  • Contamination Shield
				  • CM Crew-Operated Switches
				  • CM Crew Displays
				  • CM 16-mm DAC/18-mm Lens

Table 2-1. Lunar Orbit Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT/OBJECTIVE	SPACECRAFT LOCATION	DEPLOYMENT	EQUIPMENT
S-170	Bistatic Radar	Command and Service Module	None	• CSM S-band and VHF Communication Subsystems

----	Subsatellite	Stowed in Service Module (SIM Bay) Until Ejection	Ejected by spring mechanism after deployment and spin-up from SIM on launch platform	• Launch Platform
				• Deployment/Spin-up Mechanism
				• Subsatellite
				  • Booms
				  • Charged Particle Detectors
				  • Magnetometer
				  • Data Storage Unit
				  • Solar Aspect System
				  • Solar Cell-Battery Power System
				  • S-Band Communications Subsystem
				• Contamination Shield Enclosure (SIM Bay)
				• CM Crew-Operated Switch
				• CM Crew Display

S-164	S-Band Transponder	Subsatellite	None	• Subsatellite S-band Communications Subsystem
S-173	Particle Shadows/Boundary Layer	Subsatellite	None	• Charged Particle Detectors • Subsatellite Support Subsystems

Table 2-1. Lunar Orbit Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT/OBJECTIVE	SPACECRAFT LOCATION	DEPLOYMENT	EQUIPMENT
S-174	Subsatellite Magnetometer	Subsatellite	1.52-meter Subsatellite Boom	• Magnetometer • Deployment Boom • Magnetic Sector Generator • Subsatellite Support Subsystems

Table 2-2. Lunar Surface Science Equipment Summary

EXP. NO.	EXPERIMENT	CENTRAL STATION INTERFACE	EQUIPMENT
-----	ALSEP Central Station (Apollo 16 ALSEP)	--	• ALSEP Communications Subsystem (including antenna) • ALSEP Data Subsystem • Electronics Subsystems for ALSEP Seismic Experiments • Housing and Thermal Control/ Protection for Above Subsystems • Astronaut Switch Panel • RTG Power Source and Power Conditioning Unit • 70-mm Hasselblad Electric Data Camera/60-mm Lens
S-031	Passive Seismic Experiment (Apollo 16 ALSEP)	Yes	• Long Period and Short Period Seismic Sensing Assemblies • Support Structure and Thermal Shroud • Electronics Package (in Central Station) • 70-mm Hasselblad Electric Data Camera/60-mm Lens

Table 2-2. Lunar Surface Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT	CENTRAL STATION INTERFACE	EQUIPMENT

S-033	Active Seismic Experiment (Apollo 16 ALSEP)	Yes	• Thumper/Geophone Assembly
			  • Thumper
			  • ASI Charges (19)*
			  • Geophones (3)
			• Mortar Package Assembly
			  • Grenade Launch Tube Assembly
			  • Grenade Assemblies (4)
			  • Electronics
			  • Antenna
			  • Inclinometer
			  • MPA Subpallet (for mounting)
			• Central Station Electronics
			• Connecting Cables/Geophone Line
			  • Geophone Line Flags (2)
			• 70-mm Hasselblad Electric Data Camera/60-mm Lens
			• GCTA

S-034	Lunar Surface Magnetometer (Apollo 16 ALSEP)	Yes	• Boom-Mounted, Flux Gate Magnetometers (3) • Electric Drive Motors • Electronics Package • Sun Shield • 70-mm Hasselblad Electric Data Camera/60-mm Lens

*Two of the original 21 ASI charges are fired at KSC as a part of the ASE preflight checkout procedure.

Table 2-2. Lunar Surface Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT	CENTRAL STATION INTERFACE	EQUIPMENT

S-037	Heat Flow Experiment (Apollo 16 ALSEP)	Yes	• Apollo Lunar Surface Drill
			  • Power Head and Spindle
			  • Bore Stems (6)
			  • 1.37-Meter Section (2)
			  • 0.71 Meter Section (4)
			  • Bore Bit (2)
			  • Bore Stem Wrench
			• Heat Probes (2)
			  • Radiation Shield (6)
			  • Probe Emplacement Tool
			  • Electronics Package
			  • 70-mm Hasselblad Electric Data Camera/60-mm Lens

S-059	Lunar Geology Investigation	No	• PLSS-mounted Tool Carrier (2)
			• Apollo Lunar Hand Tool Carrier and Tools
			  • Hammer
			  • Extension Handle (2)
			  • 32-Inch Tongs (2)
			  • Lunar Surface Rake
			  • Large Sampling Scoop
			  • Gnomon with Photometric Chart
			  • Sample Scale (LM Ascent Stage)
			  • Core Tubes* (9)
			  • Core Tube Cap Dispensers (5)
			  • Special Surface Sampler (2)
			  • UHT

*One upper core tube sample is to be returned in the CSVC as a pristine core sample.

Table 2-2. Lunar Surface Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT	CENTRAL STATION INTERFACE	EQUIPMENT

S-059 (Continued)	Lunar Geology Investigation	No	• Core Tube Follower Tool (2)
			• Core Tube Stowage Bag (Used for Contingency Stowage Only)
			• Documented Sample Bag Dispenser (7)
			  • Three 20-Bag Documented Sample Bag Dispensers in ALSRC No. 1
			  • Four 20-Bag Documented Sample Bag Dispensers in ALSRC No. 2
			  • 2 Padded Bags
			• Sample Collection Bag (4)
			  • One in each ALSRC
			  • Two on LRV Aft Pallet
			• Extra Sample Collection Bag* (4)
			• Sample Containment Bag (6)
			• Sample Return Bag (1)
			• Apollo Lunar Sample Return Container (2)
			• Special Environmental Sample Container (1)
			• Core Sample Vacuum Container (CSVC) (1)
			• Apollo Lunar Surface Drill
			  • Power Head and Spindle
			  • Core Stem Sections (3)
			  • Core Stem Caps and Retainer Dispenser (1)
			  • Coring Adapter
			  • Core Stem Wrench
			  • Core Stem Vise

*Extra sample collection bag is same configuration as sample collection bag with exception of no external or internal pockets.

Table 2-2. Lunar Surface Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT	CENTRAL STATION INTERFACE	EQUIPMENT
S-059 (Continued)	Lunar Geology Investigation	No	• Treadle • Drill String Rack • Core Stem Extractor • 70-mm Hasselblad Electric Data Camera • 60-mm Lens • 500-mm Lens • Polarizing Filter • Science Support • Lunar Surface 16-mm Data Acquisition Camera (Battery-Operated)/10-mm Lens • GCTA • LRV
S-080	Solar Wind Composition	No	• Foil/Reel Assembly • Lunar Surface Support/Emplacement Structure • SWC Stowage Bag • 70-mm Hasselblad Electric Data Camera/60-mm Lens

Table 2-2. Lunar Surface Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT	CENTRAL STATION INTERFACE	EQUIPMENT

S-152	Cosmic Ray Detector (Sheets)	No	• Panel/Frame Assembly
			  • Frame
			  • Detector Panels (4)
			  • Temperature Indicators (10)
			  • Irradiated Samples (6)
			  • Crew Lanyards (3)
			• Stowage Bag
			  • Temperature Indicators (4)
			• 70-mm Hasselblad Electric Data Camera/60-mm Lens

S-198	Portable Magnetometer	No	• Sensor Assembly
			  • Flux Gate Magnetometers (3)
			  • Tripod Mount
			• Electronics Box
			  • Digital Magnetic Field Readout
			  • Glare Shield
			  • Temperature Monitors
			  • Sensor Controls
			  • Mercury Batteries
			• Flat Cable-Sensor to Electronics Box - And Reel
			• 70-mm Hasselblad Electric Data Camera/60-mm Lens
			• Science Support
			  • LRV
			  • GCTA

Table 2-2. Lunar Surface Science Equipment Summary (Continued)

EXP. NO.	EXPERIMENT	CENTRAL STATION INTERFACE	EQUIPMENT

S-200	Soil Mechanics	No	• Self-Recording Penetrometer
			  • Recording Drum
			  • Cones (2)
			  • Load Plate
			• S-059 Equipment
			• 70-mm Hasselblad Electric Data Camera/60-mm Lens
			• Science Support
			  • GCTA
			  • LRV

S-201	Far UV Camera/Spectroscope	No	• 3-Inch Schmidt Electronographic Camera
			  • Tripod Mount
			  • Battery Pack/Connecting Cable
			  • Filters (2)
			  • Film Transport Device
			  • Leveling/Pointing Mechanism
			  • Camera Controls
			• Film Transport Stowage Bag
			• 70-mm Hasselblad Electric Data Camera/60-mm Lens

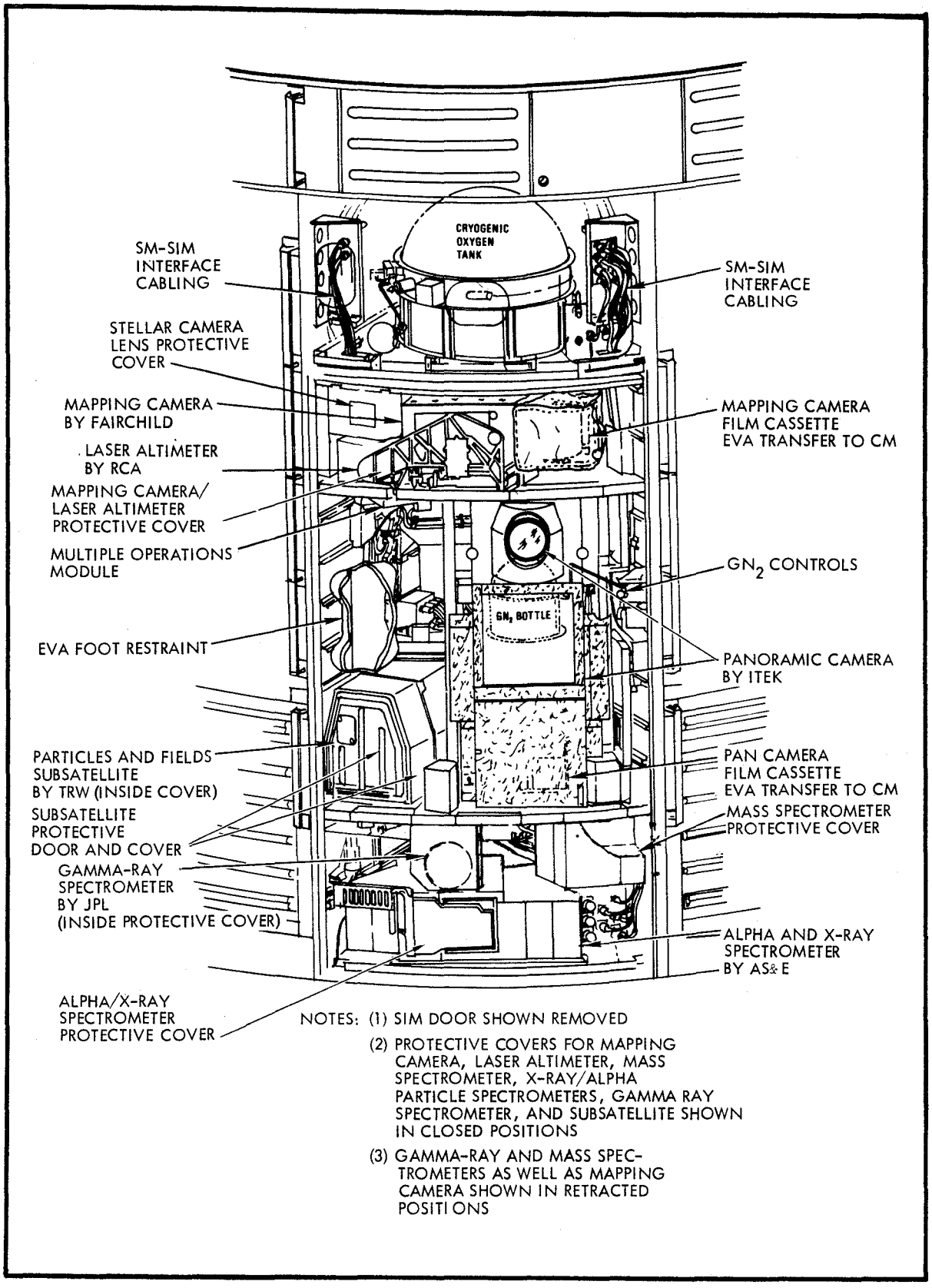


Figure 2-1. J-2 Mission SIM Bay Experiment Sensors and Cameras

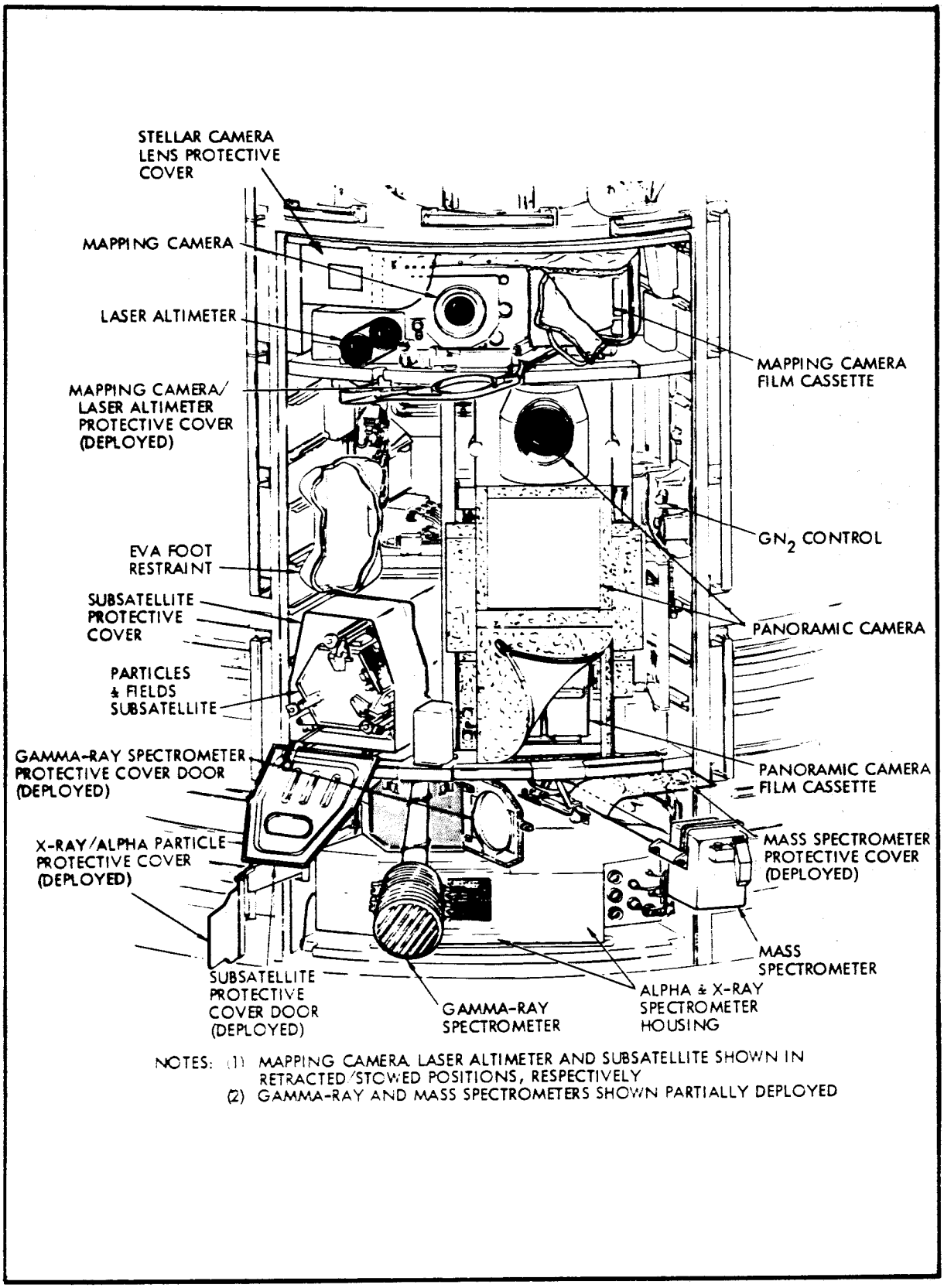


Figure 2-2. Deployed SIM Bay Experiment Sensors and Cameras

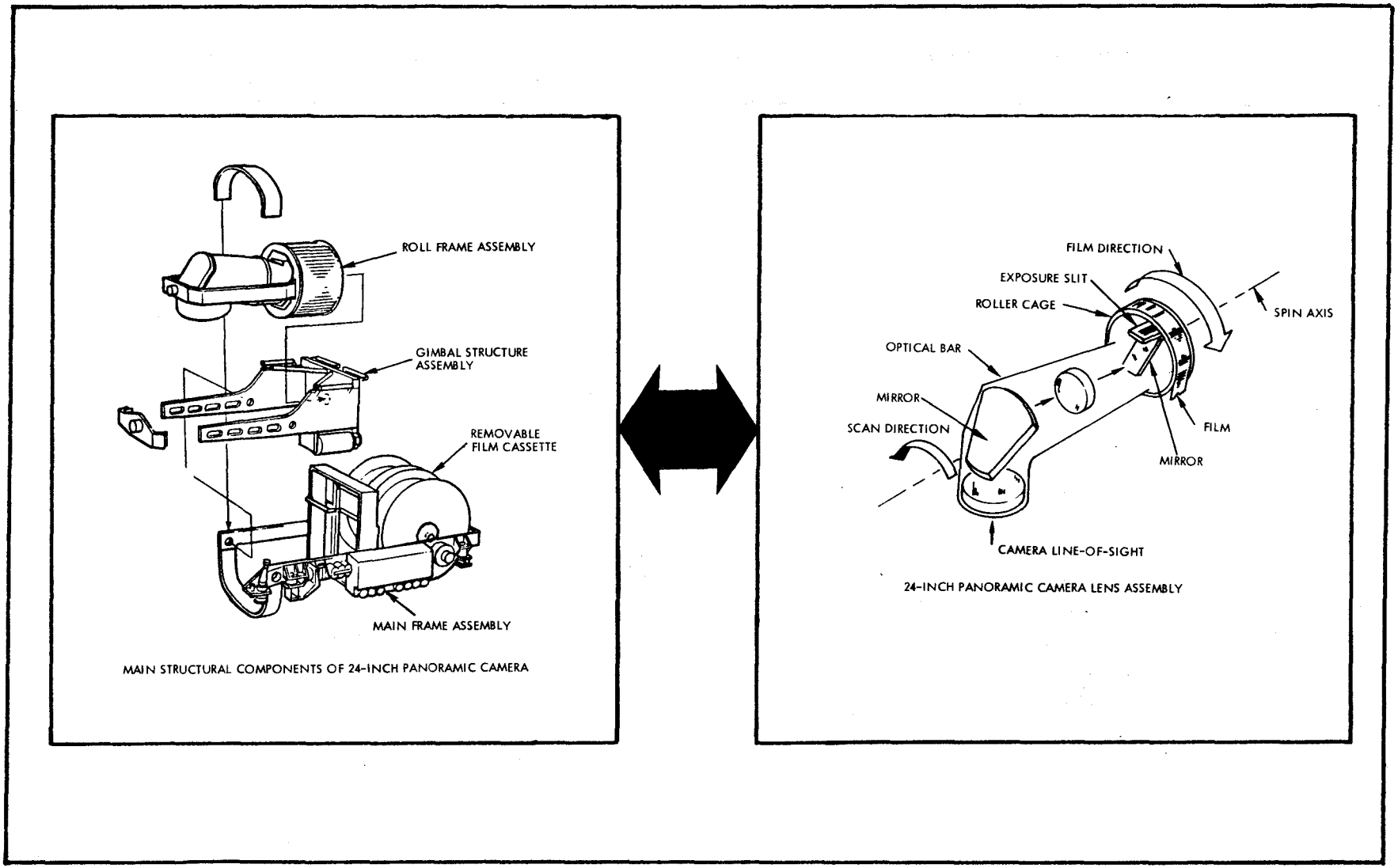


Figure 2-3(a). SIM Bay 24-Inch Panoramic Camera - Structural/Lens Detail

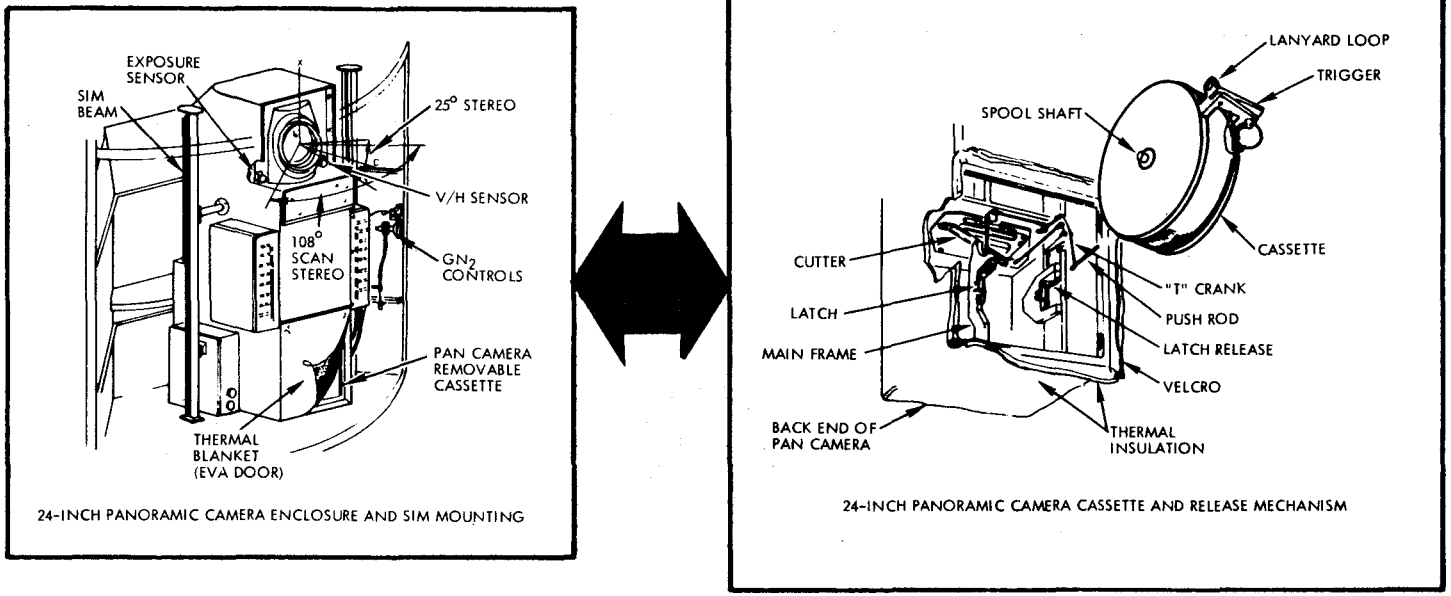


Figure 2-3(b). SIM Bay 24-Inch Panoramic Camera - Mounting/Cassette Detail

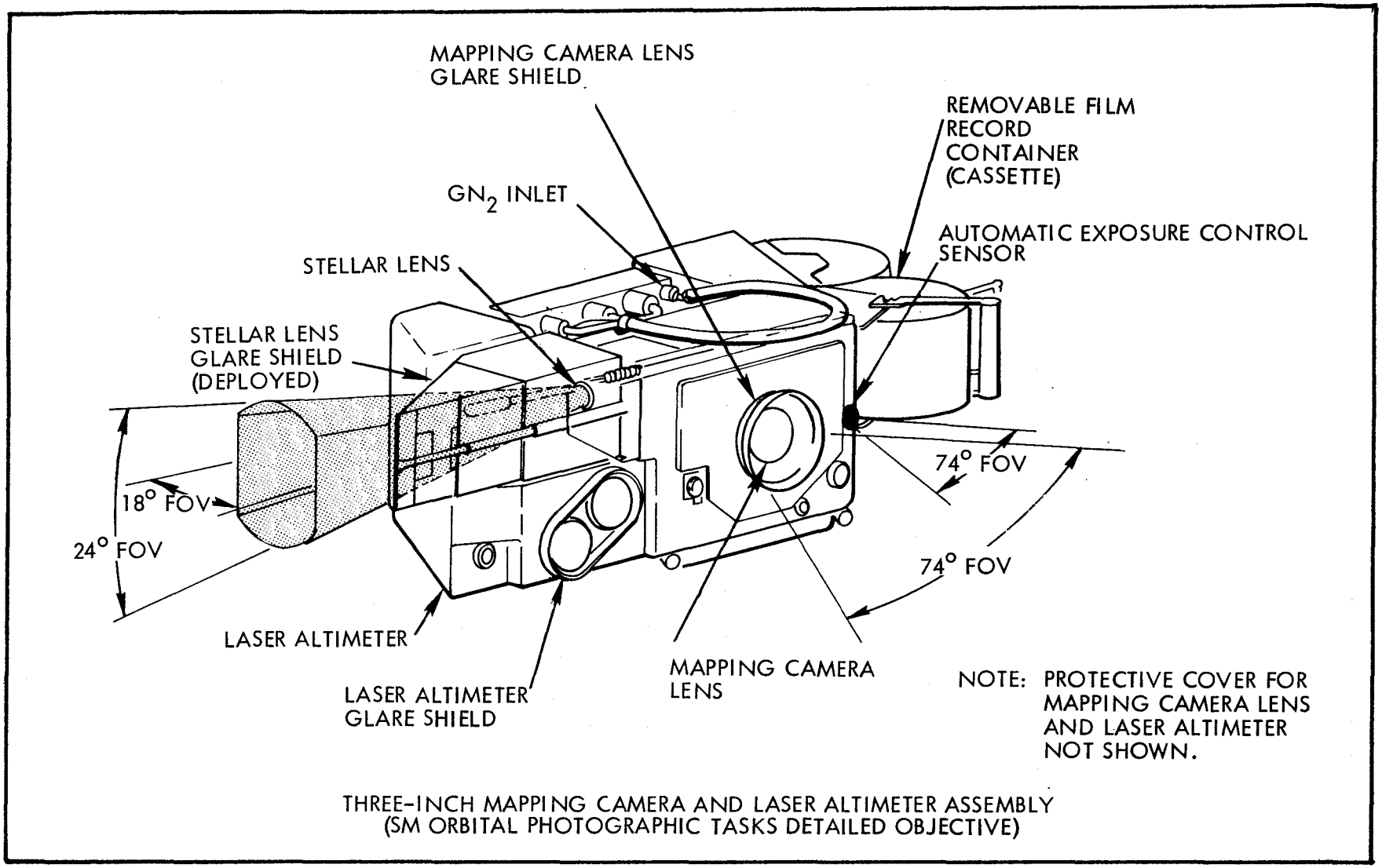


Figure 2-4(a). SIM Bay 3-Inch Mapping Camera Assembly - Mapping Camera/Stellar Camera/Laser Altimeter Detail

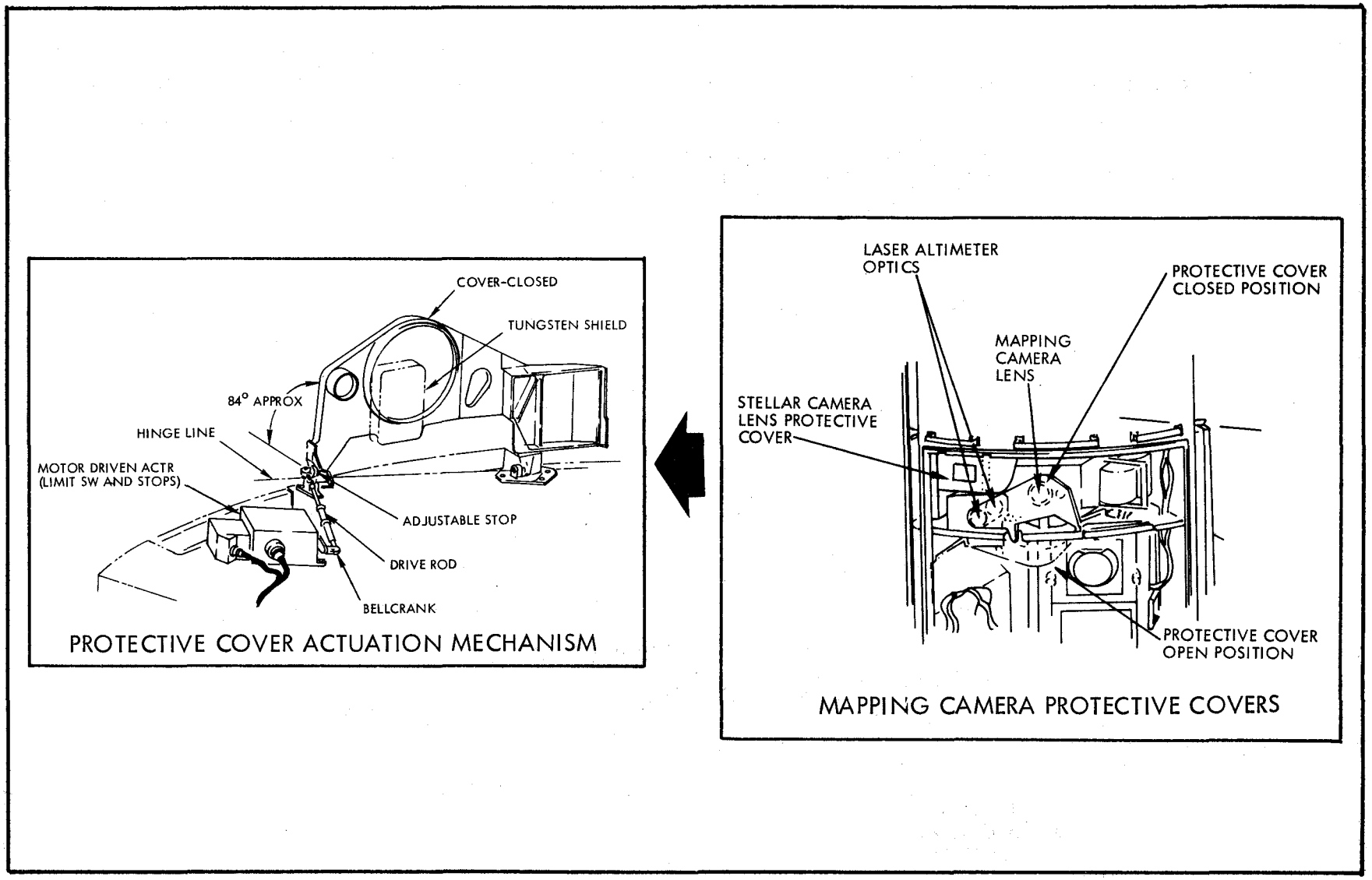


Figure 2-4(b). SIM Bay 3-Inch Mapping Camera Assembly - Protective Covers Details

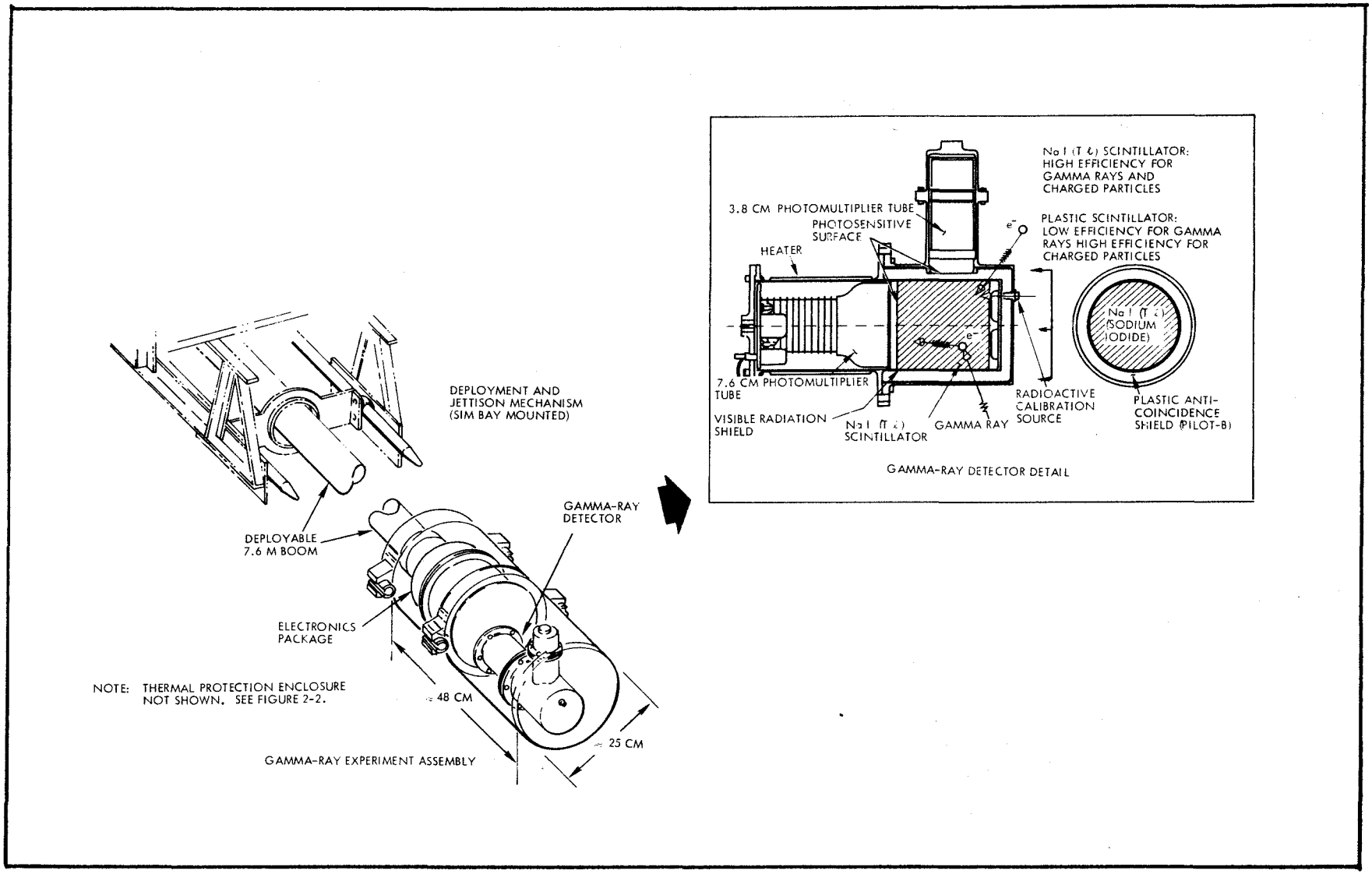
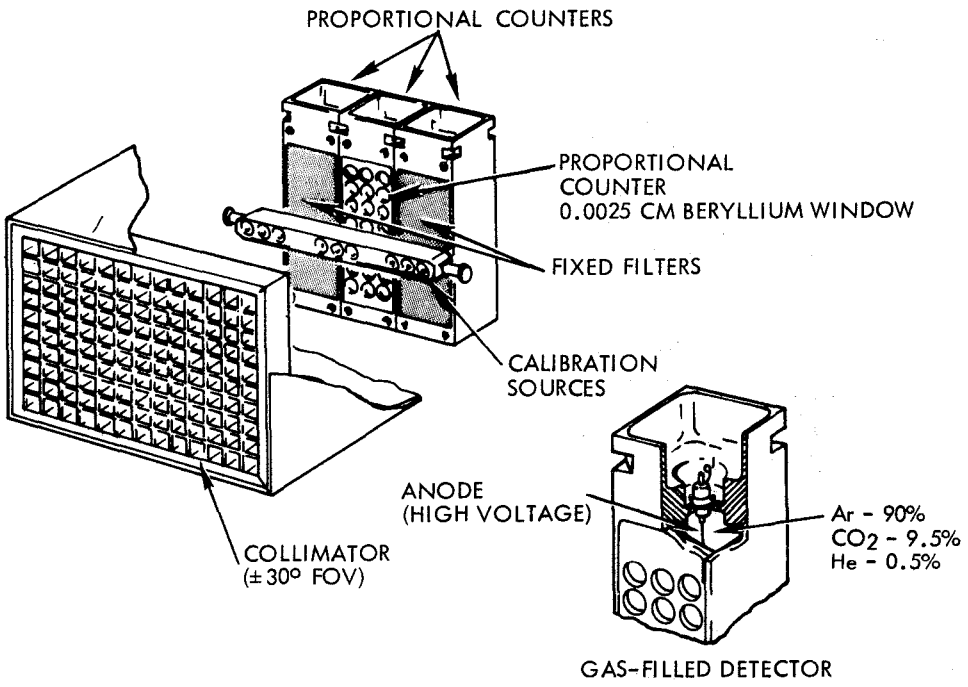
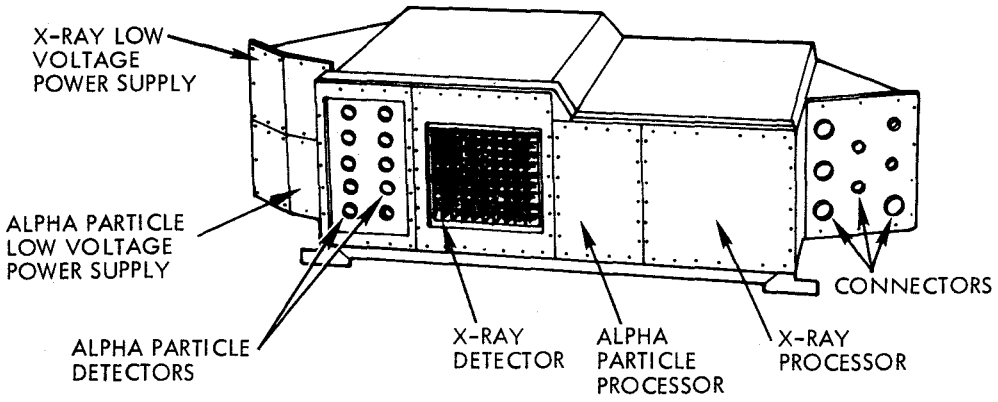


Figure 2-5. SIM Bay Gamma-Ray Spectrometer Assembly

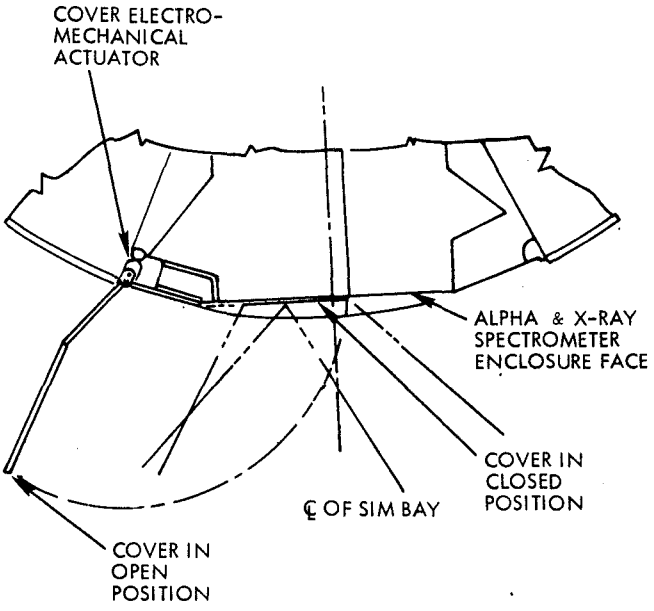


X-RAY DETECTOR CONFIGURATION

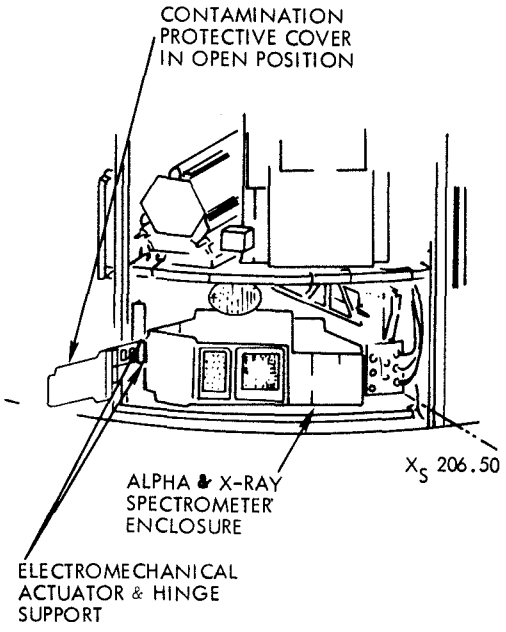


X-RAY/ALPHA PARTICLE EXPERIMENT ENCLOSURE

Figure 2-6(a). SIM Bay X-Ray/Alpha Particle Spectrometer Assembly - Enclosure/Detector Detail



PROTECTIVE COVER ACTUATOR DETAIL



X-RAY/ALPHA PARTICLE PROTECTIVE COVER DETAIL

Figure 2-6(b). SIM Bay X-Ray/Alpha Particle Spectrometer Assembly - Protective Cover Detail

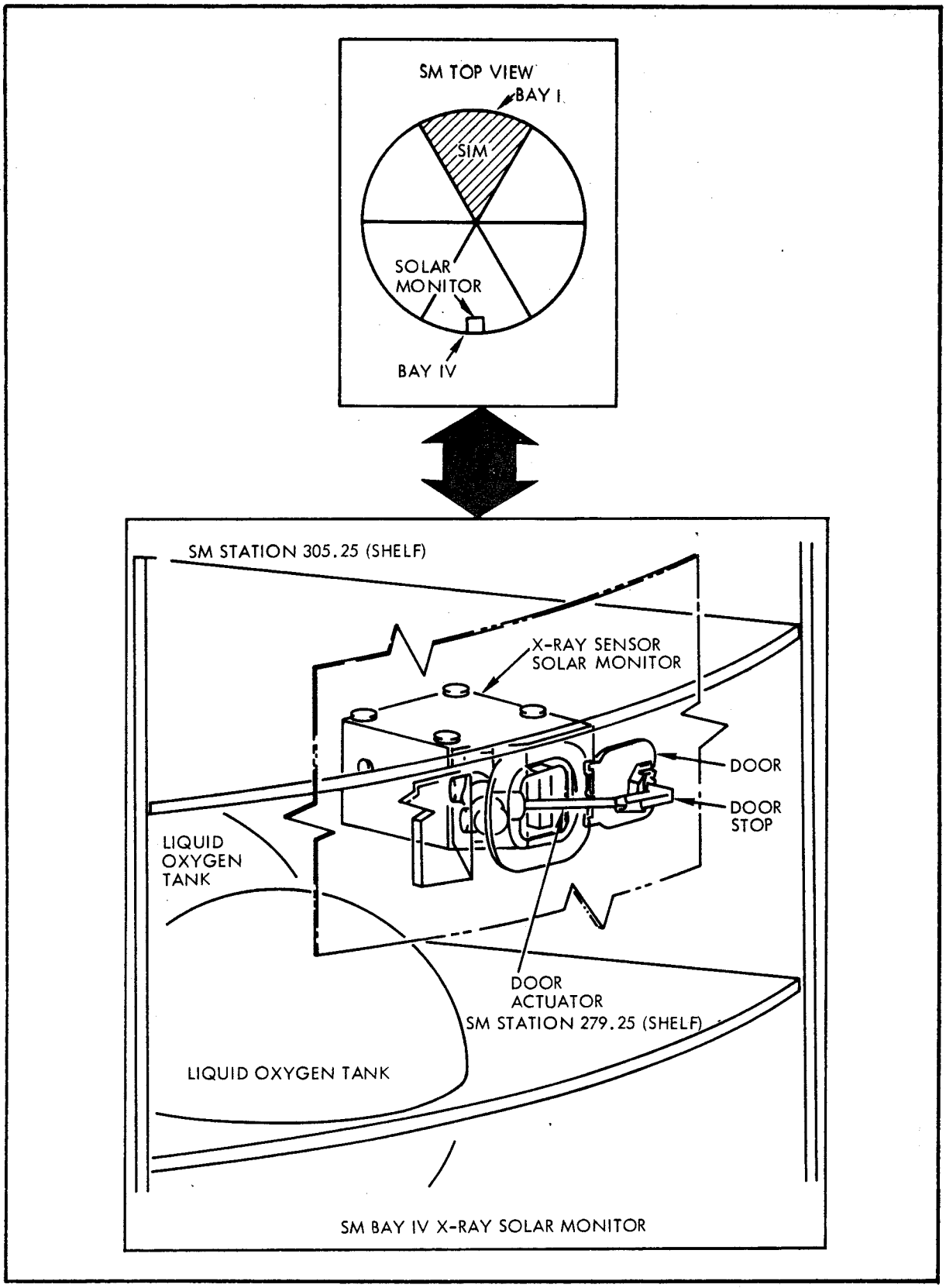


Figure 2-7(a). X-Ray Solar Monitor Assembly - SM Bay IV Mounting Detail

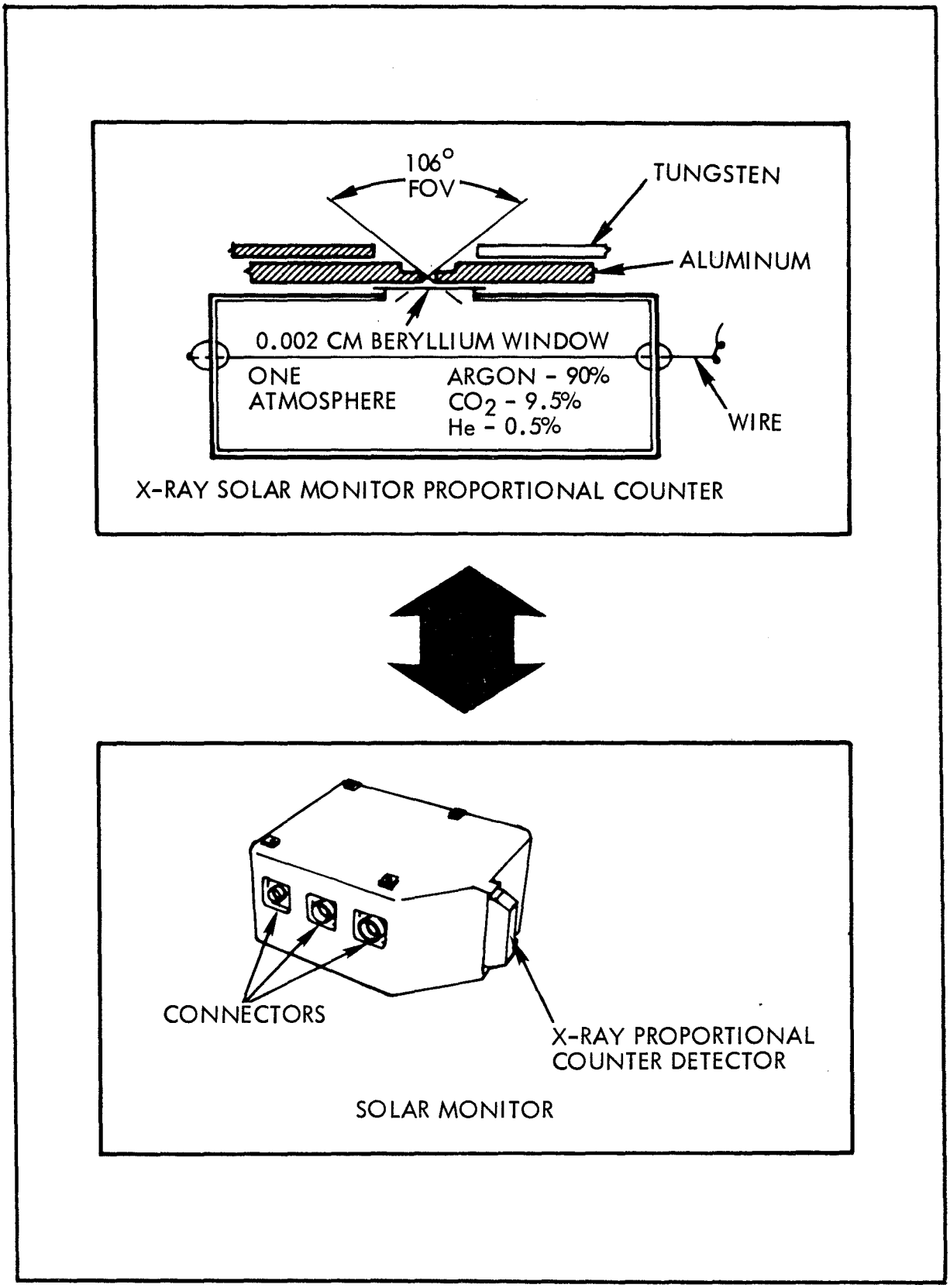


Figure 2-7(b). X-Ray Solar Monitor Assembly - Detector Detail

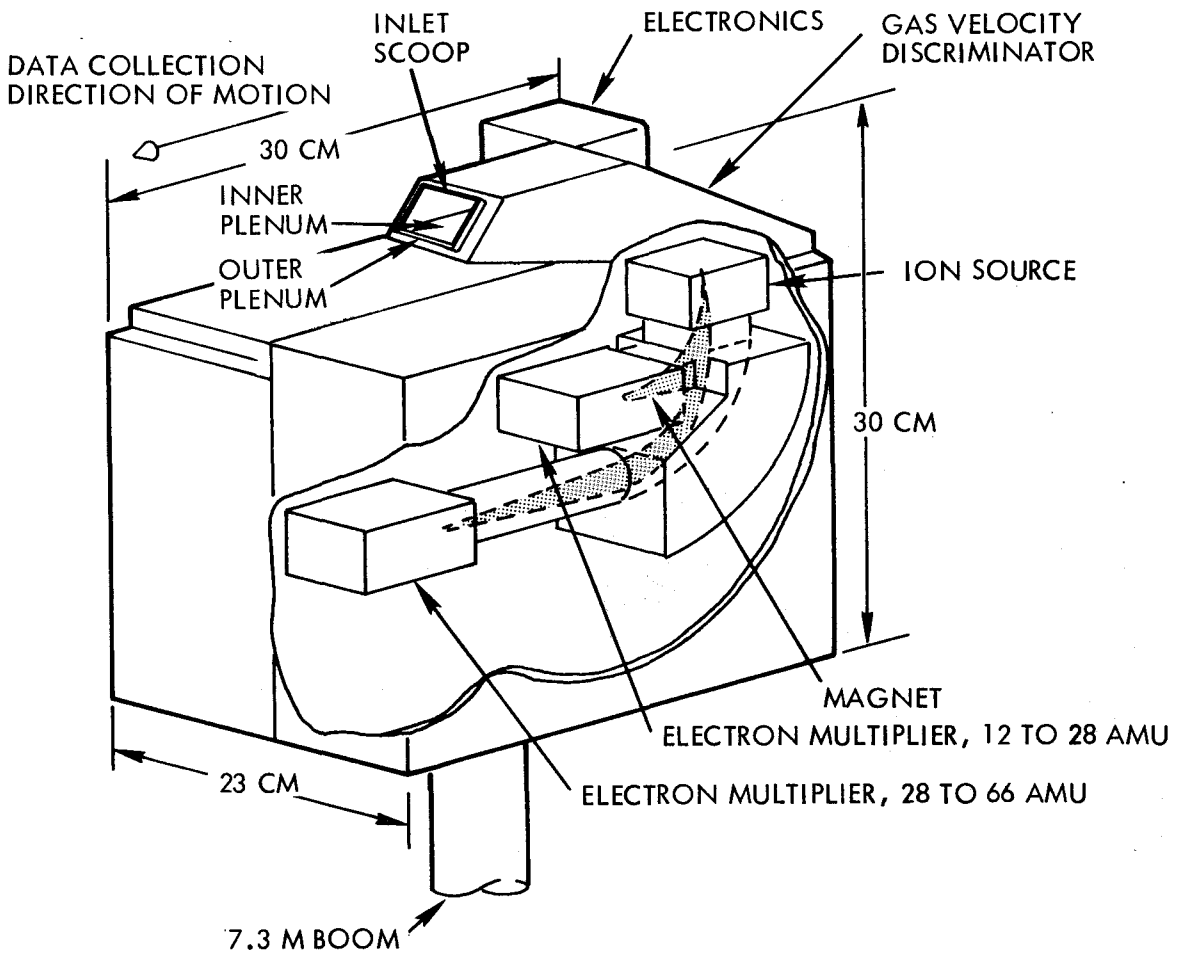


Figure 2-8(a). SIM Bay Mass Spectrometer Assembly - Detector Detail

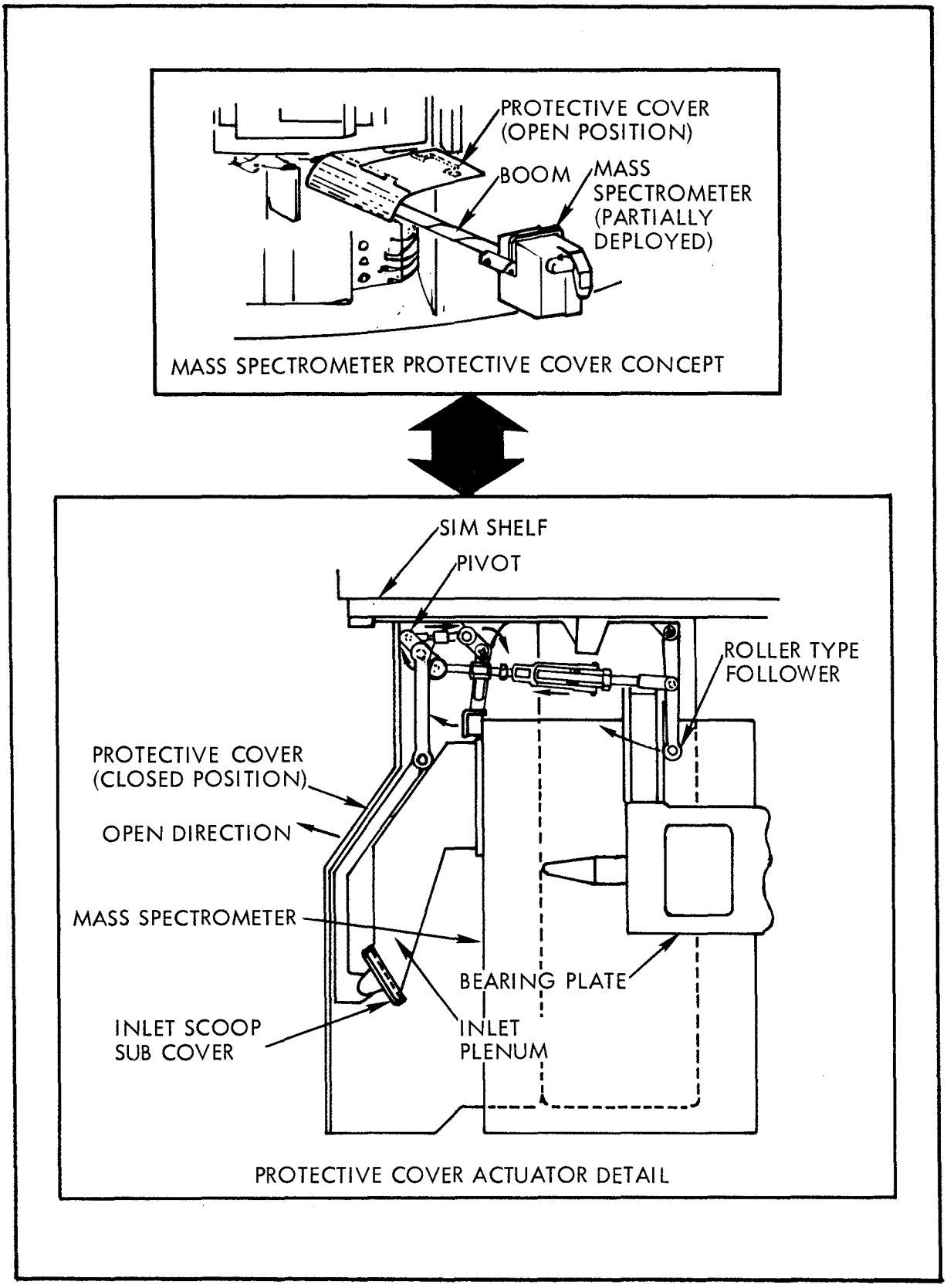


Figure 2-8(b). SIM Bay Mass Spectrometer Assembly - Protective Cover Detail

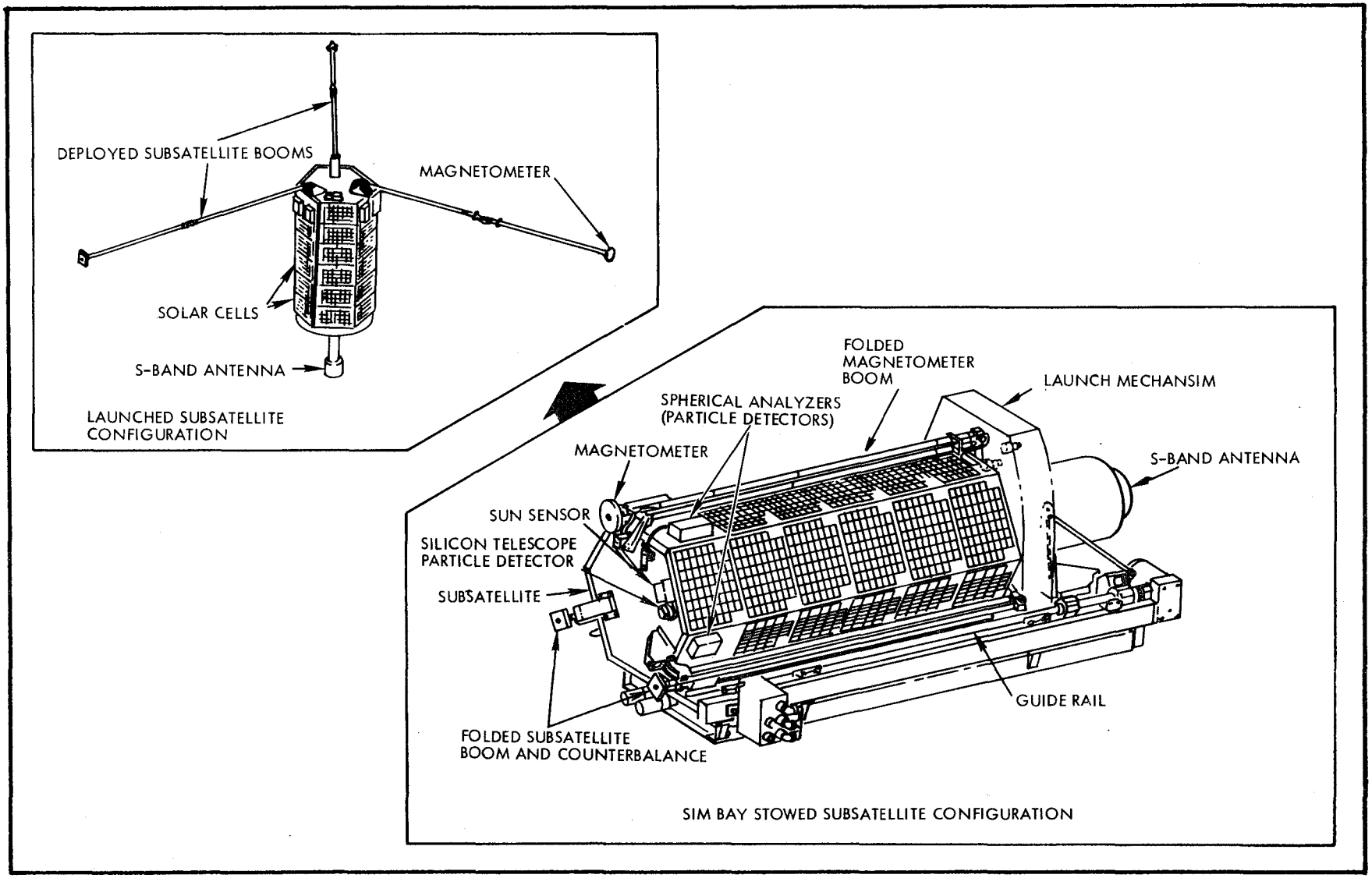


Figure 2-9. SIM Bay Subsatellite

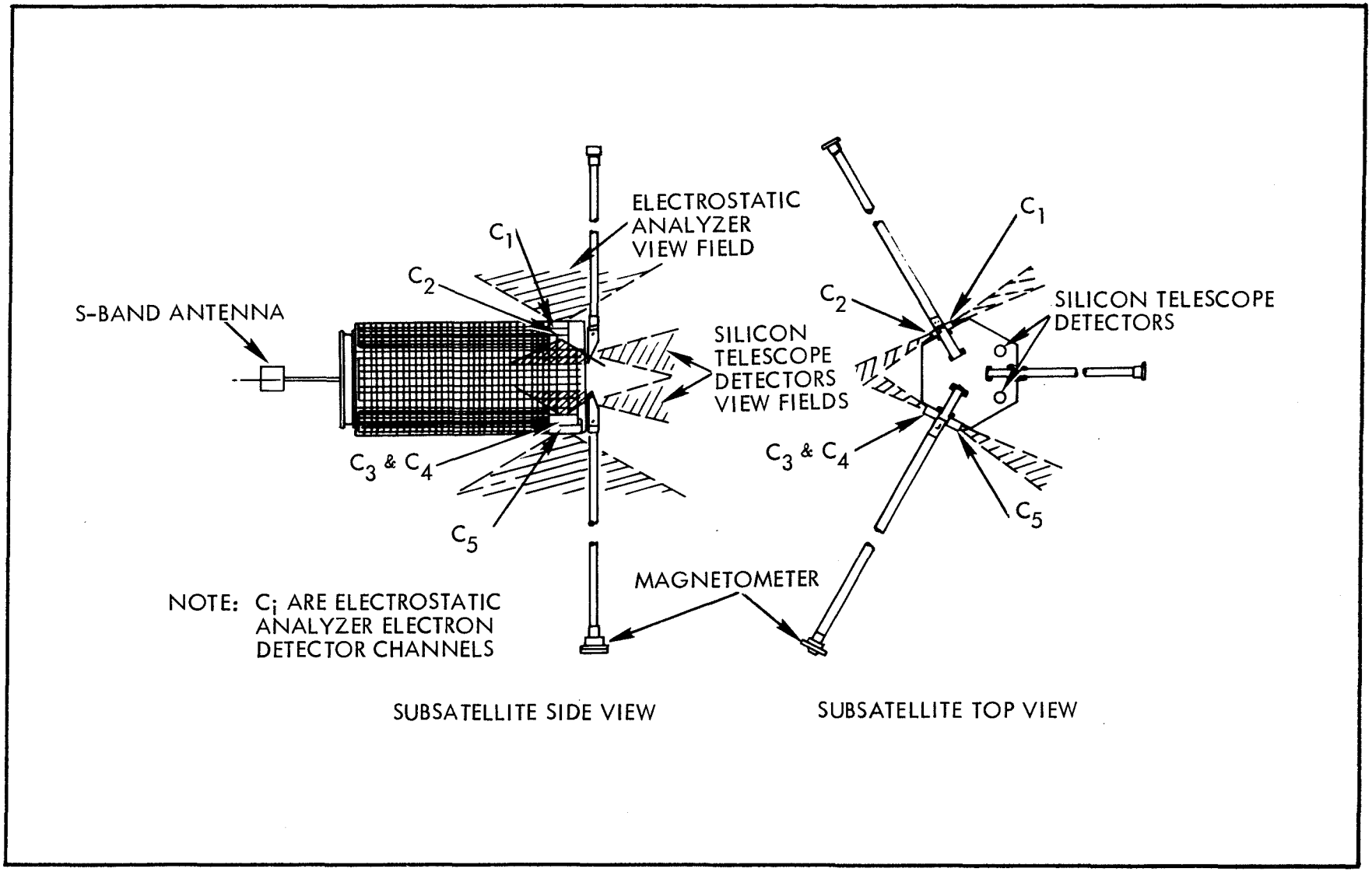


Figure 2-10(a). Subsatellite Charged Particle Detectors - Placement and Viewing Angles

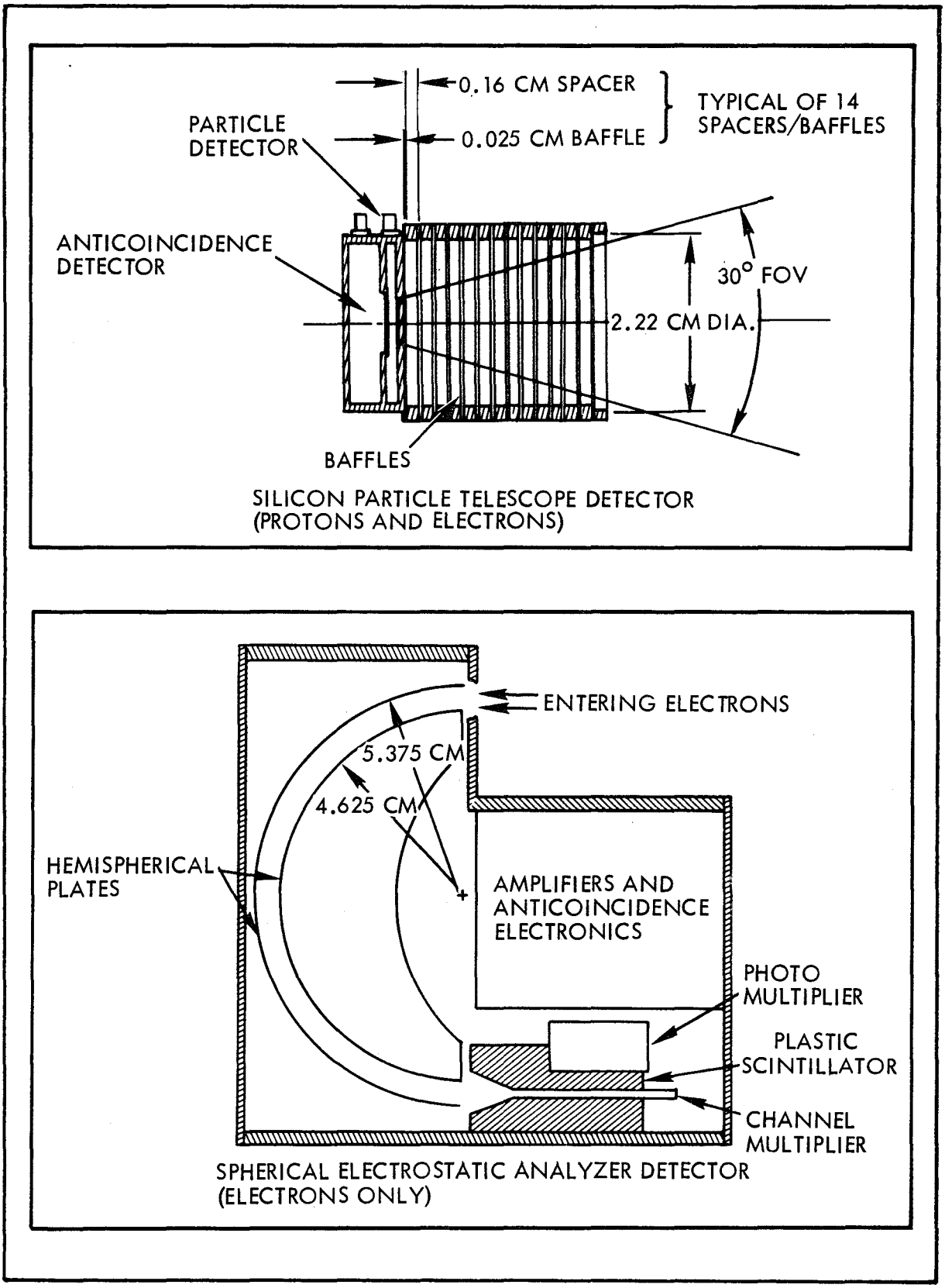


Figure 2-10(b). Subsatellite Charged Particle Detectors - Detector Detail

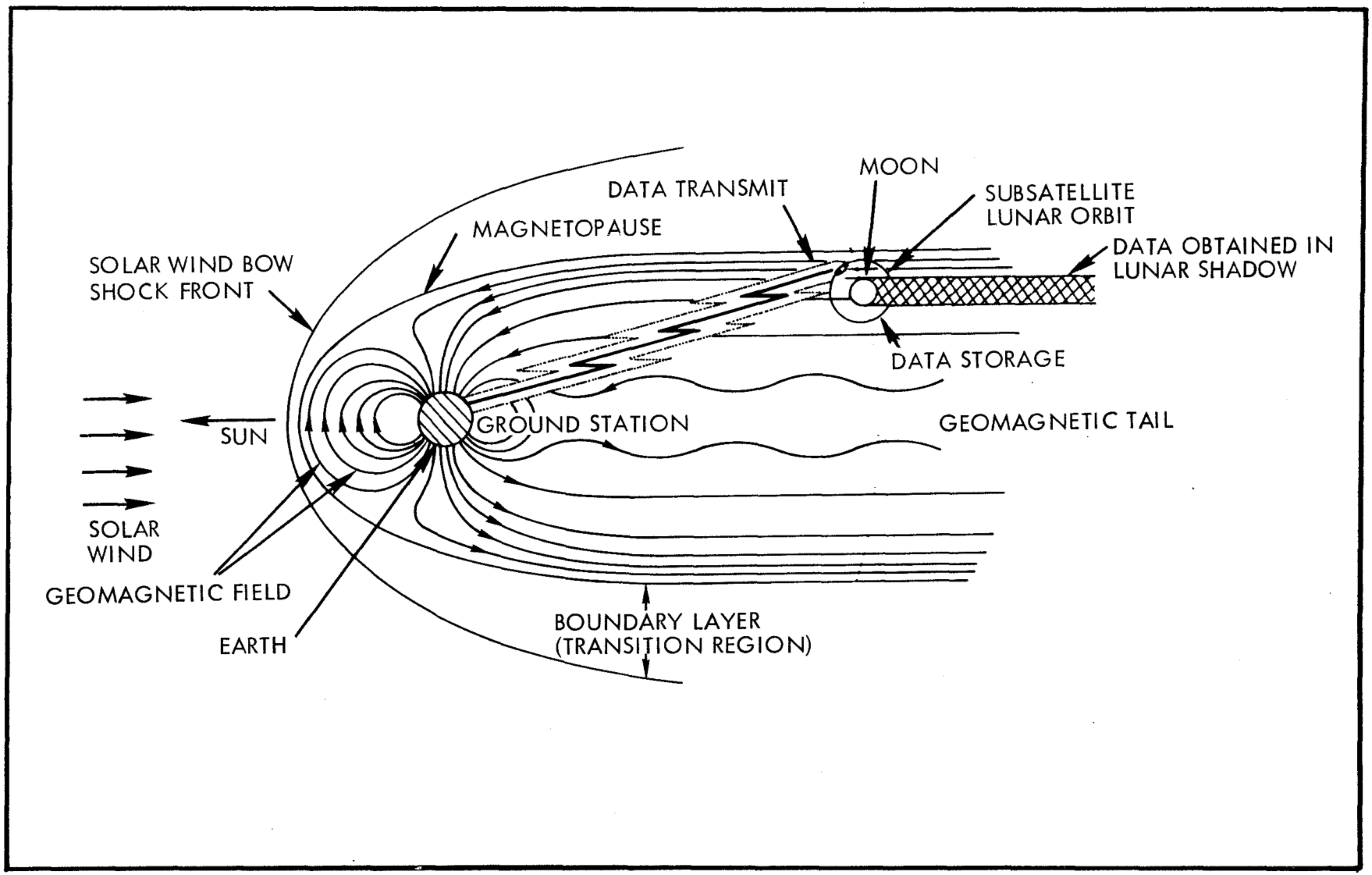


Figure 2-11. Concept of Subsatellite Particles and Fields Experiments (S-173 and S-174)

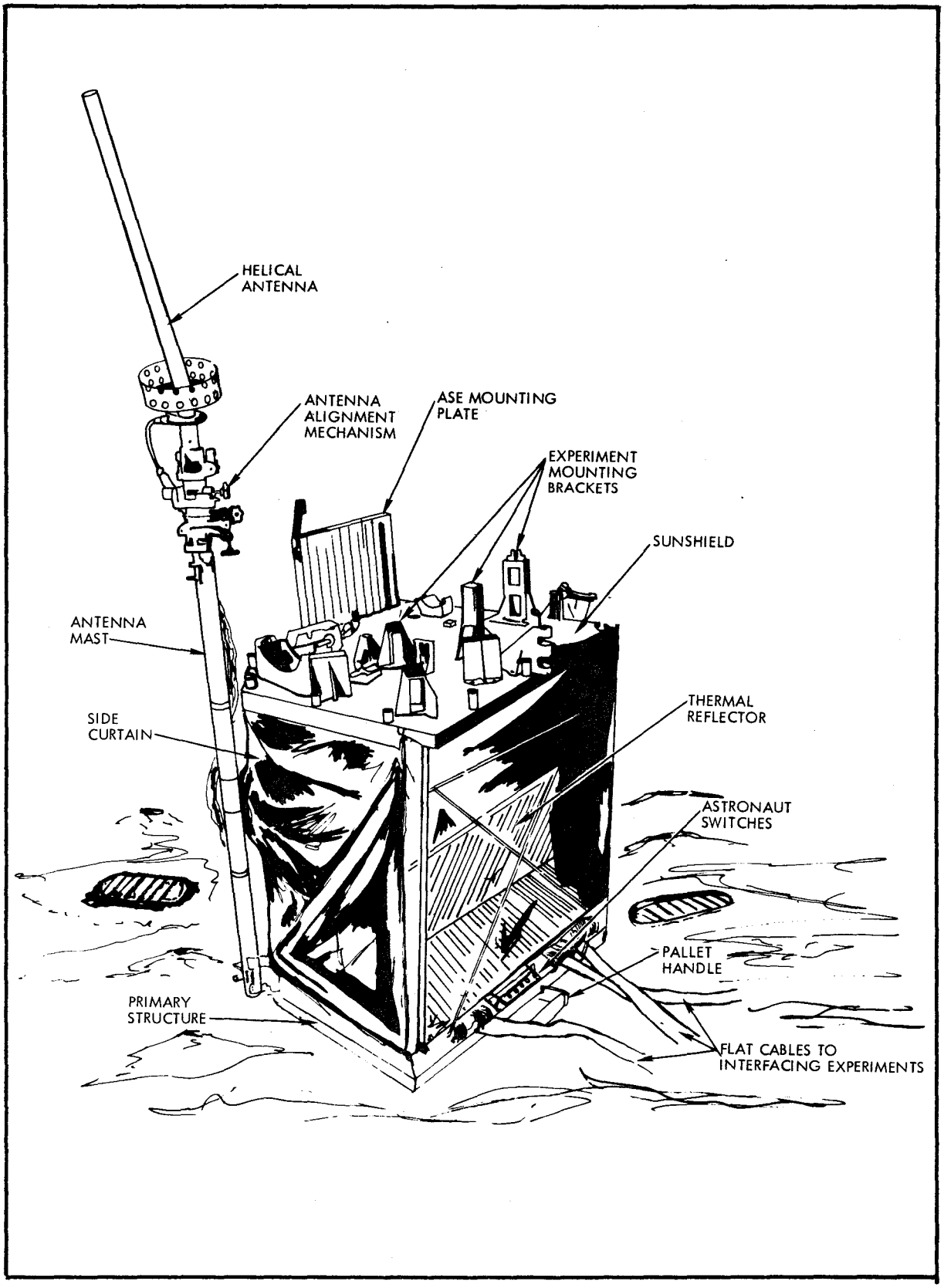


Figure 2-12. Apollo 16 ALSEP Central Station

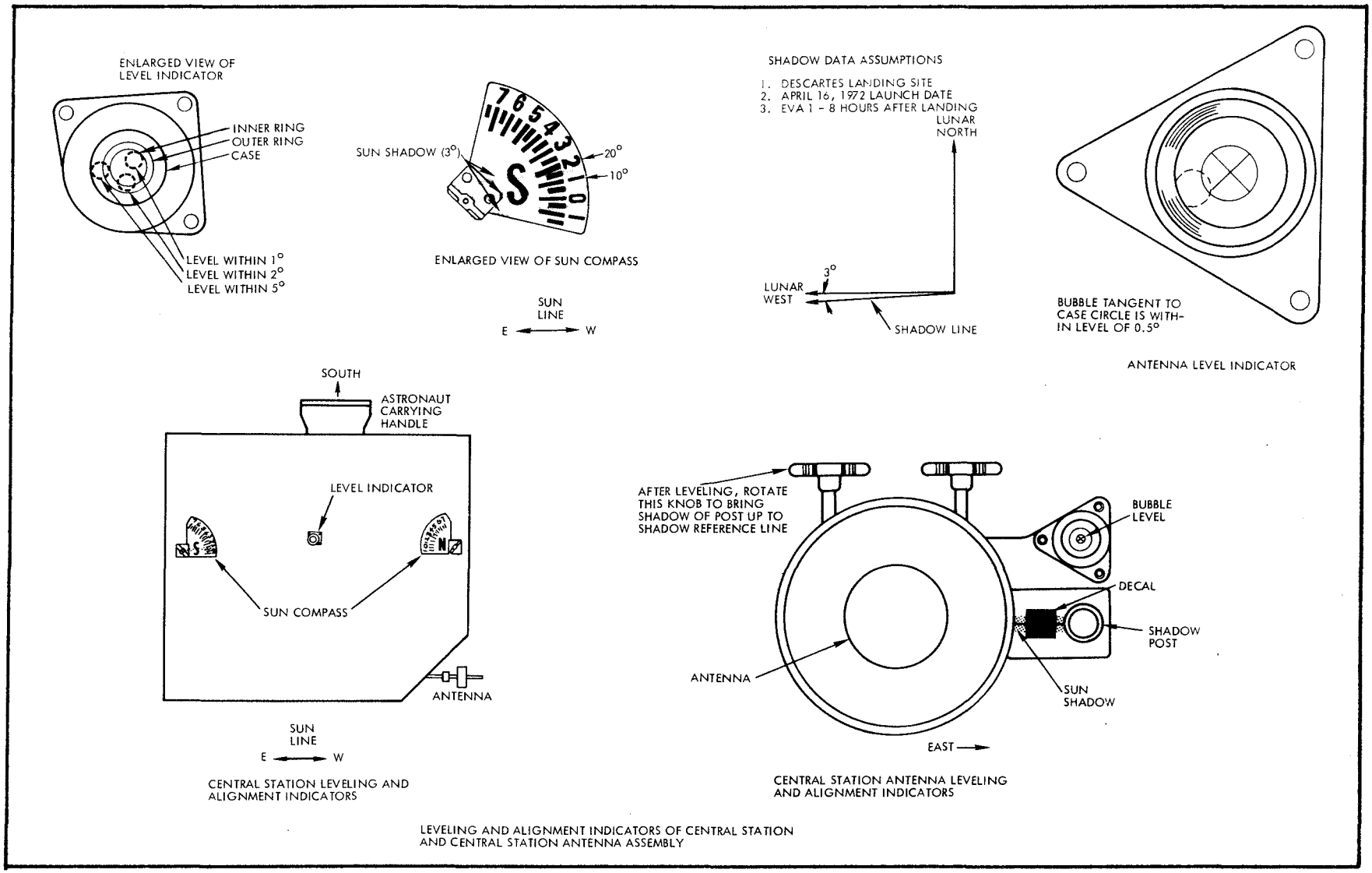


Figure 2-13. ALSEP Central Station Leveling and Alignment

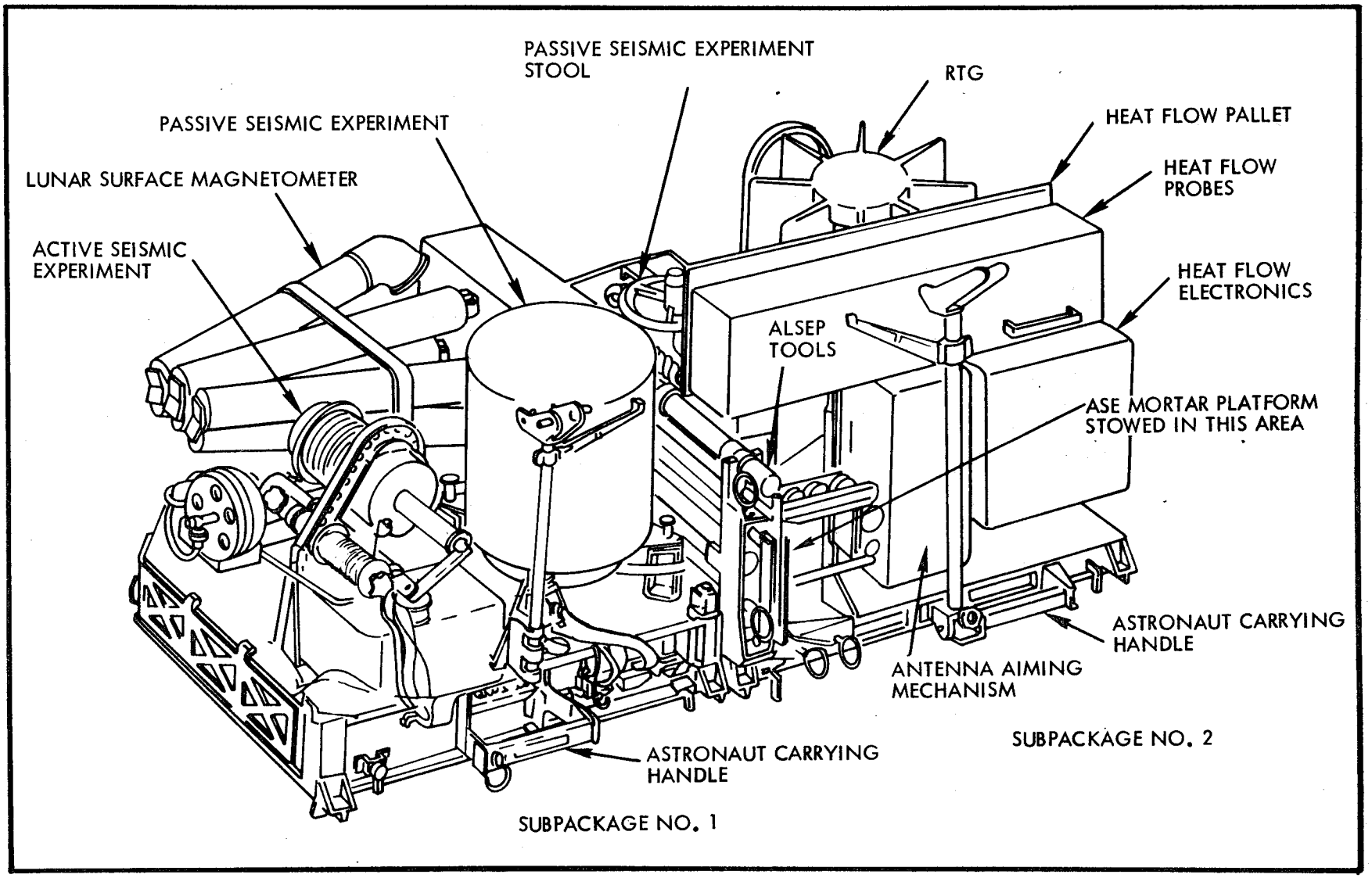
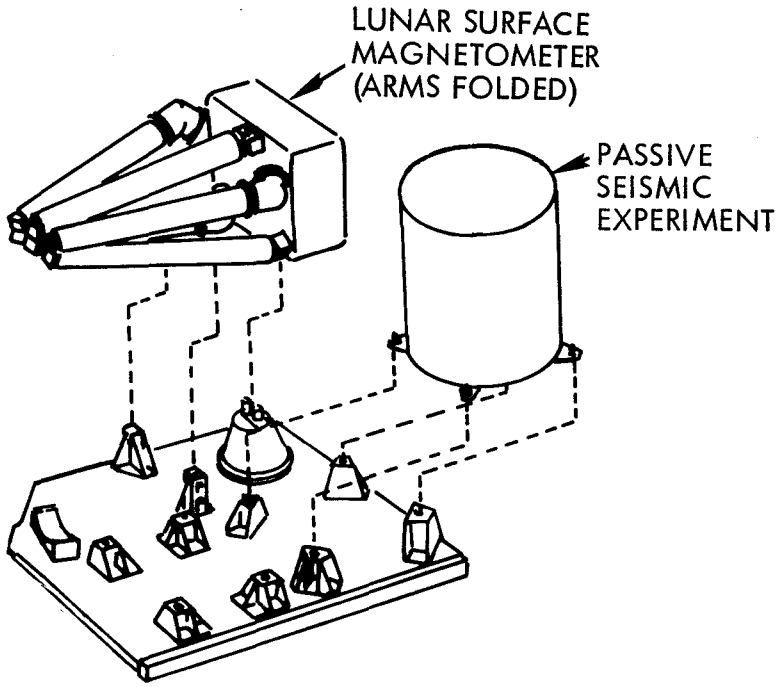
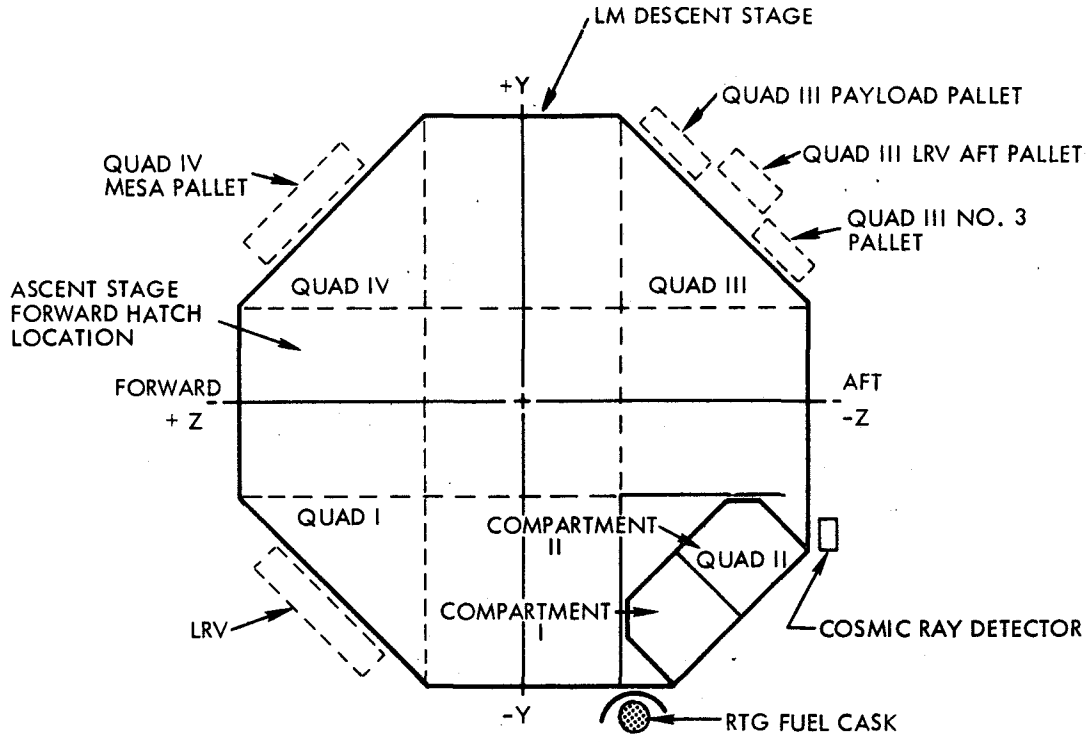


Figure 2-14. Apollo 16 ALSEP Subpackages



TYPICAL EXPERIMENT MOUNTING - SUBPACKAGE NO. 1

Figure 2-15. Typical ALSEP Experiment/Subpackage Integration Detail



QUAD I
- LUNAR ROVING VEHICLE

QUAD II SEQ BAY
- APOLLO 16 ALSEP
  - SUBPACKAGE NO. 1
  - SUBPACKAGE NO. 2

QUAD III PAYLOAD PALLET
- FAR UV CAMERA/SPECTROSCOPE

QUAD III NO. 3 PALLET
- UNUSED

QUAD IV MESA PALLET
- LUNAR SURFACE DRILL ASSEMBLY
- 16-MM DATA ACQUISITION CAMERA AND STAFF
- LUNAR SURFACE HASSELBLAD ELECTRIC CAMERA
- CAMERA ACCESSORIES
- GROUND-COMMANDED TV CAMERA, CONTROL UNIT, AND ACCESSORIES
- SAMPLE RETURN CONTAINERS (2)
- LUNAR SURFACE RAKE
- RETURN BAG FOR COSMIC RAY DETECTOR
- SOLAR WIND COMPOSITION
- SAMPLE RETURN BAG
- SAMPLE CONTAINMENT BAGS (6)
- CORE STEMS/BORE STEMS

QUAD III LRV AFT PALLET
- LARGE SAMPLING SCOOP
- APOLLO LUNAR HAND TOOL CARRIER
- GNOMON/PHOTOMETRIC CHART
- SELF-RECORDING PENETROMETER
- HAMMER
- 32-INCH TONGS (2)
- TOOL EXTENSION HANDLE (2)
- LUNAR PORTABLE MAGNETOMETER
- SAMPLE COLLECTION BAGS (2)
- EXTRA SAMPLE COLLECTION BAGS (4)
- SPECIAL SURFACE SAMPLER (2)

Figure 2-16. LM Descent Stage Stowage of Surface Science Equipment

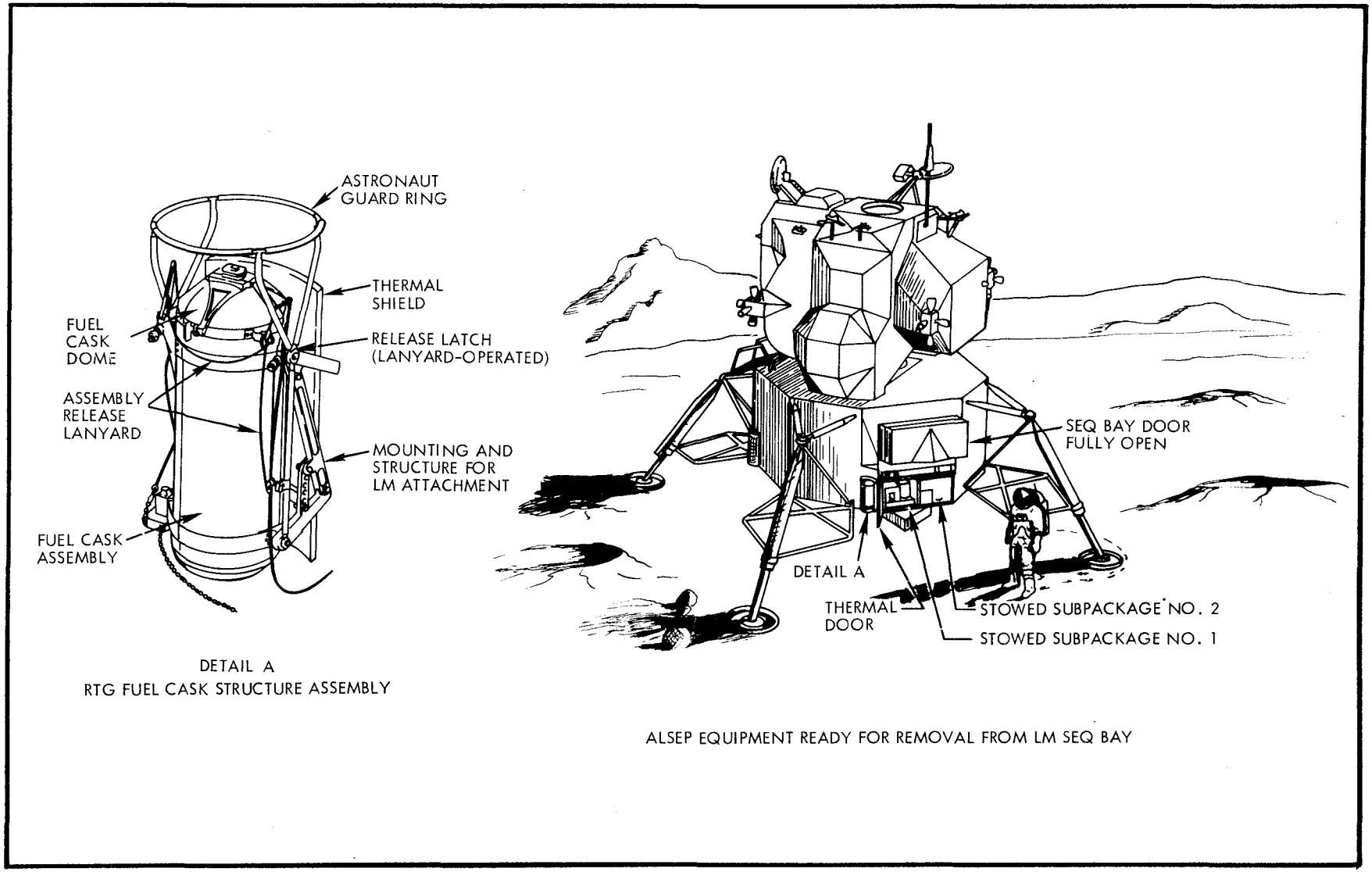


Figure 2-17. LM Mounting of RTG Fuel Cask and ALSEP Subpackages

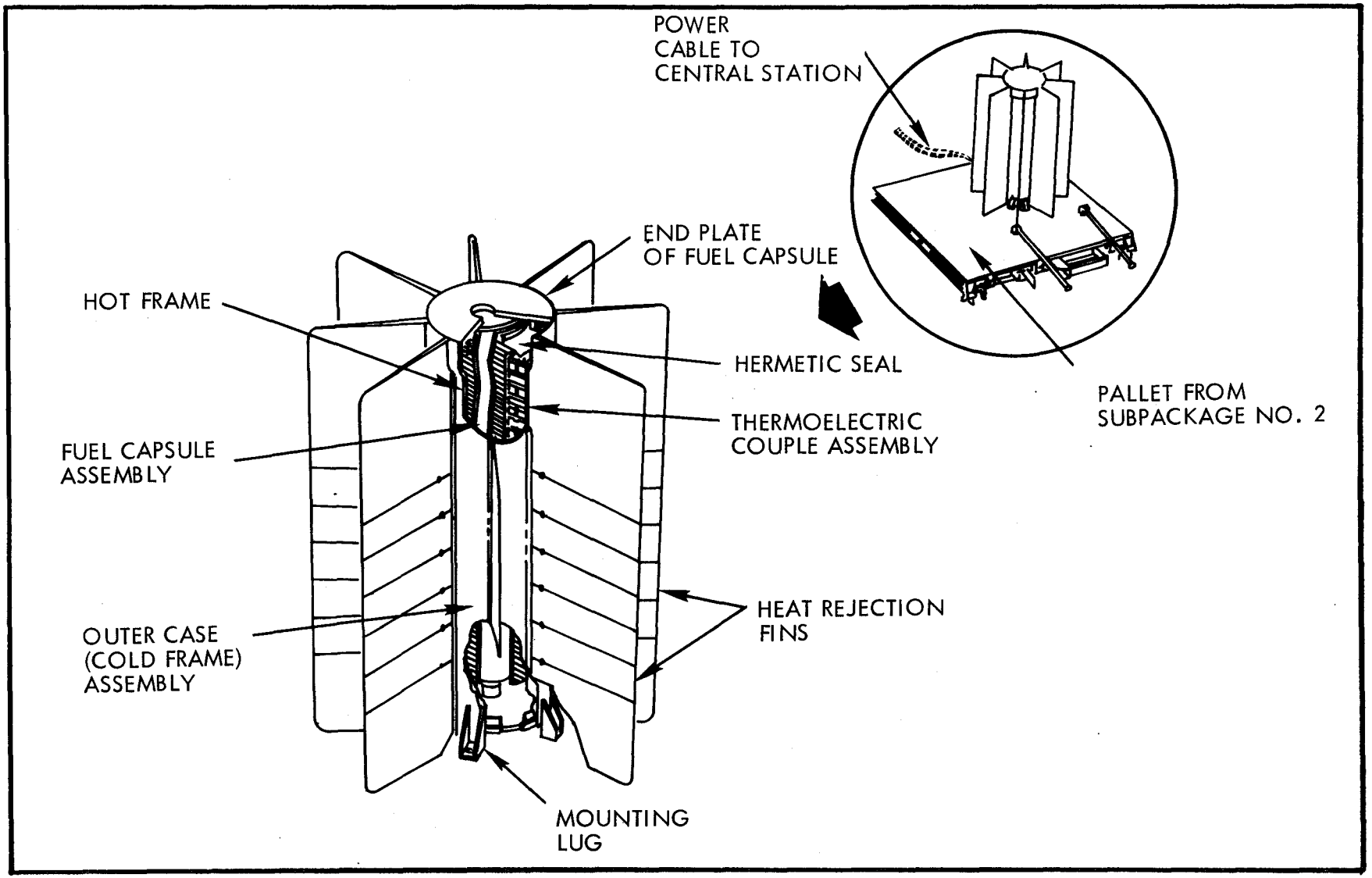


Figure 2-18. ALSEP RTG Assembly

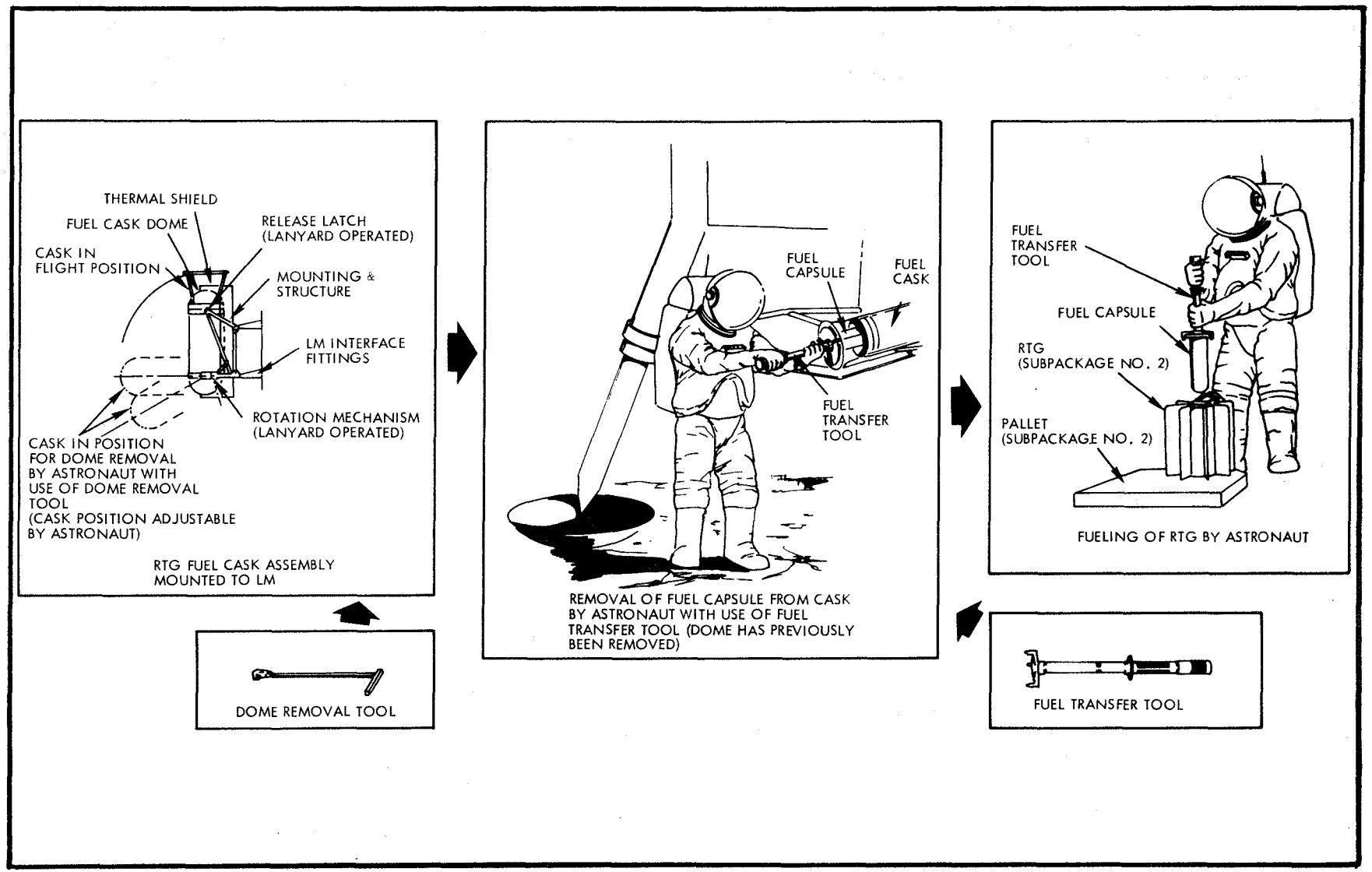


Figure 2-19. ALSEP RTG Fuel Transfer Activities

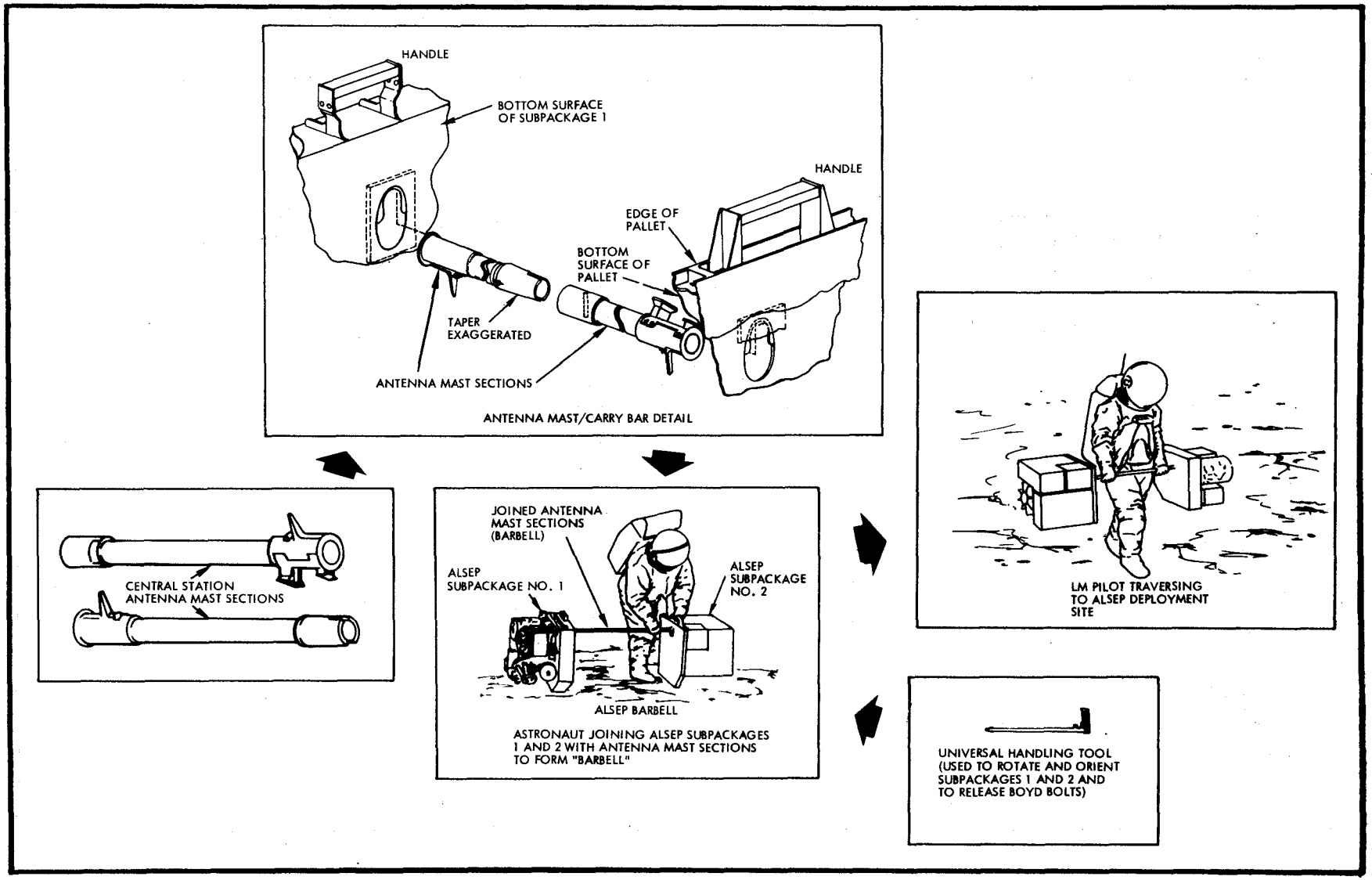


Figure 2-20. Traverse Preparation of ALSEP Subpackages

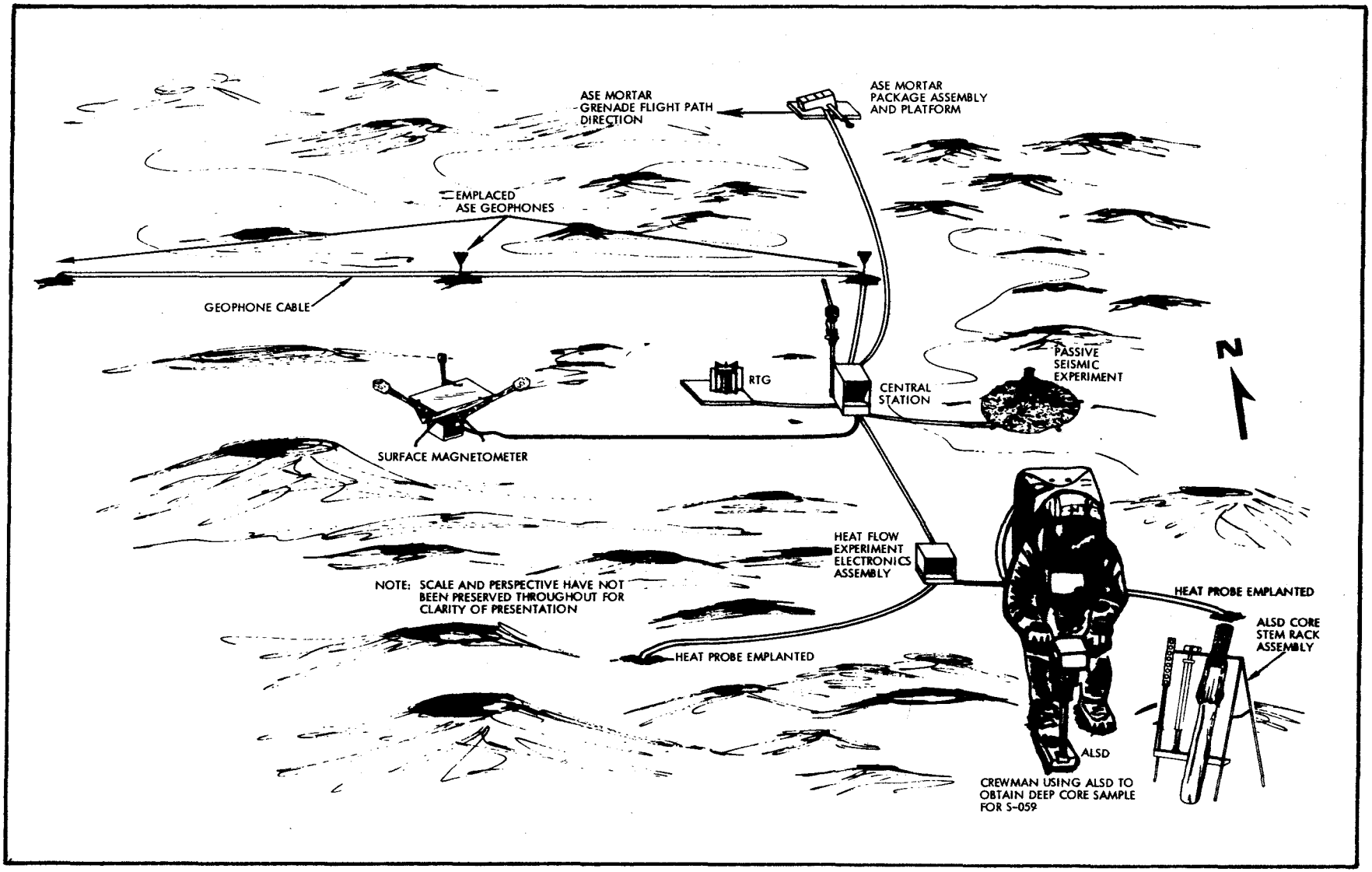


Figure 2-21. Apollo 16 ALSEP Experiment Deployment

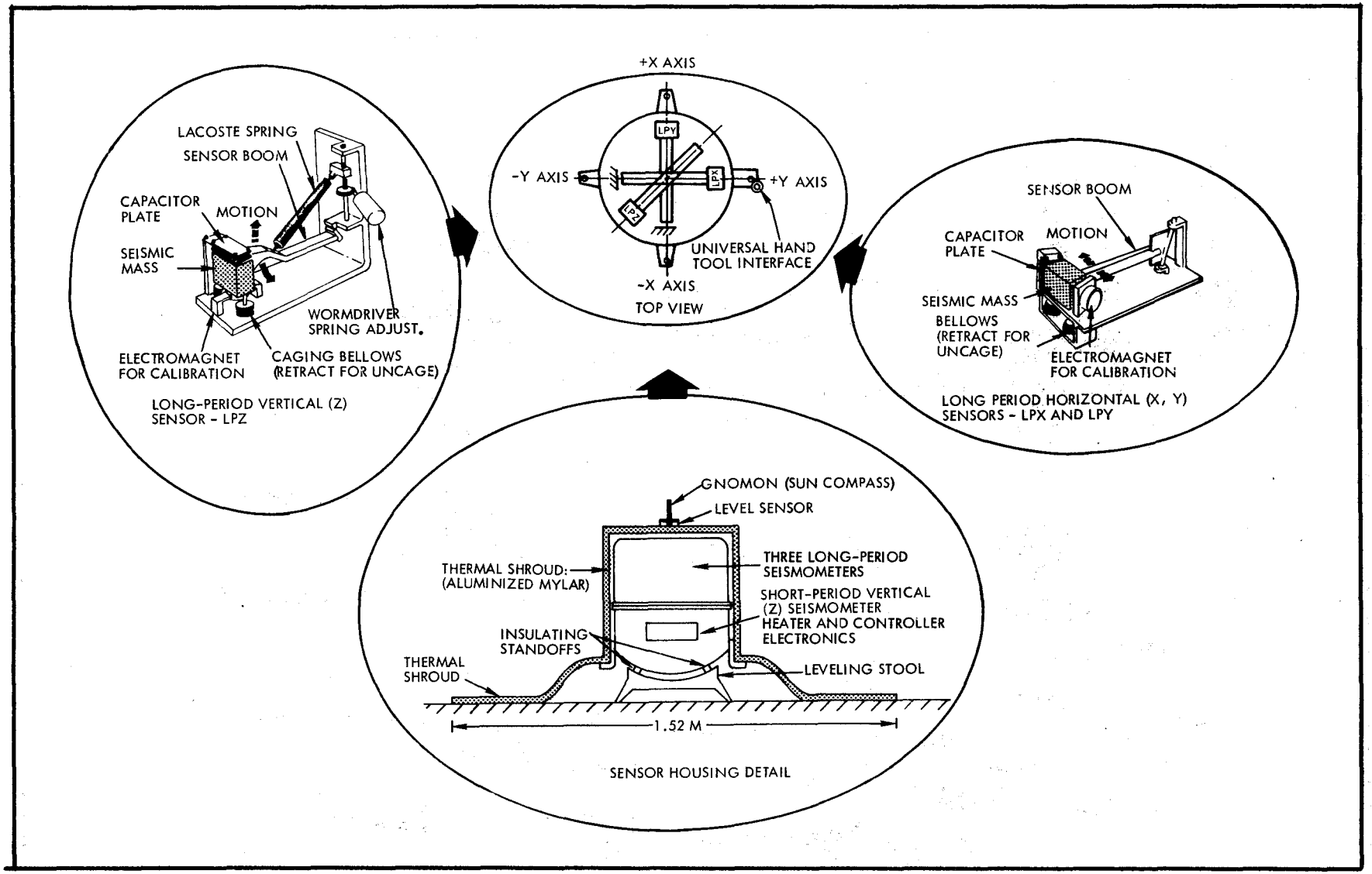


Figure 2-22(a). Passive Seismic Experiment - Sensor Details

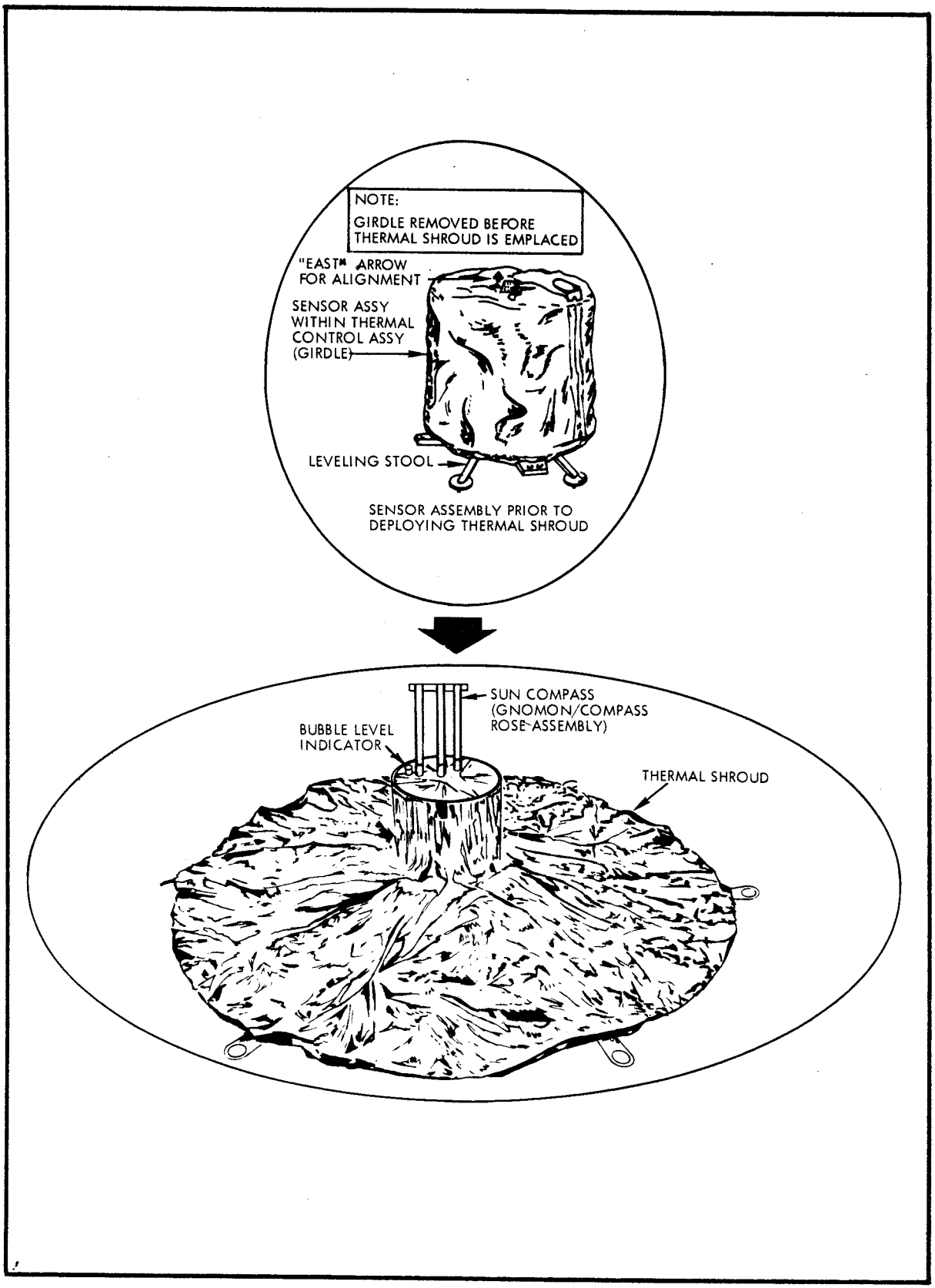


Figure 2-22(b). Passive Seismic Experiment - Deployment Detail

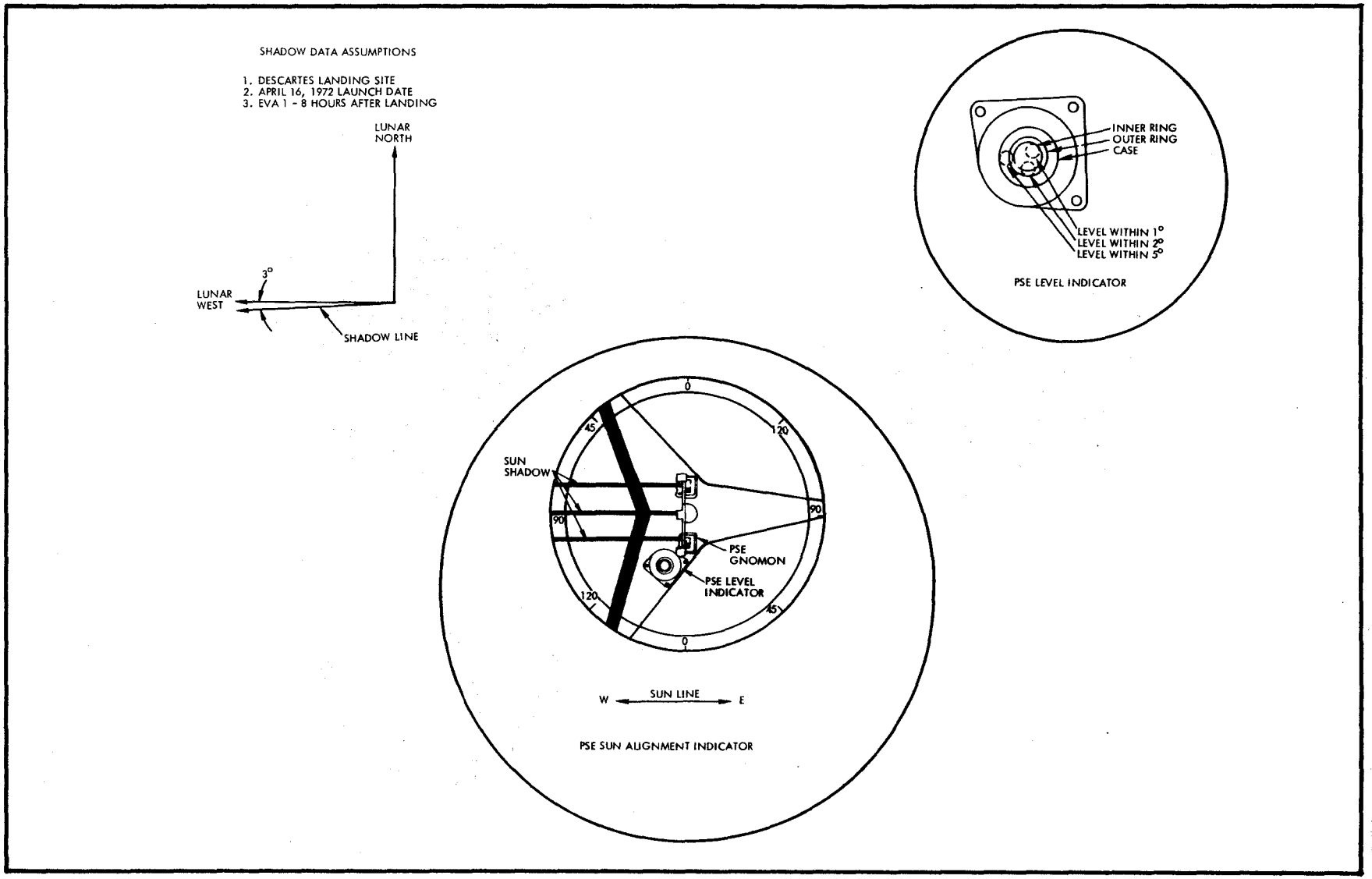


Figure 2-22(c). Passive Seismic Experiment - Alignment/Leveling Details

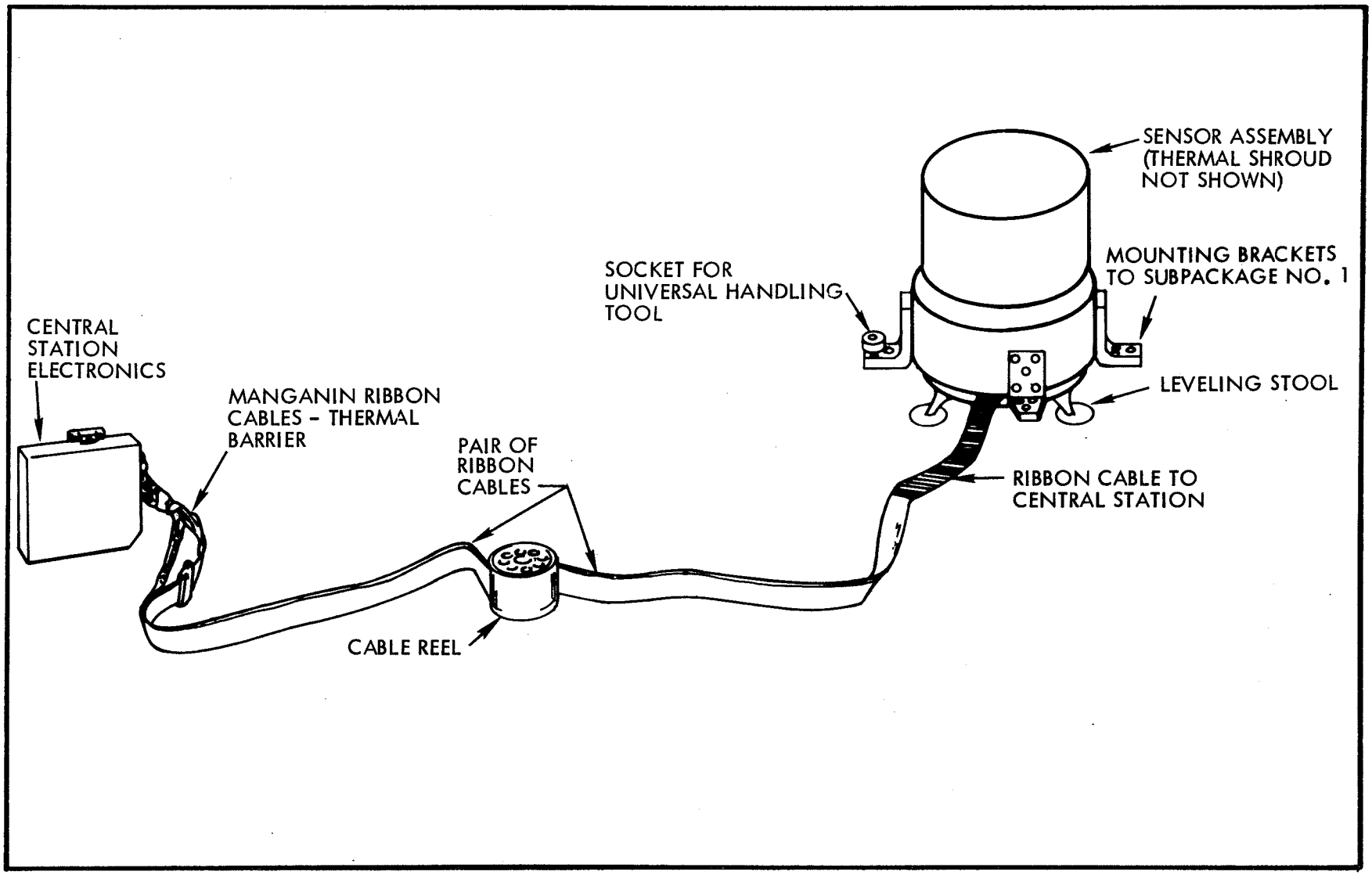


Figure 2-22(d). Passive Seismic Experiment - Central Station Interface

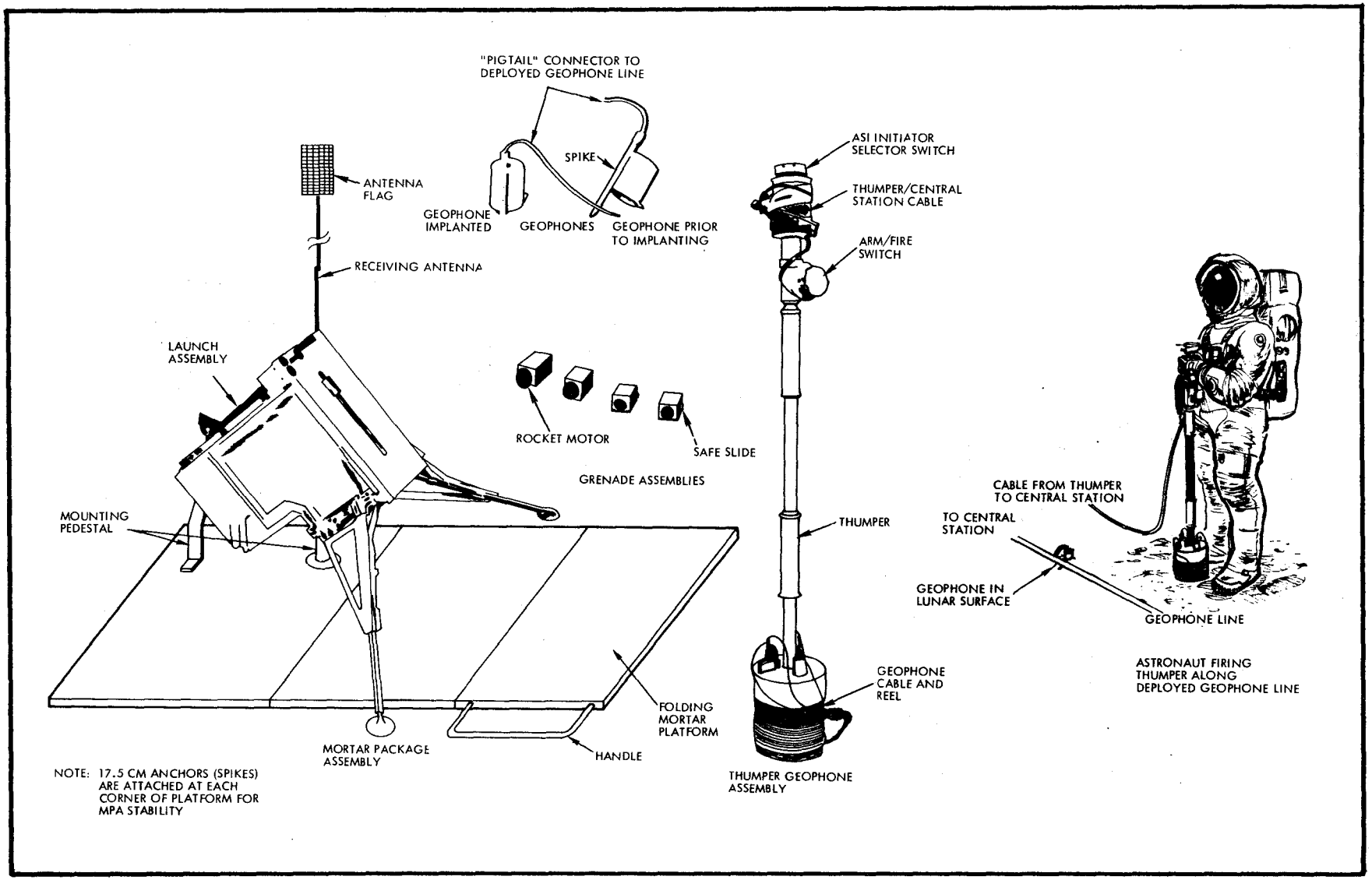


Figure 2-23(a). Active Seismic Experiment - Experiment Components

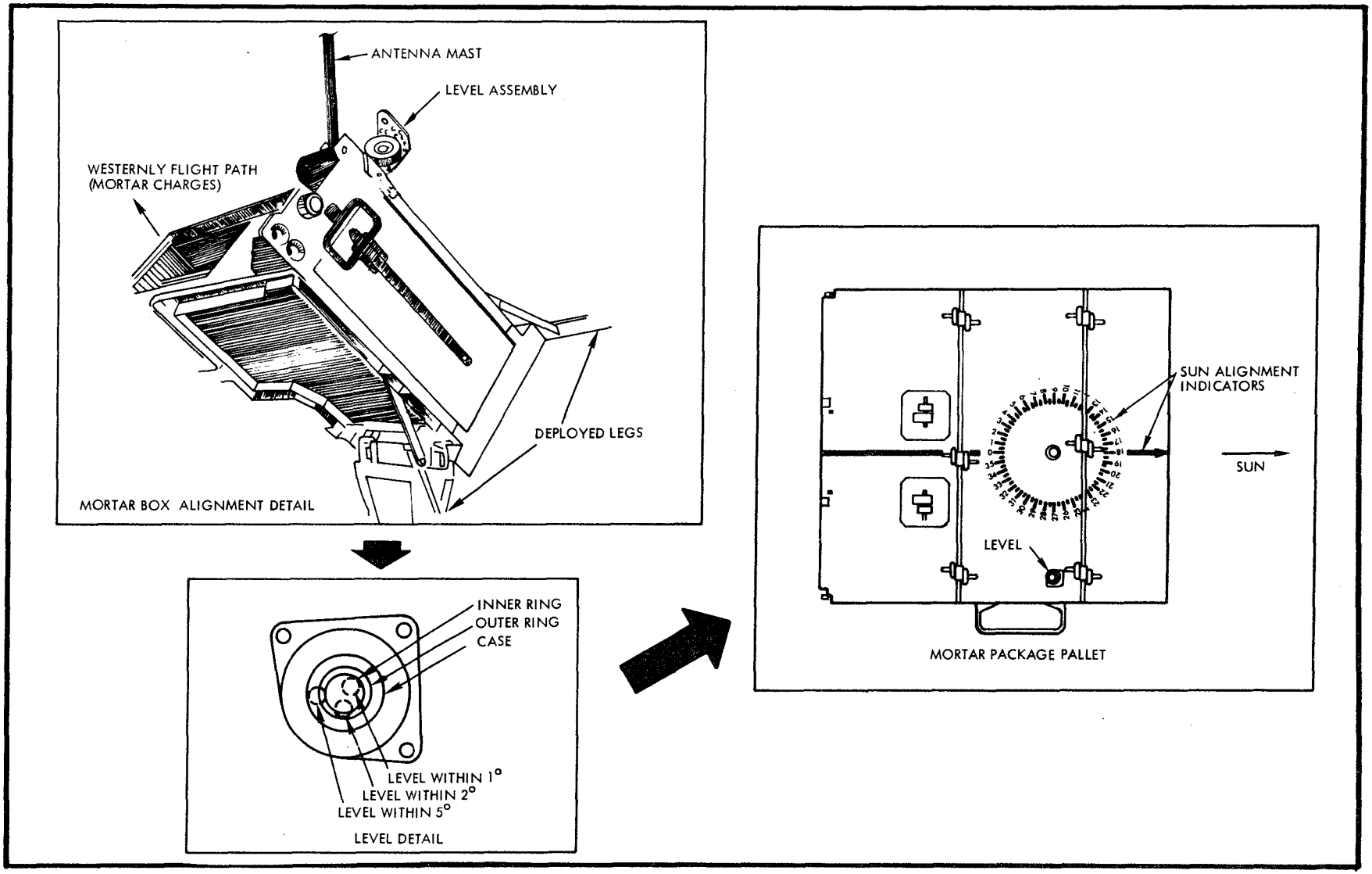


Figure 2-23(b). Active Seismic Experiment - Alignment/Leveling Details

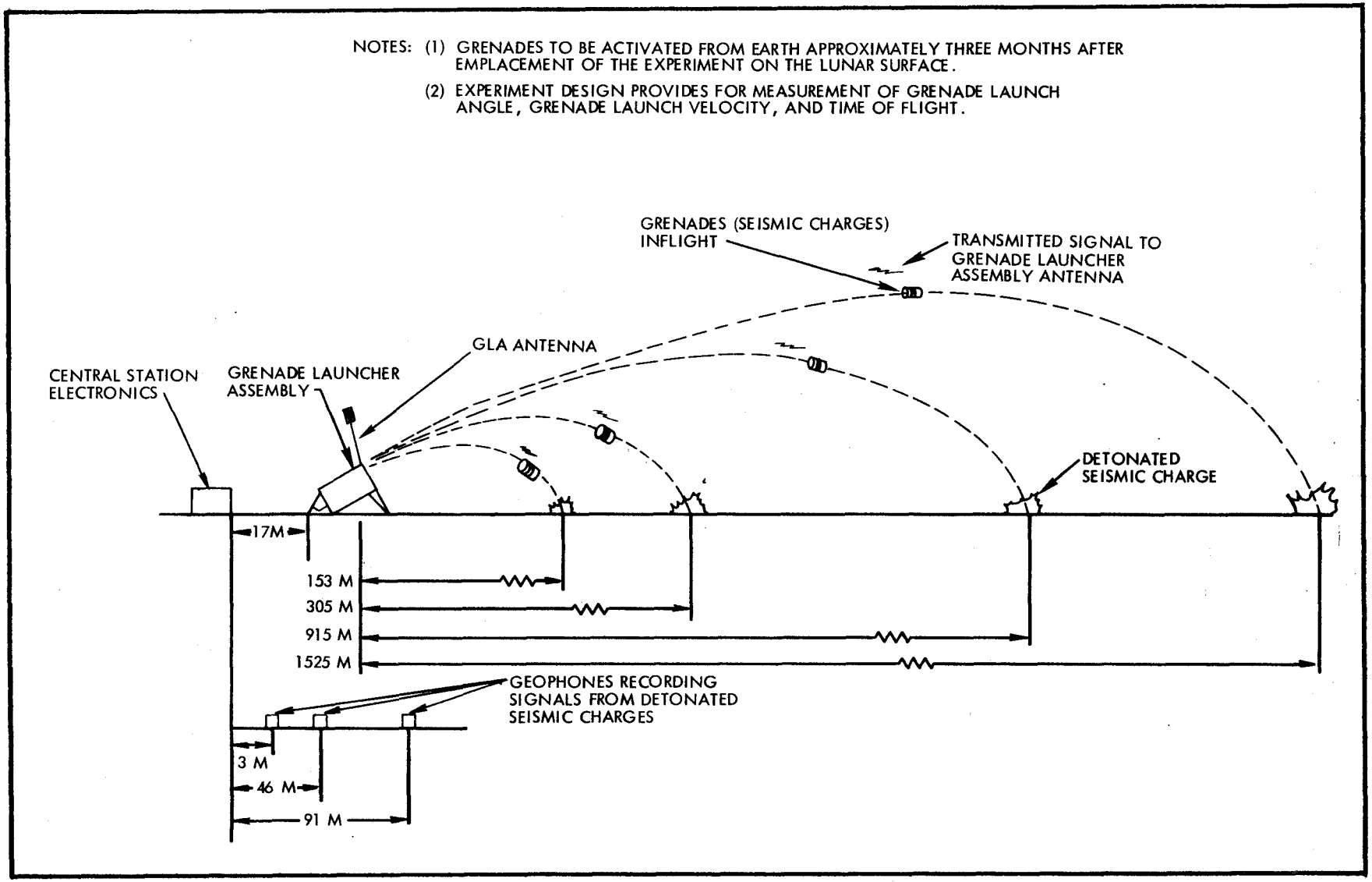


Figure 2-23(c). Active Seismic Experiment - Mortar Mode Concept

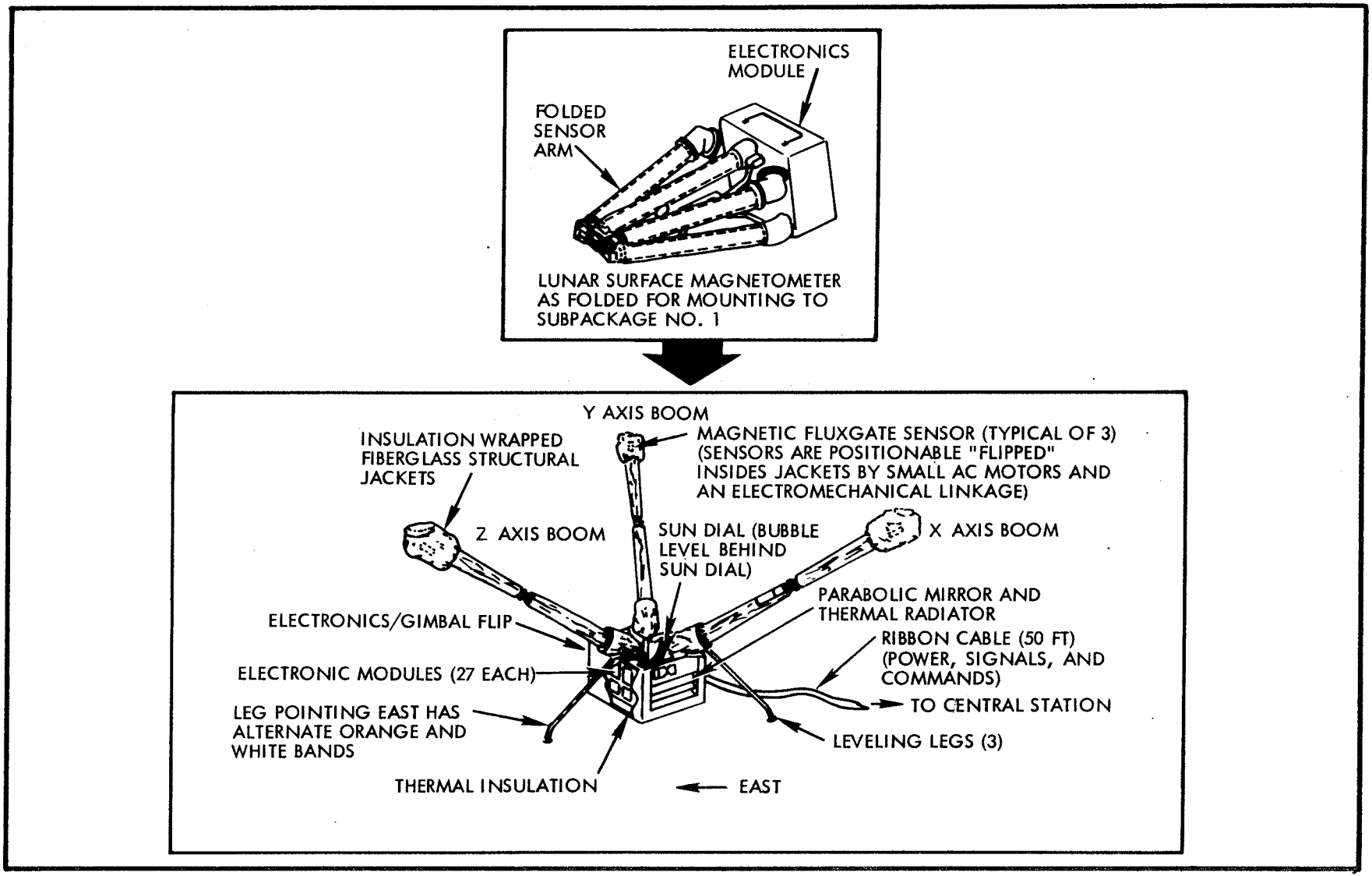


Figure 2-24(a). Lunar Surface Magnetometer Experiment - Component Identification

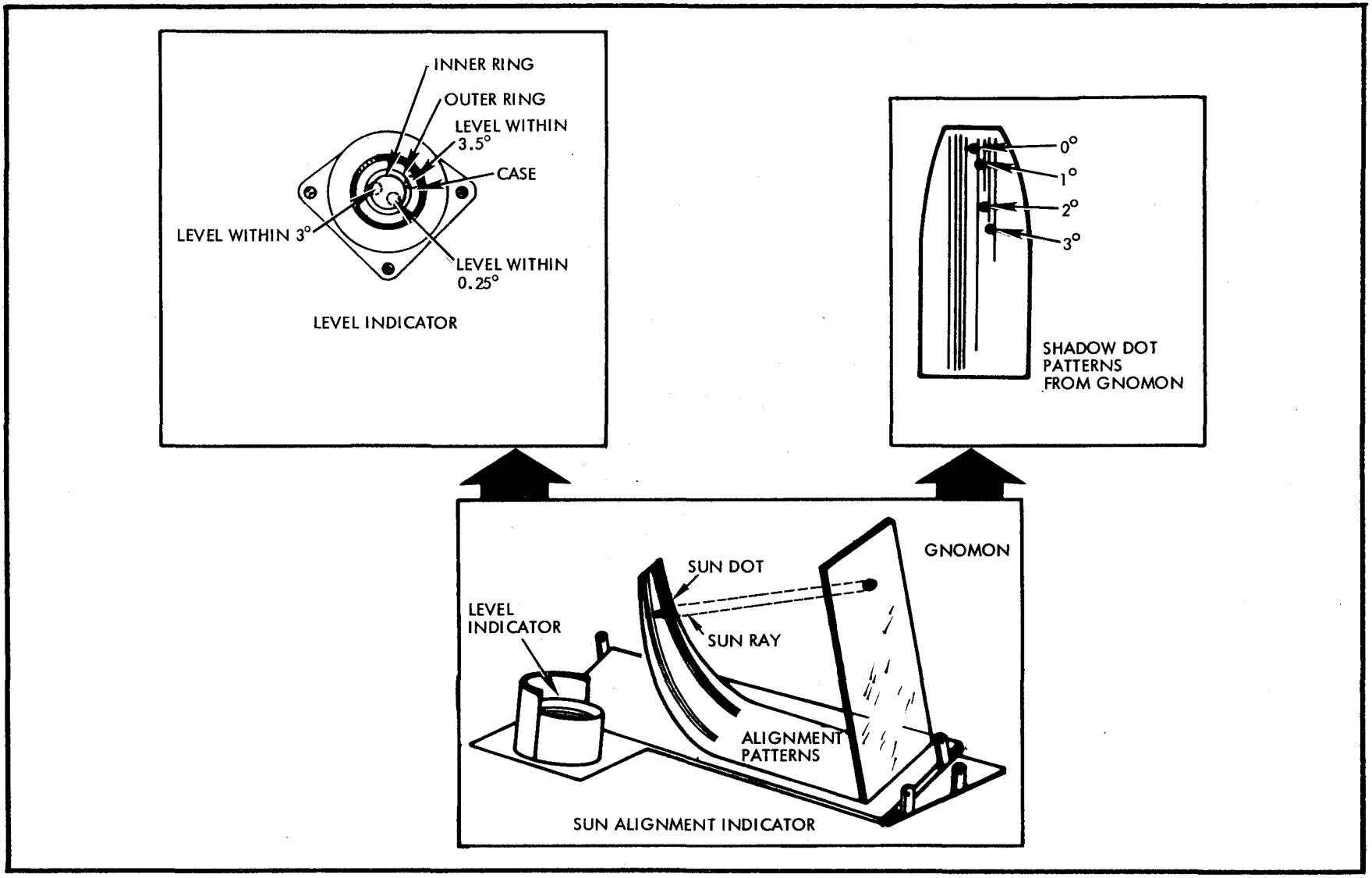


Figure 2-24(b). Lunar Surface Magnetometer Experiment - Alignment/Leveling Details

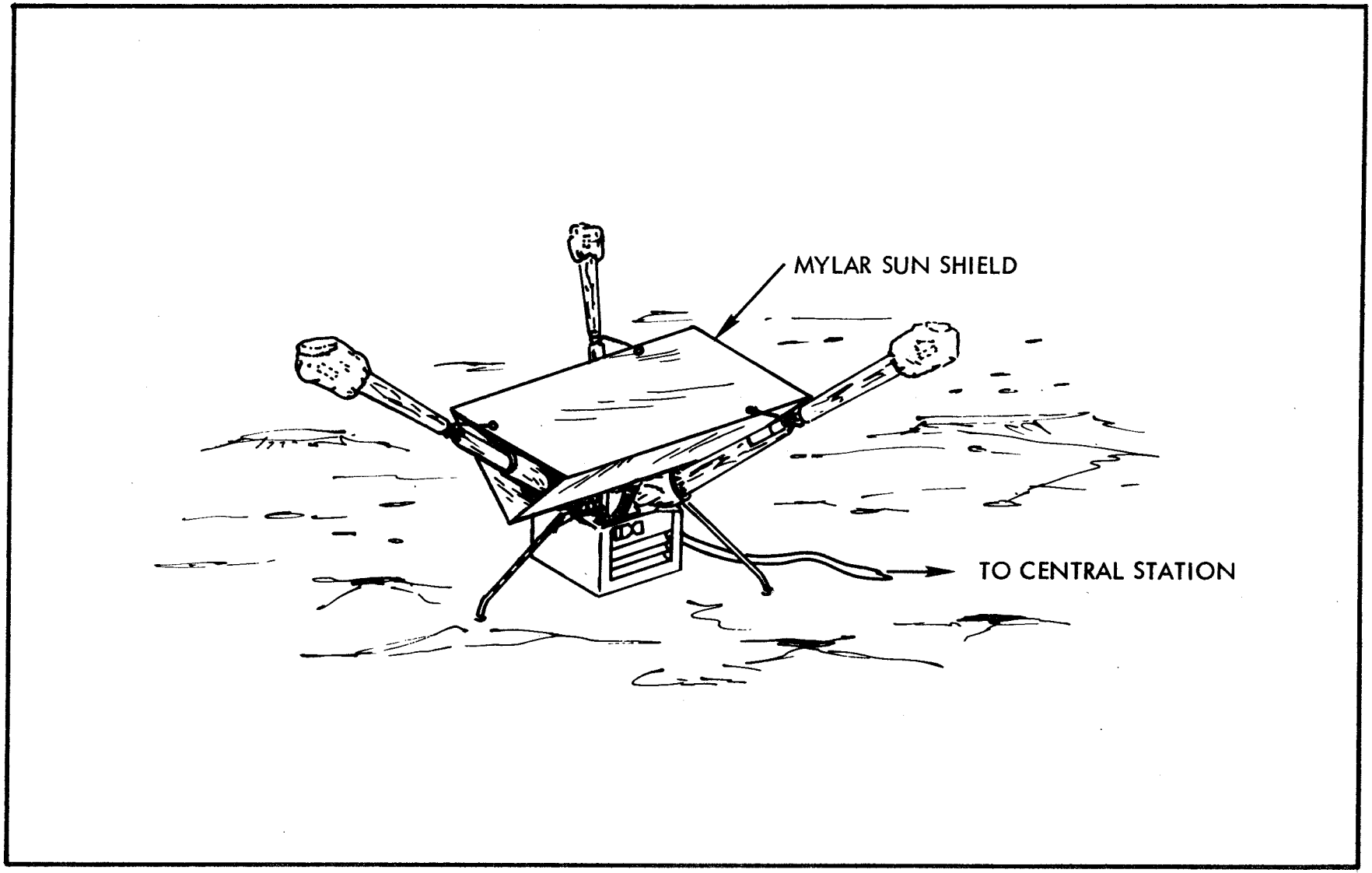


Figure 2-24(c). Lunar Surface Magnetometer Experiment - Deployed Experiment with Sun Shield

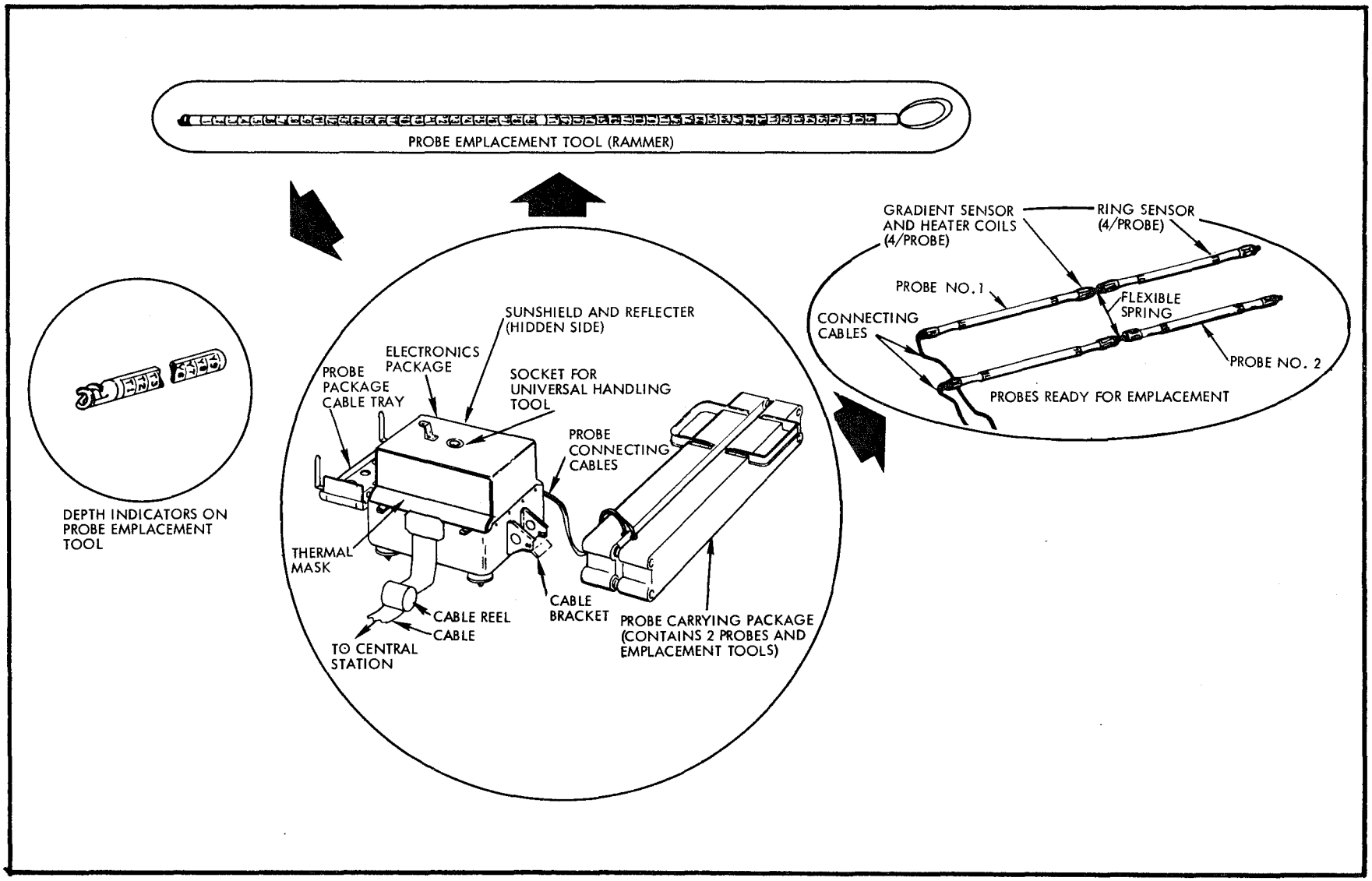


Figure 2-25(a). Heat Flow Experiment - Component Identification

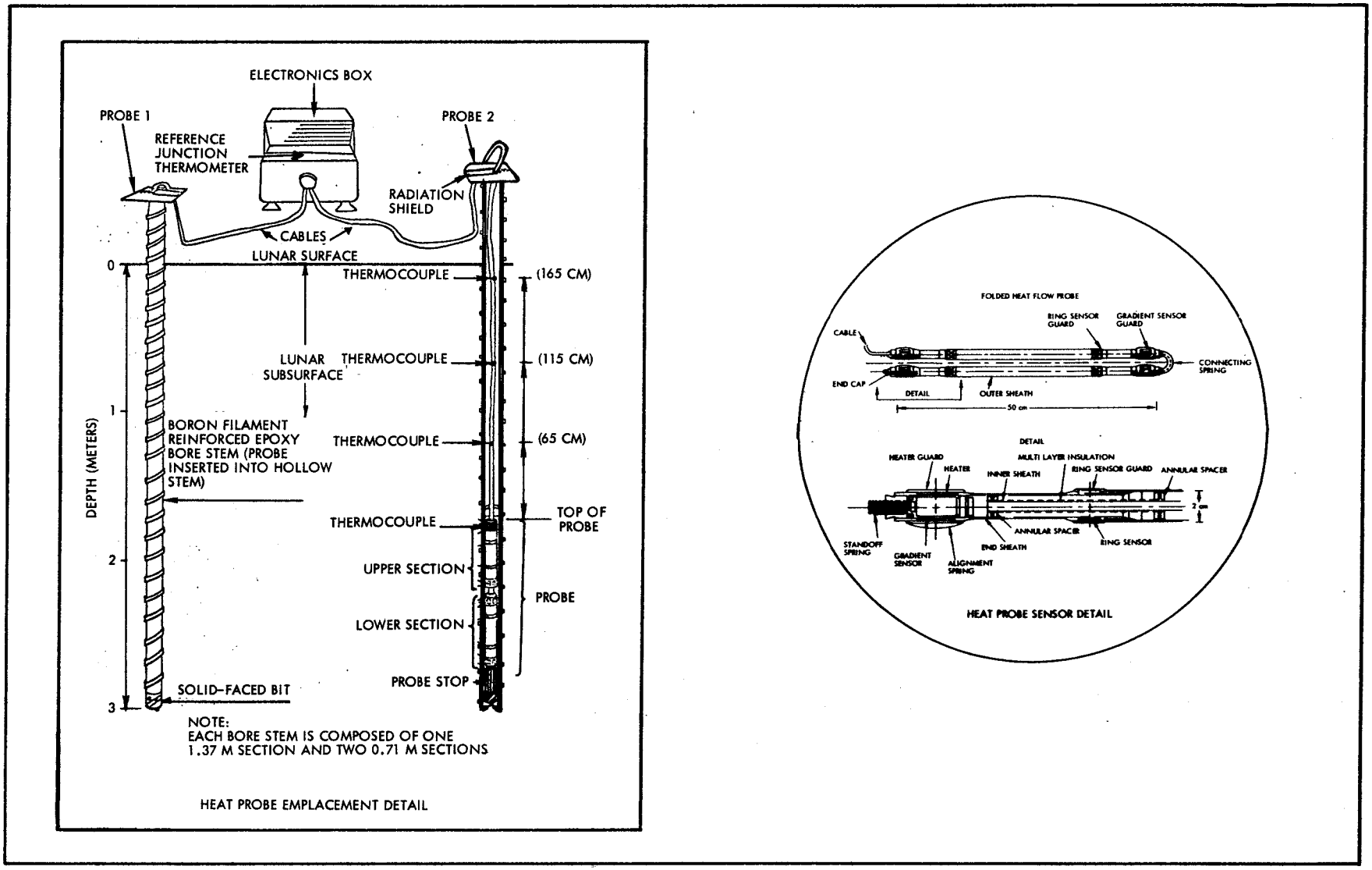


Figure 2-25(b). Heat Flow Experiment - Heat Probe Emplacement/Sensor Details

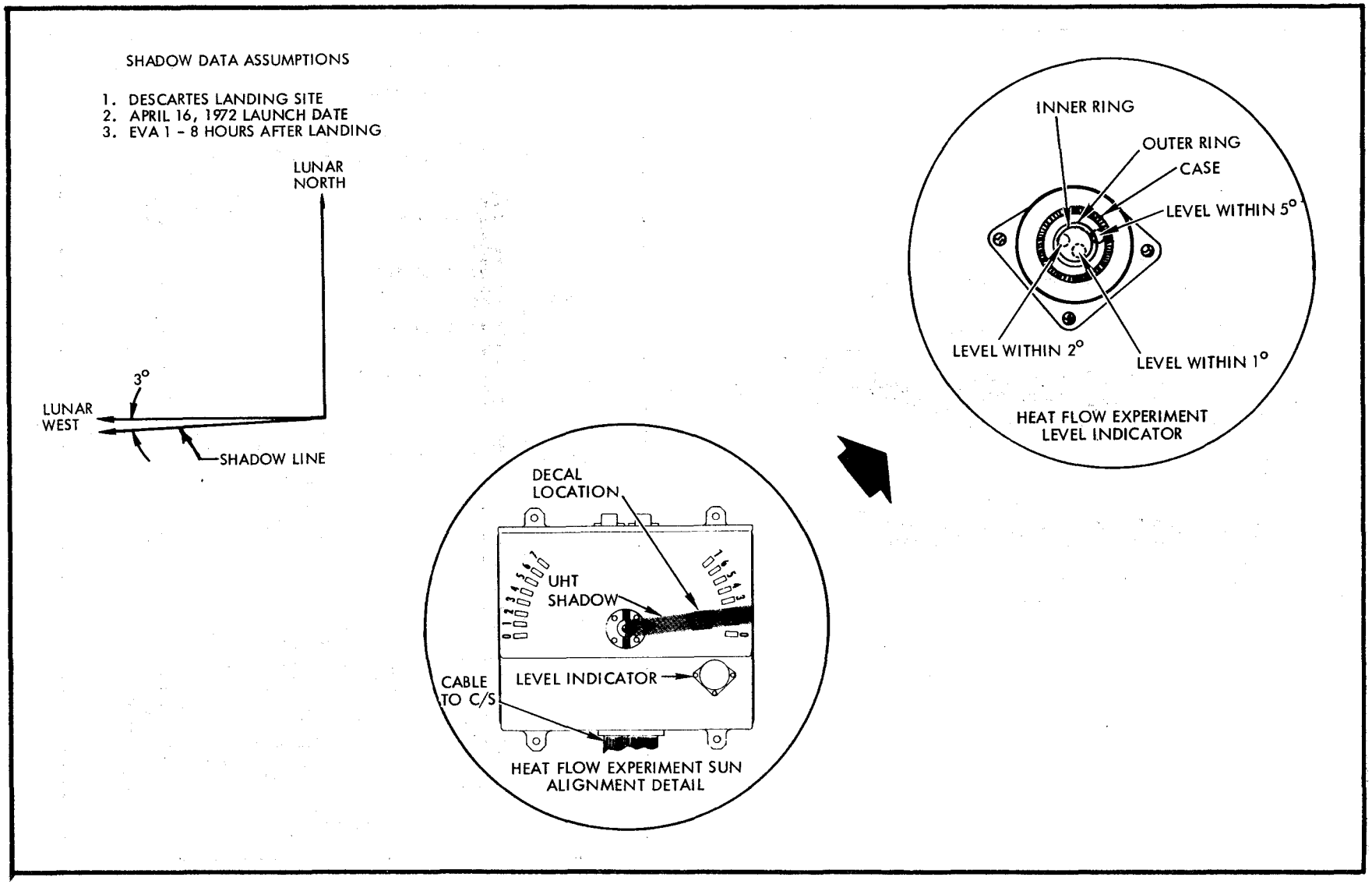


Figure 2-25(c). Heat Flow Experiment - Alignment/Leveling Details

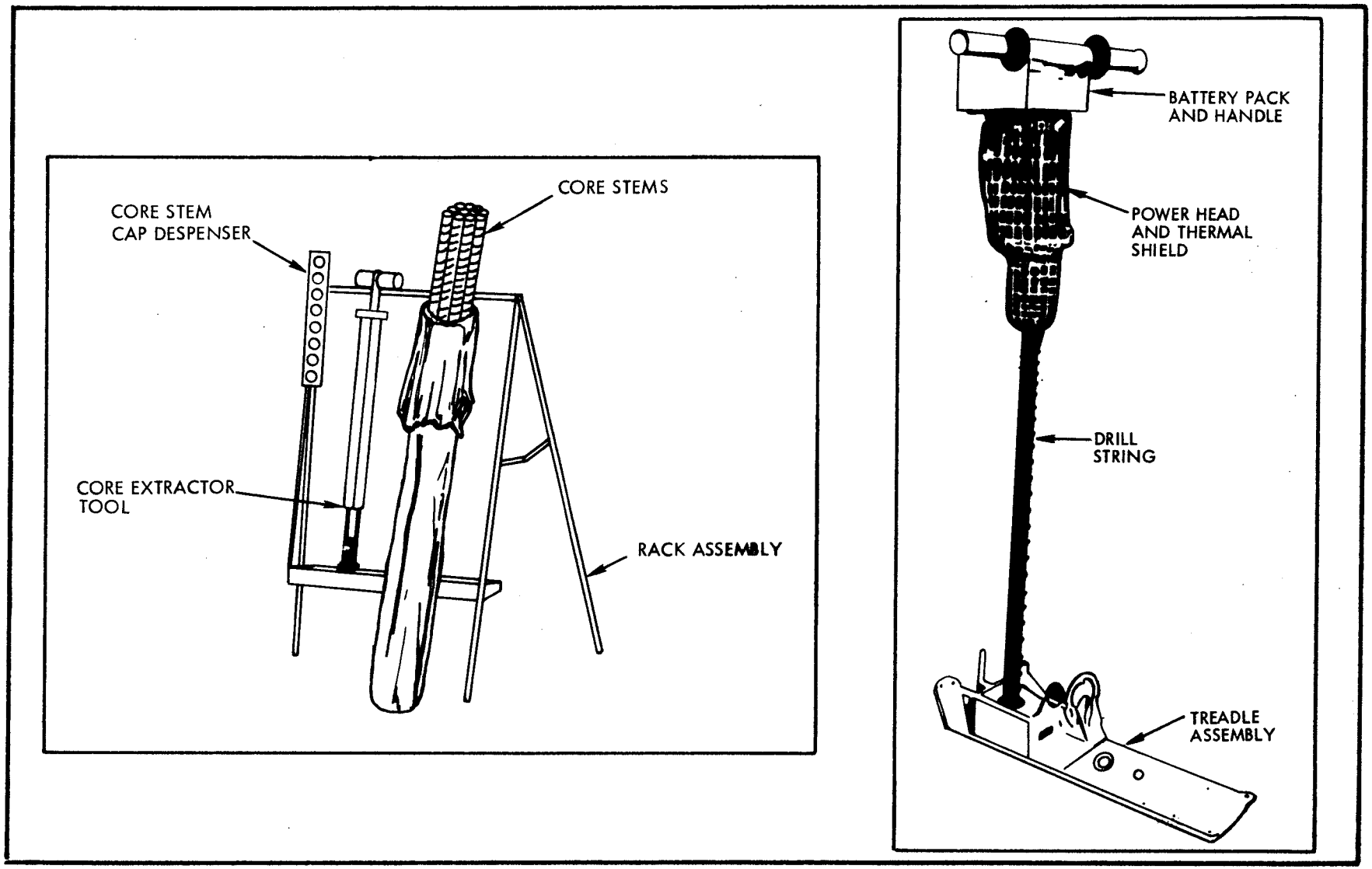


Figure 2-26(a). Apollo Lunar Surface Drill Assembly - Component Identification

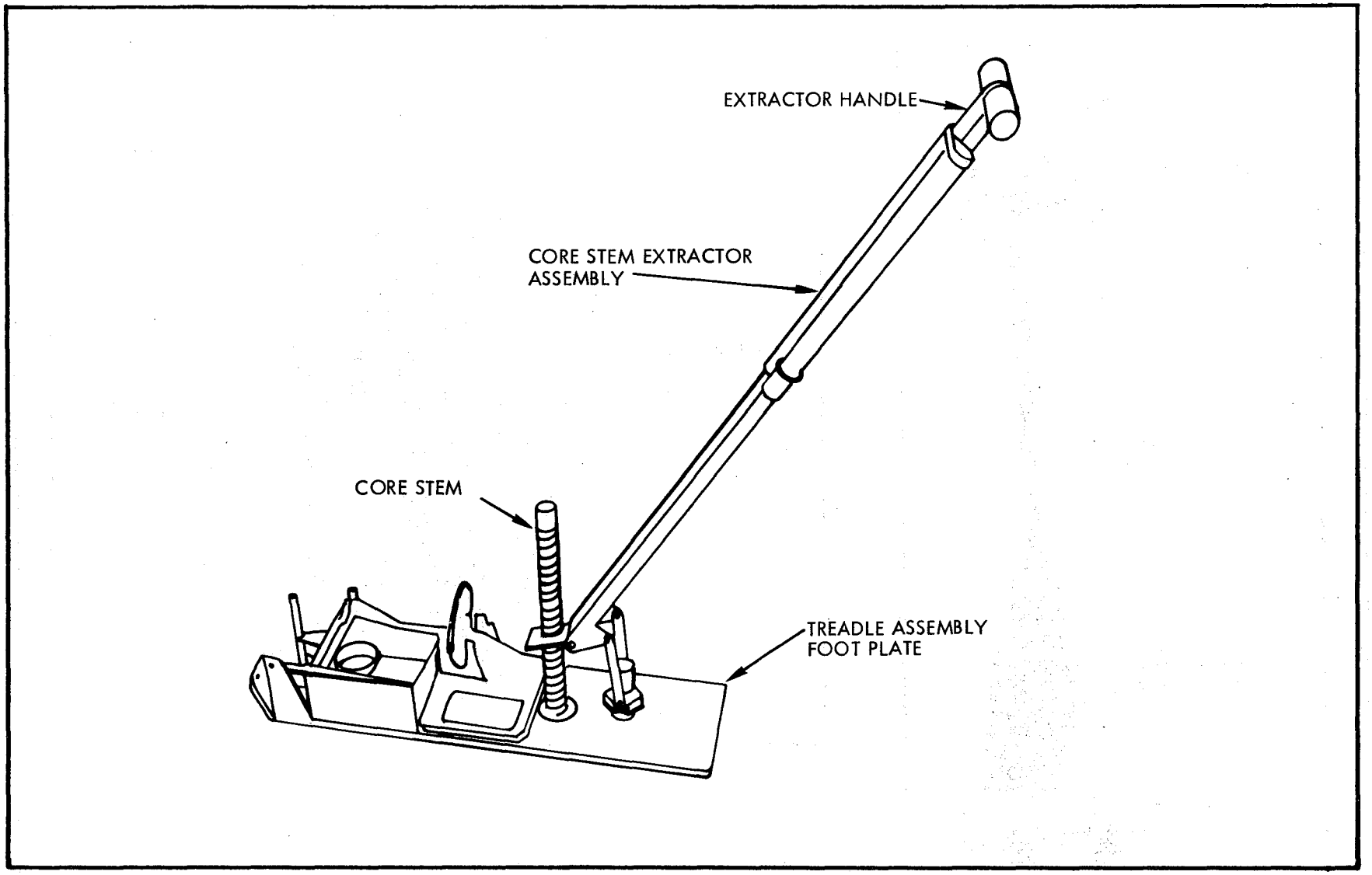


Figure 2-26(b). Apollo Lunar Surface Drill Assembly - Treadle/Core Stem Extractor Detail

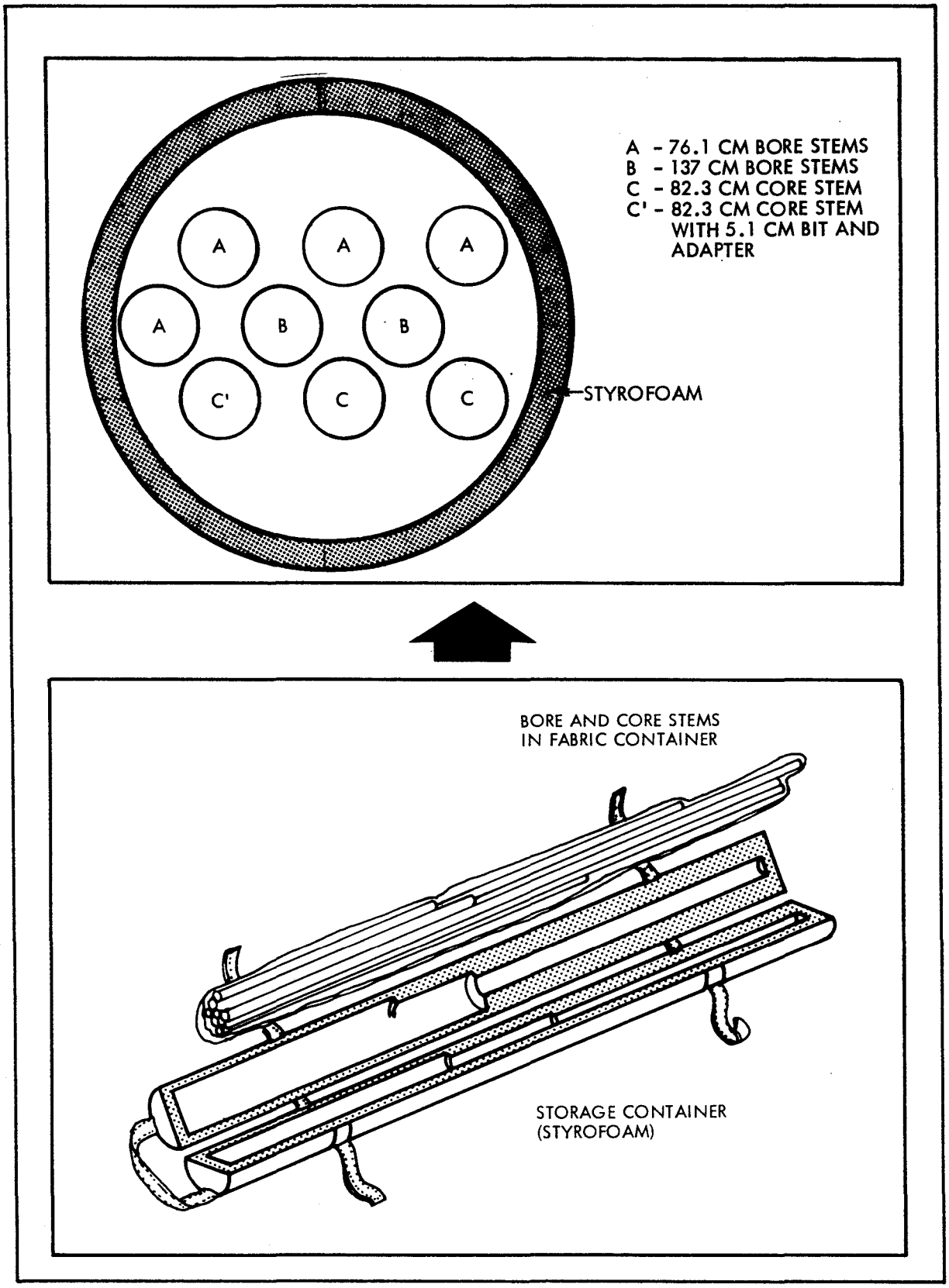


Figure 2-26(c). Apollo Lunar Surface Drill Assembly - Bore Stem/Core Stem MESA Stowage Detail

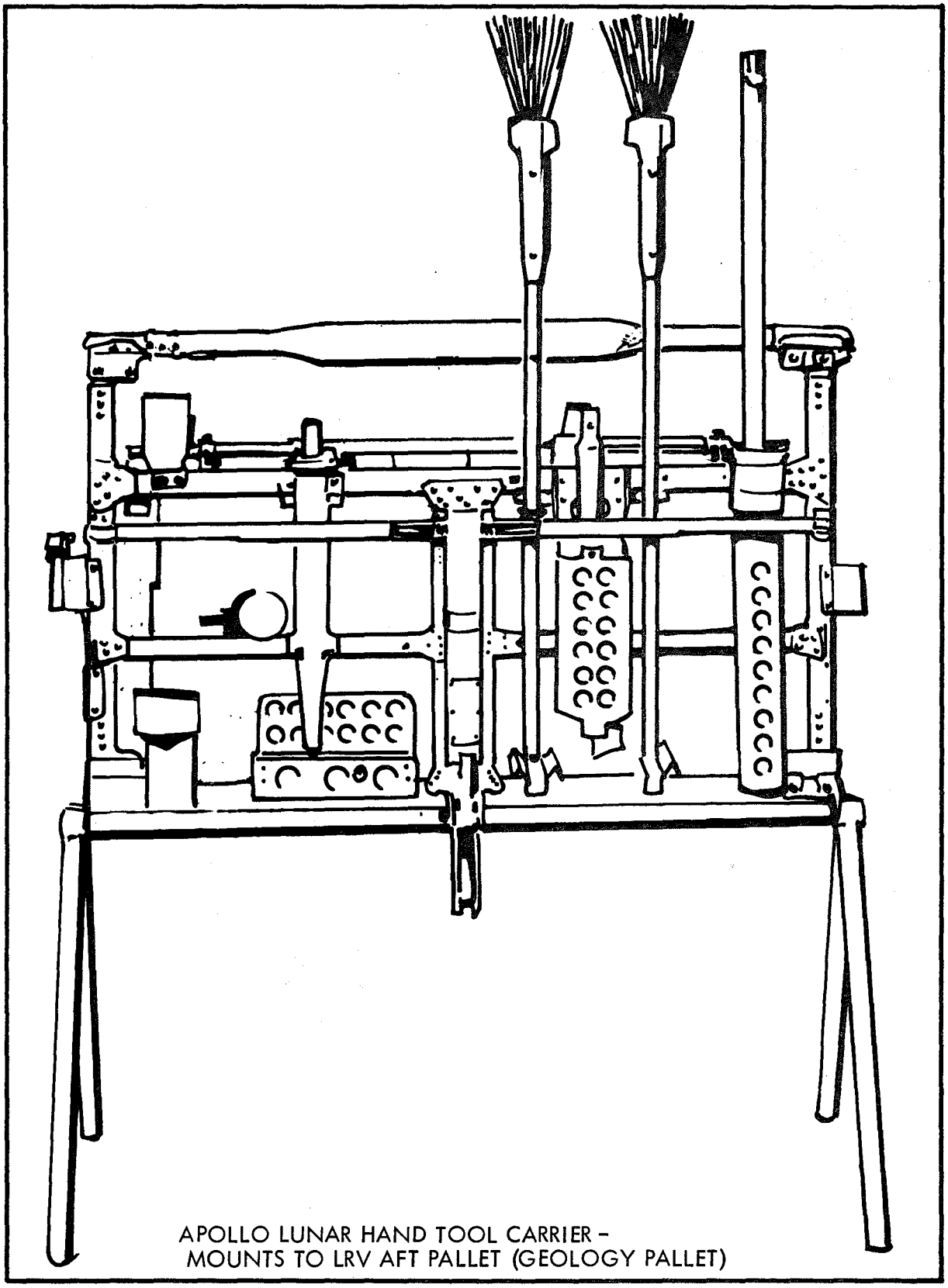


Figure 2-27(a). Lunar Geology Equipment - Apollo Lunar Hand Tool Carrier

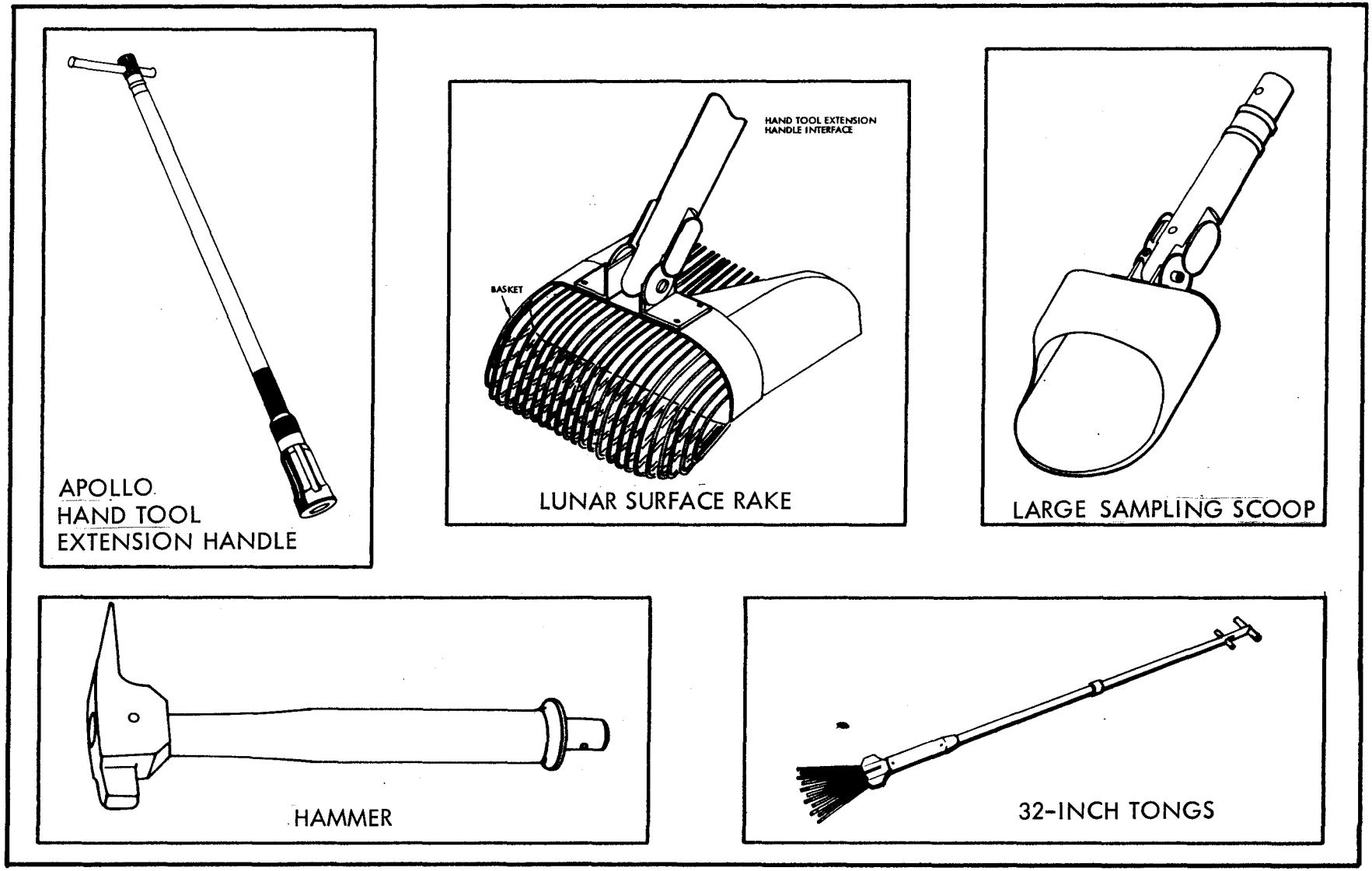
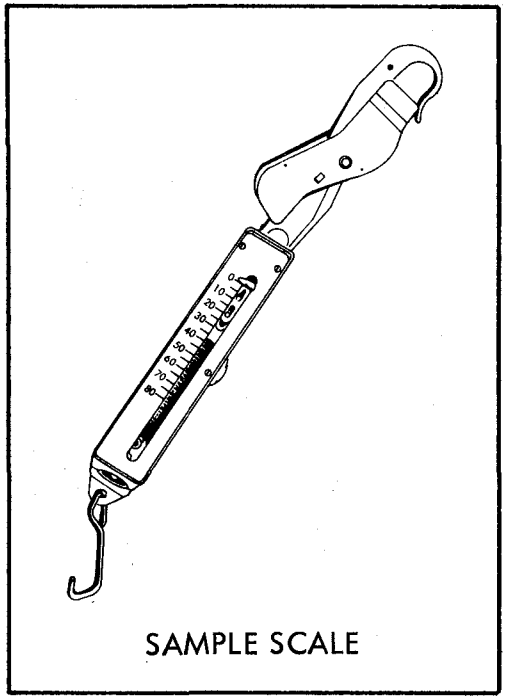
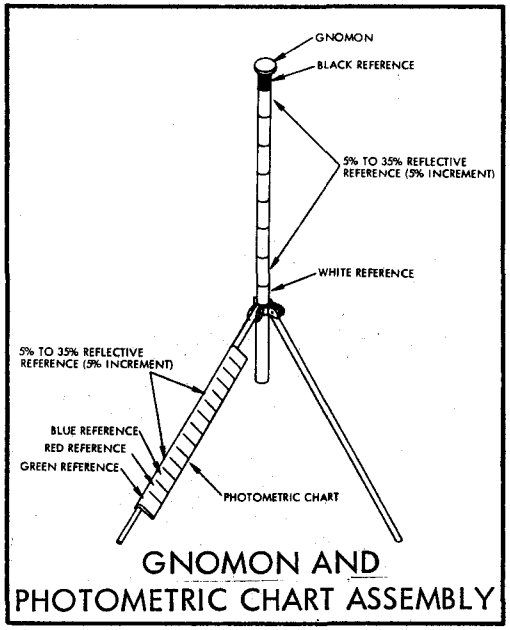


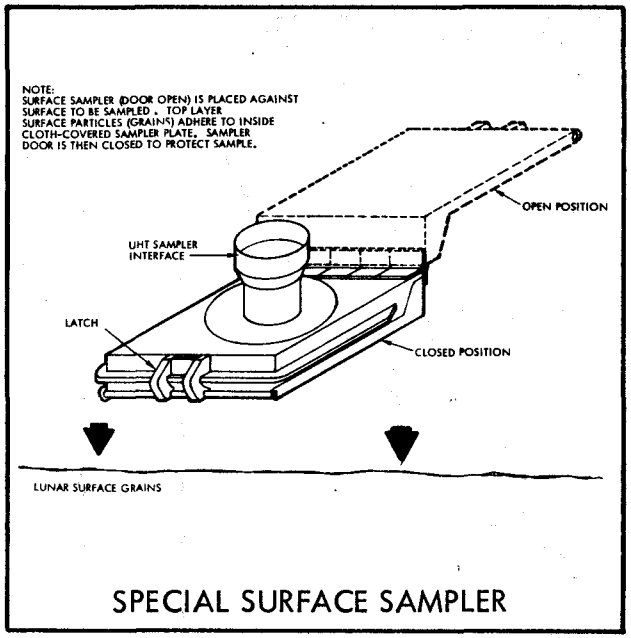
Figure 2-27(b). Lunar Geology Equipment - Apollo Lunar Hand Tools



SAMPLE SCALE



GNOMON AND PHOTOMETRIC CHART ASSEMBLY



SPECIAL SURFACE SAMPLER

Figure 2-27(c). Lunar Geology Equipment - Sample Scale/Gnomon and Photometric Chart/Surface Sampler

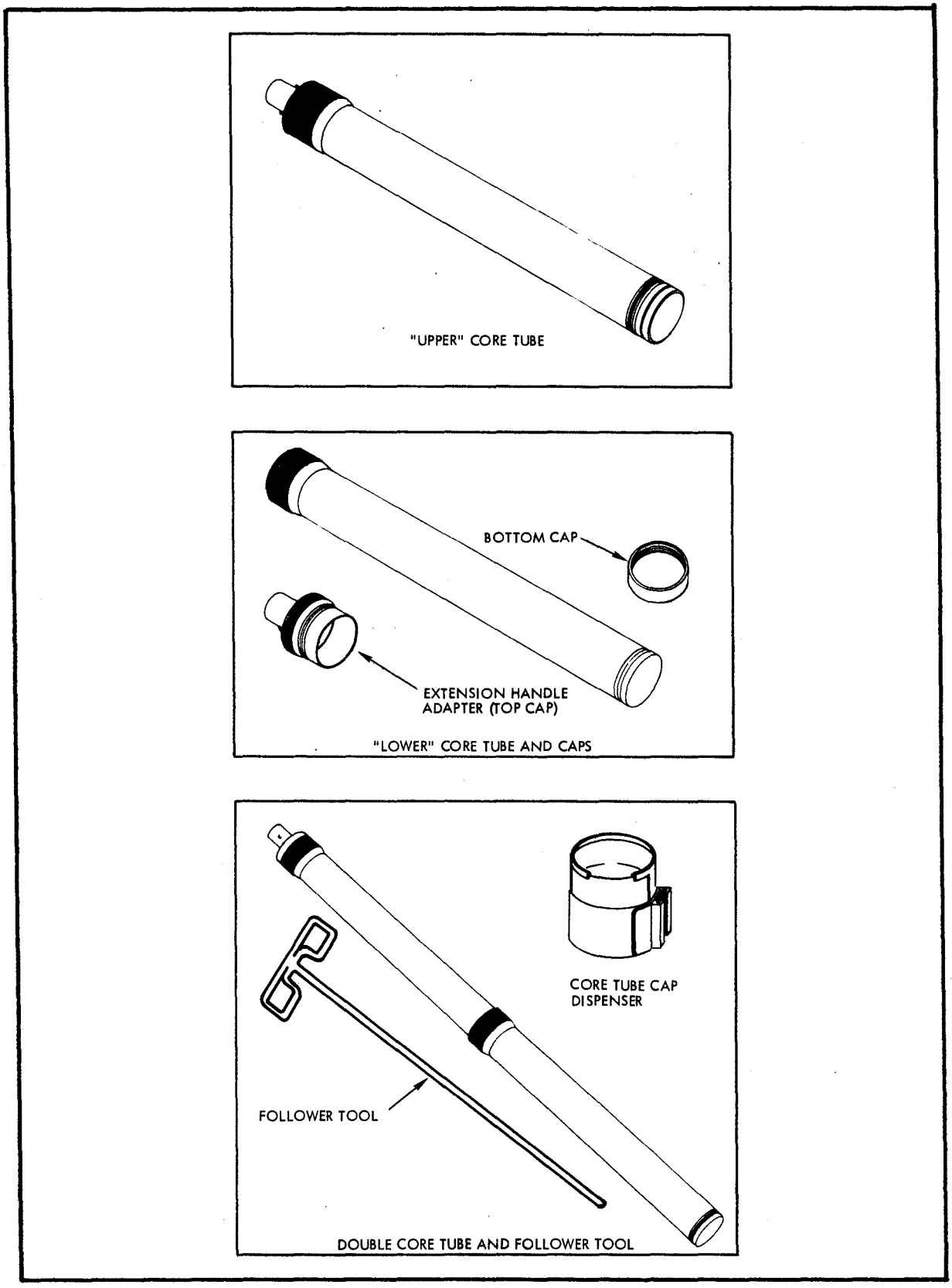


Figure 2-27(d). Lunar Geology Equipment - Core (Drive) Tubes

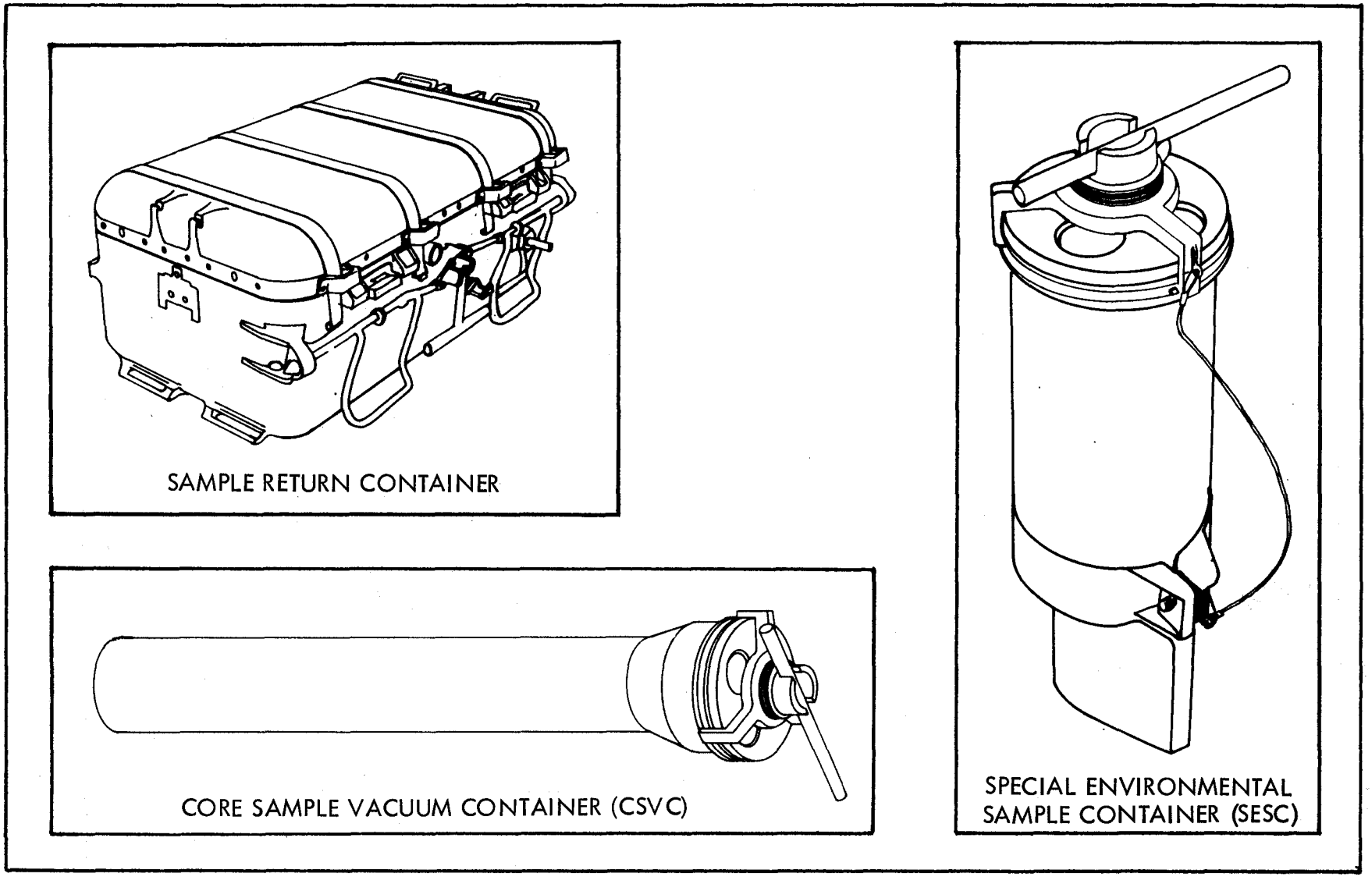


Figure 2-27(e). Lunar Geology Equipment - Sample Containers

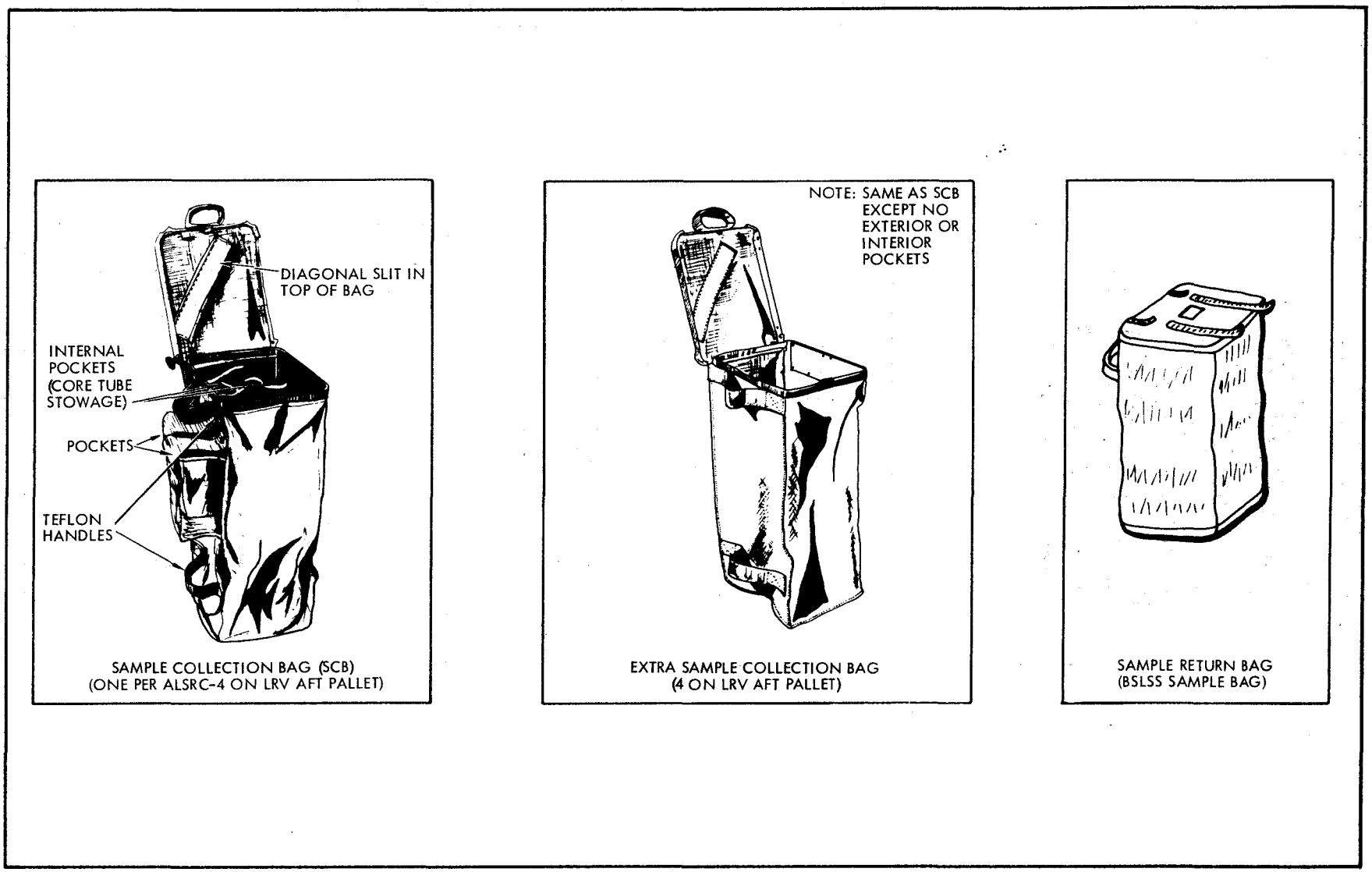
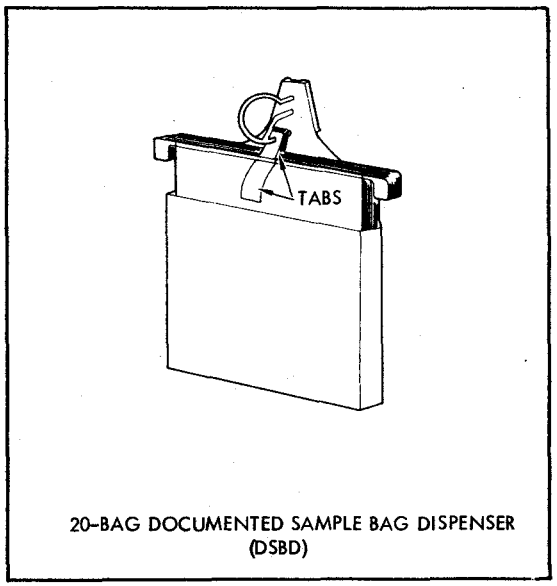
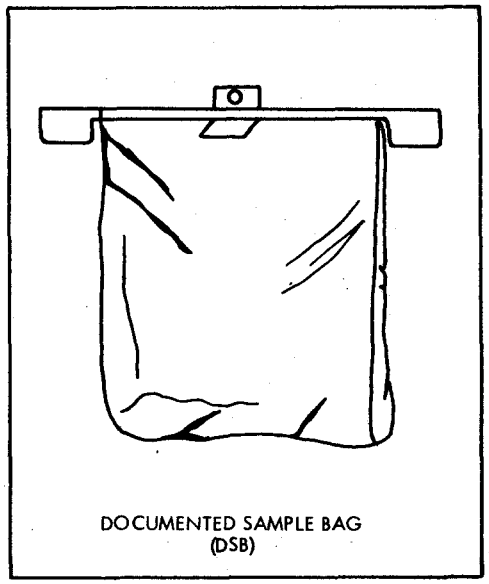


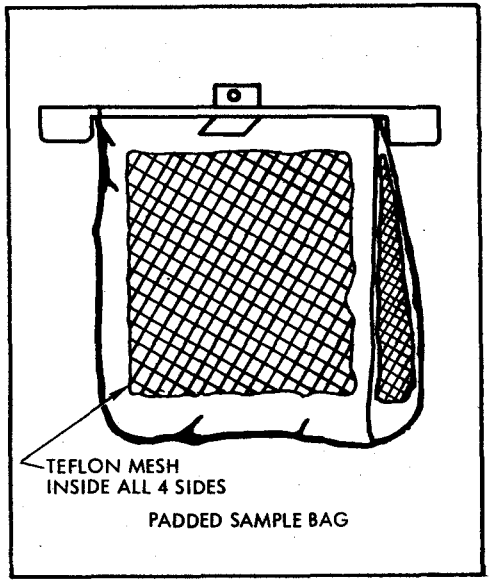
Figure 2-27(f). Lunar Geology Equipment - Large Sample Bags



20-BAG DOCUMENTED SAMPLE BAG DISPENSER
(DSBD)



DOCUMENTED SAMPLE BAG
(DSB)



PADDED SAMPLE BAG

Figure 2-27(g). Lunar Geology Equipment - Small Sample Bags

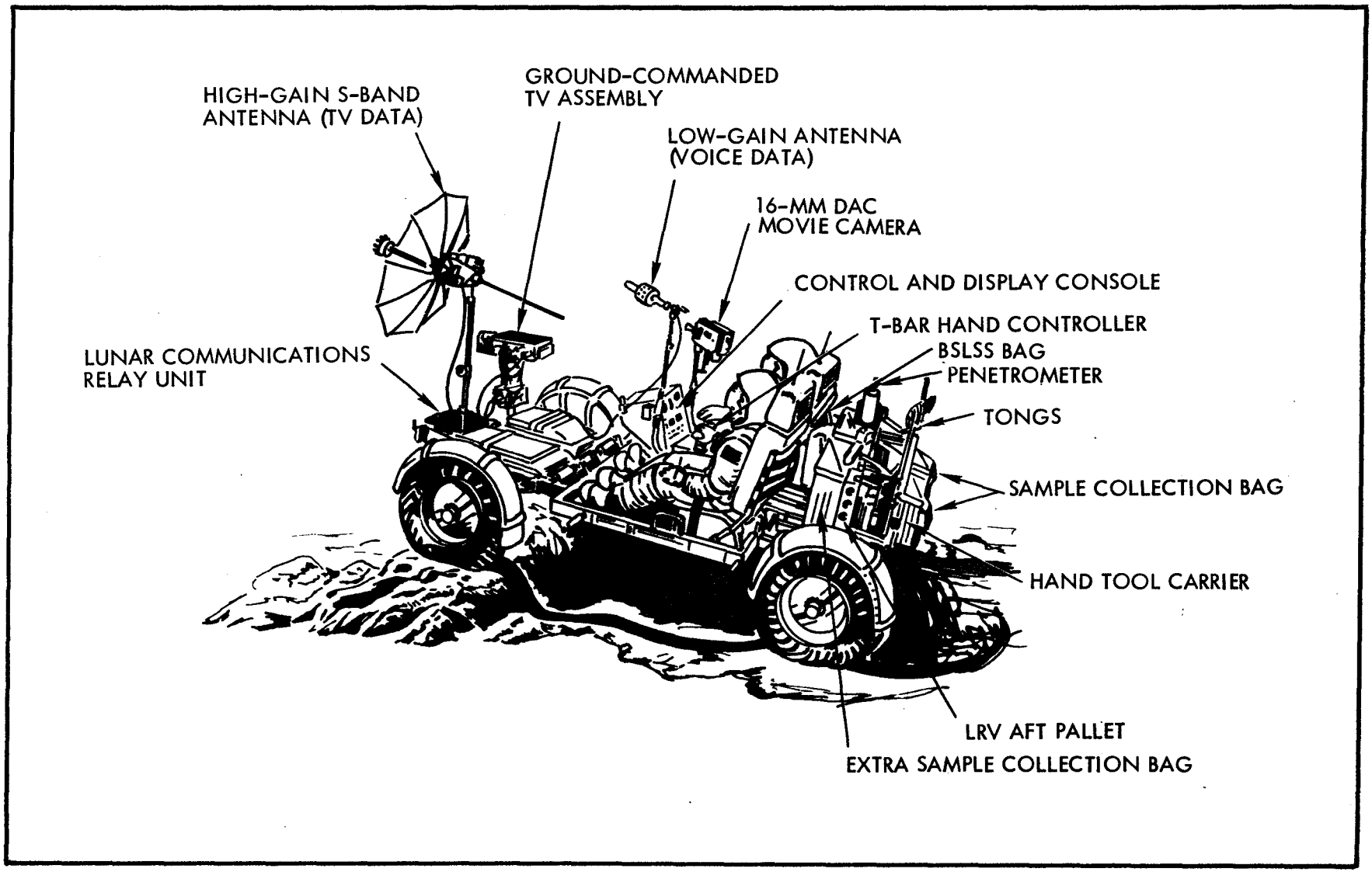
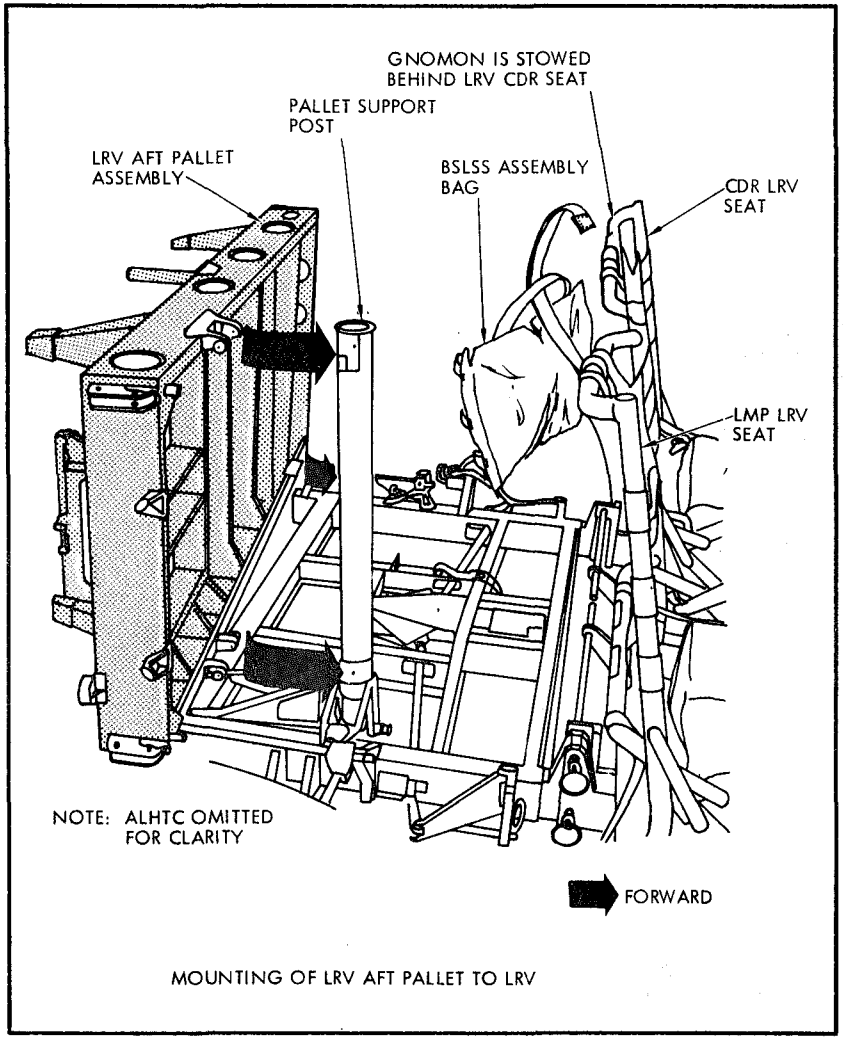
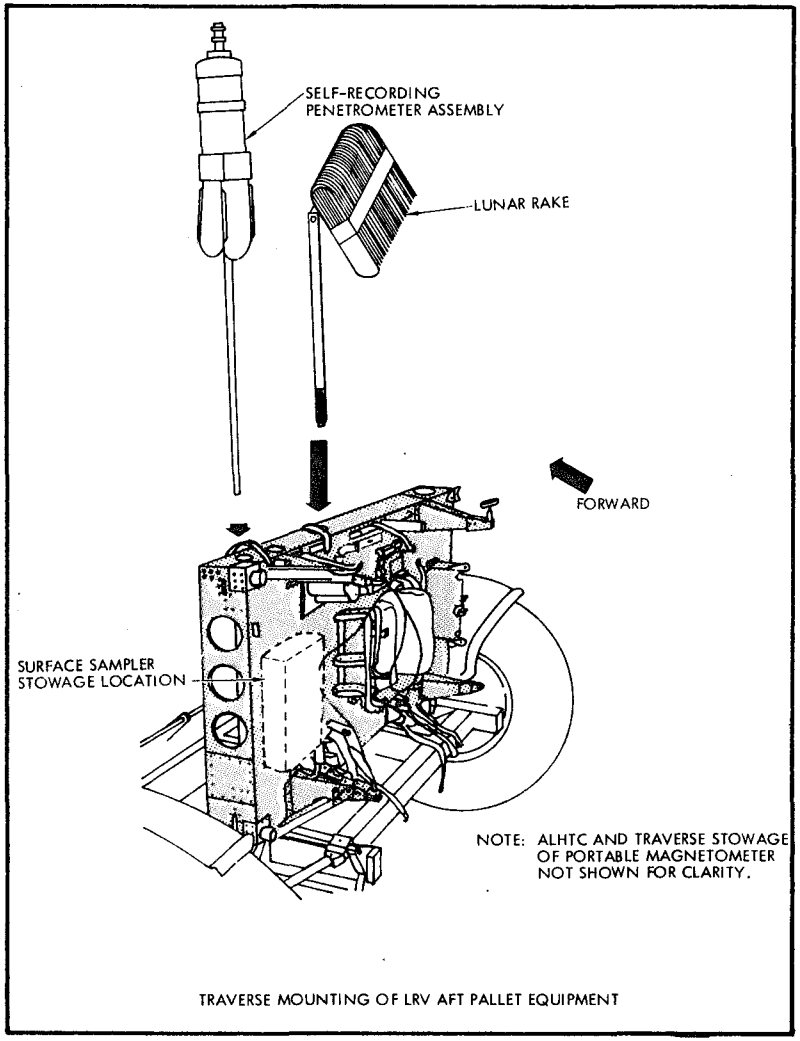


Figure 2-28. Lunar Roving Vehicle (LRV)



MOUNTING OF LRV AFT PALLET TO LRV



TRAVERSE MOUNTING OF LRV AFT PALLET EQUIPMENT

Figure 2-29(a). Lunar Geology Equipment/LRV Interface - LRV Aft (Geology) Pallet and Pallet Equipment Mounting

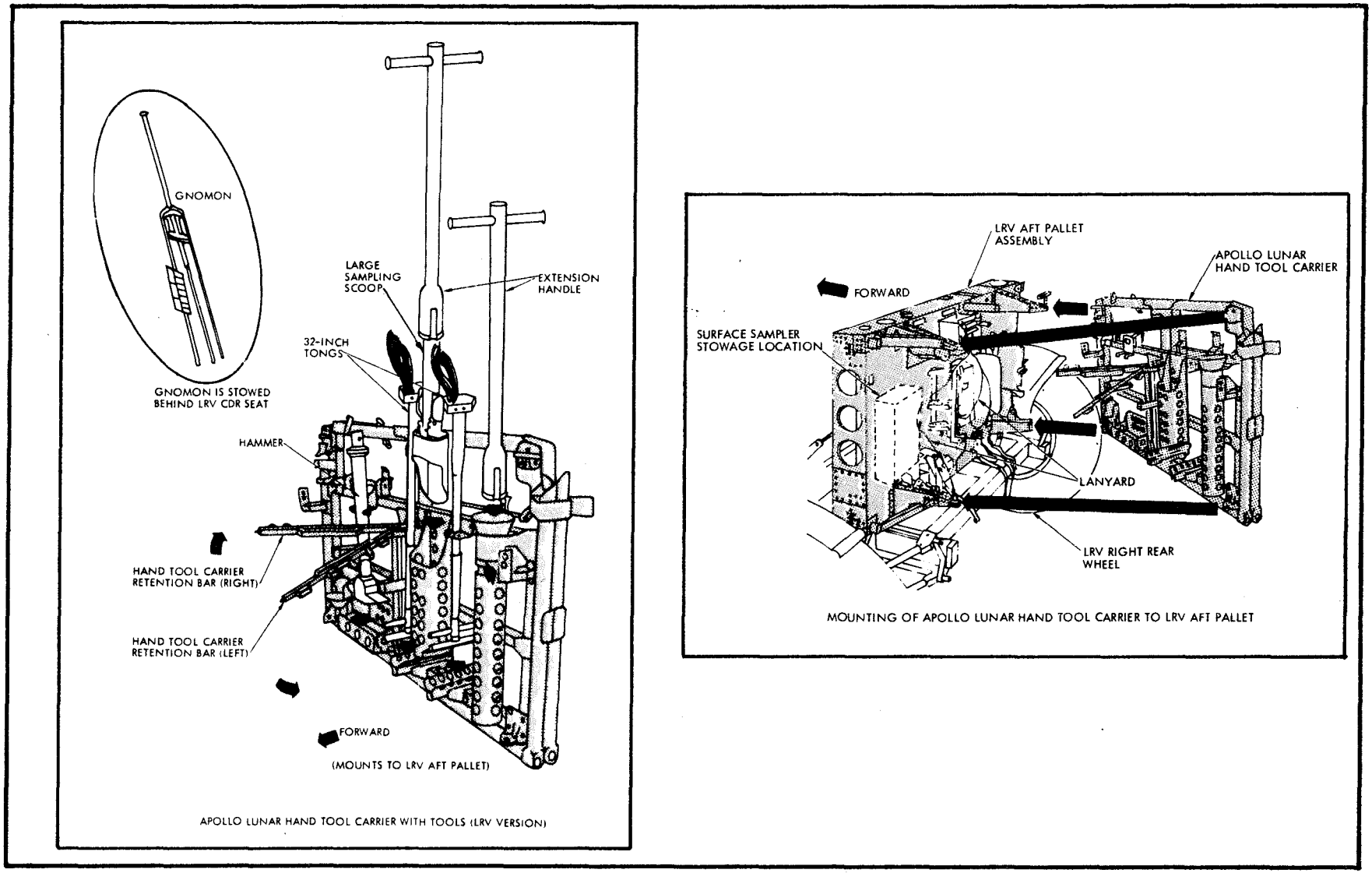
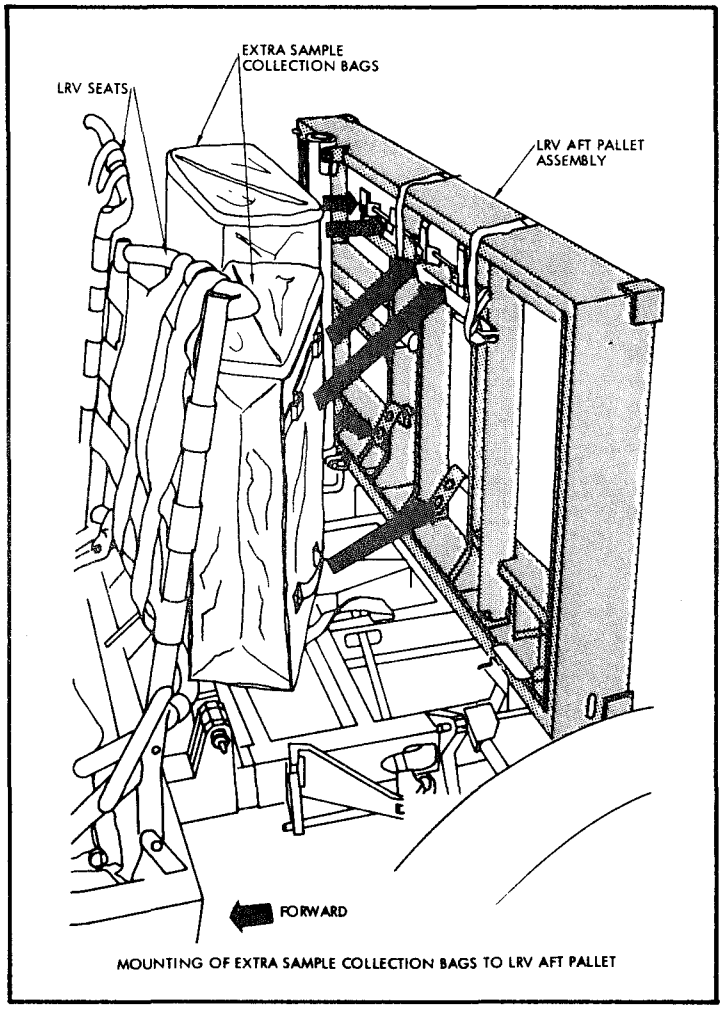


Figure 2-29(b). Lunar Geology Equipment/LRV Interface - Apollo Lunar Hand Tool Carrier and LRV Aft Pallet Mounting



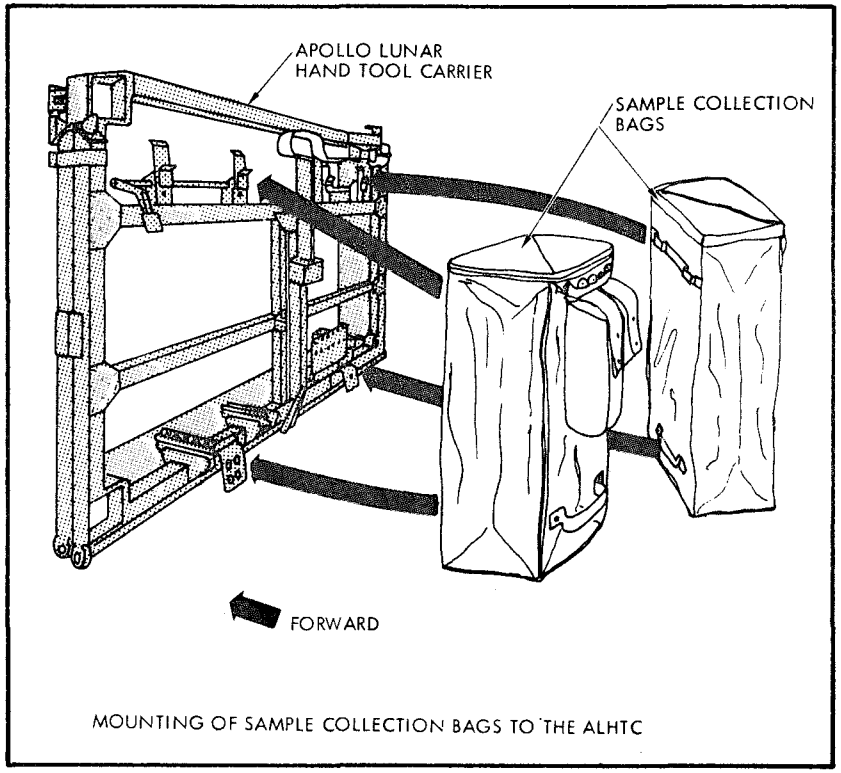
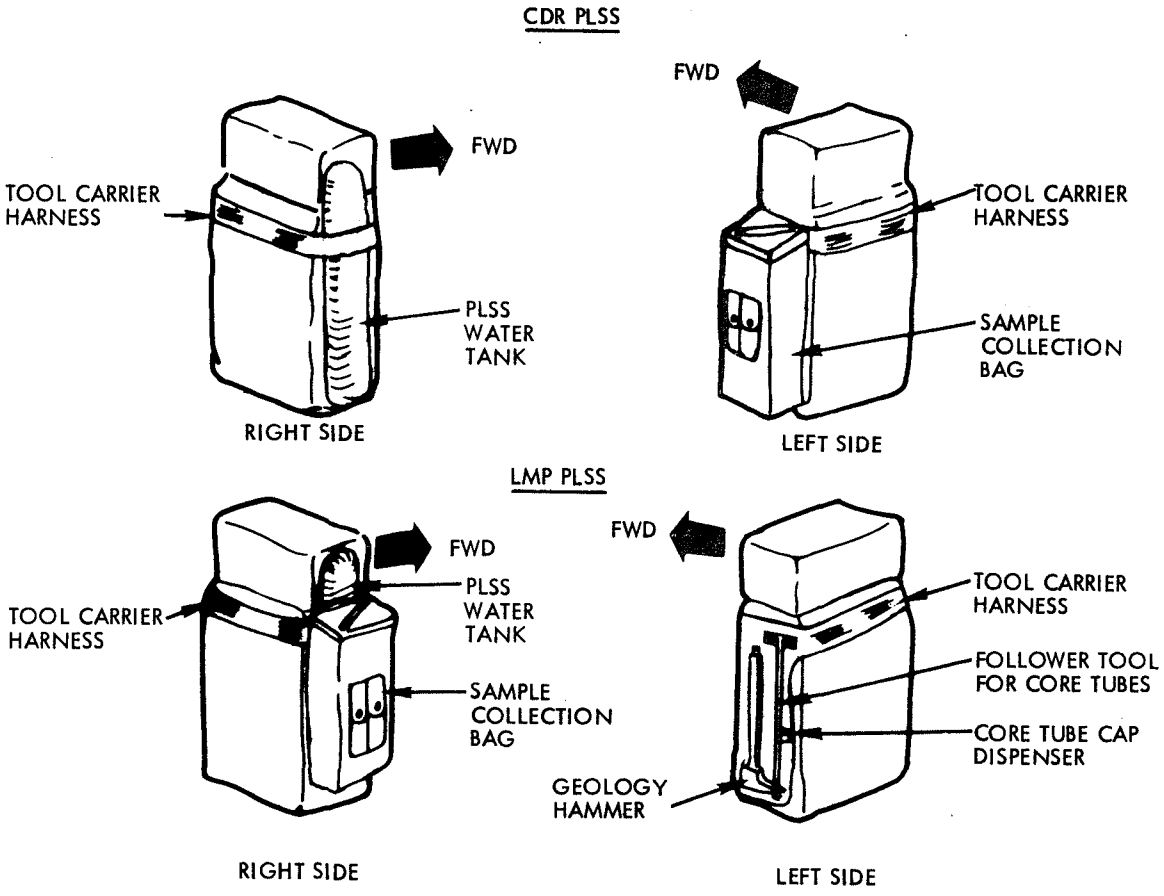


Figure 2-29(c). Lunar Geology Equipment/LRV Interface - Sample Collection Bag Mounting to LRV Aft Pallet and ALHTC

PLSS TOOL CARRIER FOR GEOLOGY ACTIVITIES



NOTES:
1. TOOL CARRIER DESIGNED FOR EMERGENCY SELF-DOFFING VIA QUICK-DISCONNECT LANYARDS ACCESSIBLE TO WEARER.
2. DOCUMENTED SAMPLE BAG DISPENSERS TO BE ATTACHED TO CREWMAN HASSELBLAD CAMERA.
3. CORE TUBES CARRIED IN SAMPLE COLLECTION BAG.
4. SAMPLE COLLECTION BAG MAY BE MOUNTED TO RIGHT SIDE OF THE CDR PLSS TOOL CARRIER IN A CONTINGENCY MODE.

Figure 2-30. PLSS Geology Tool Carrier

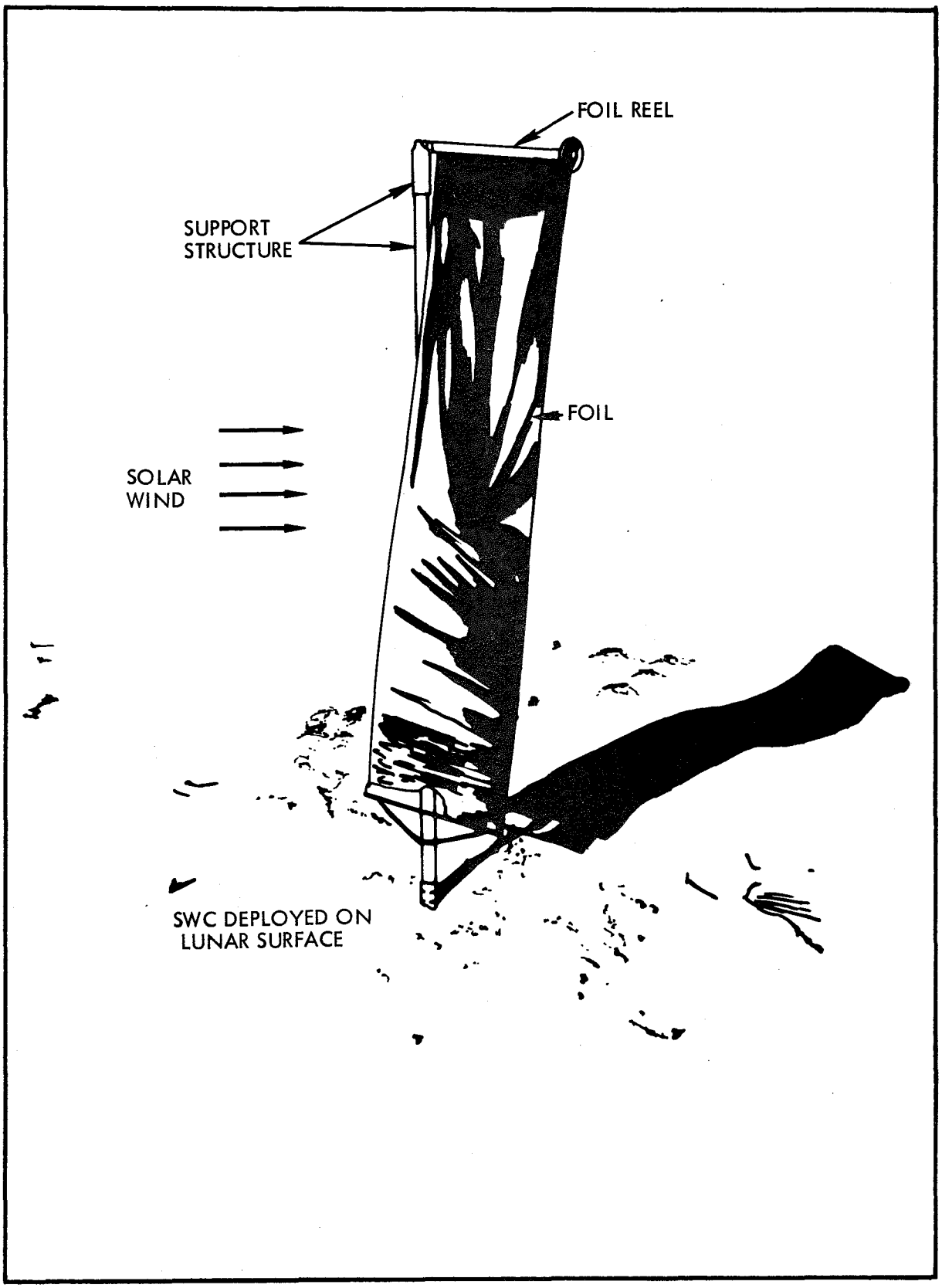
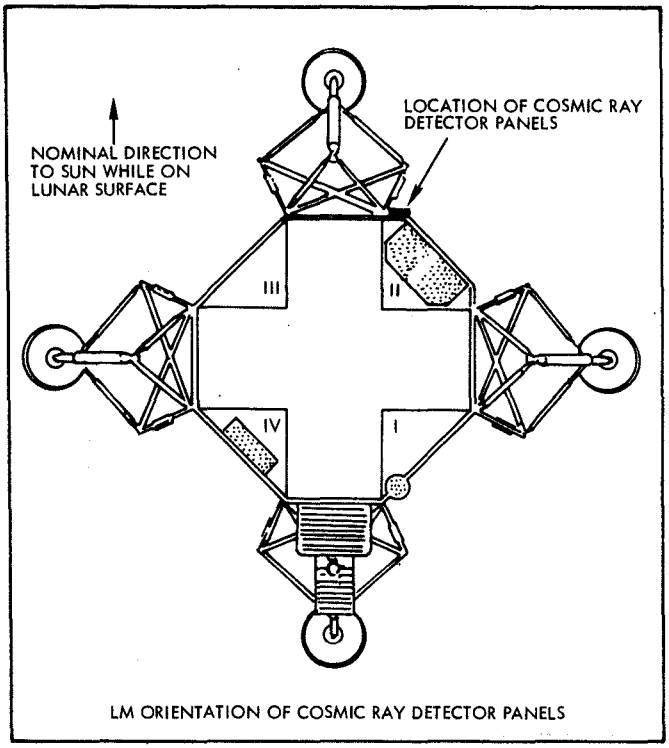
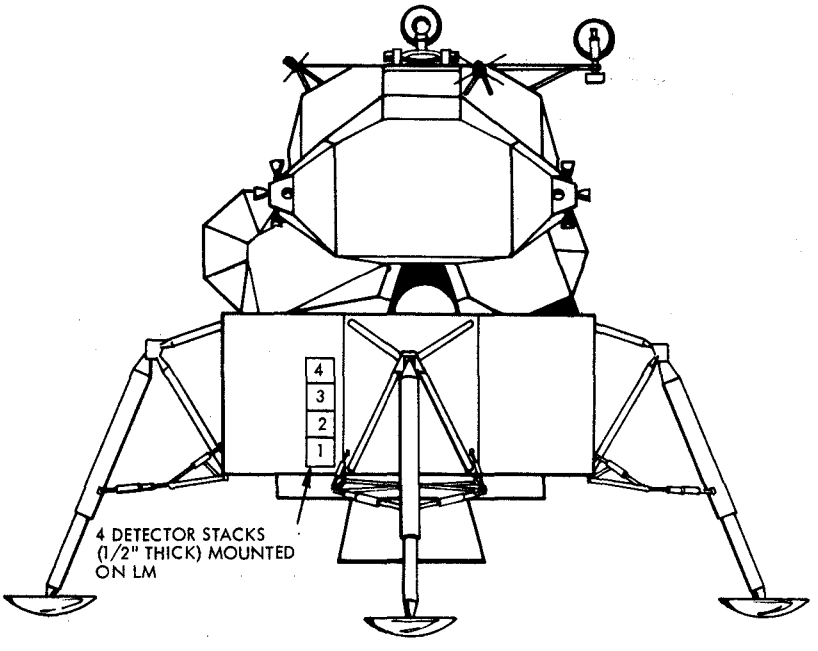


Figure 2-31. Solar Wind Composition Experiment

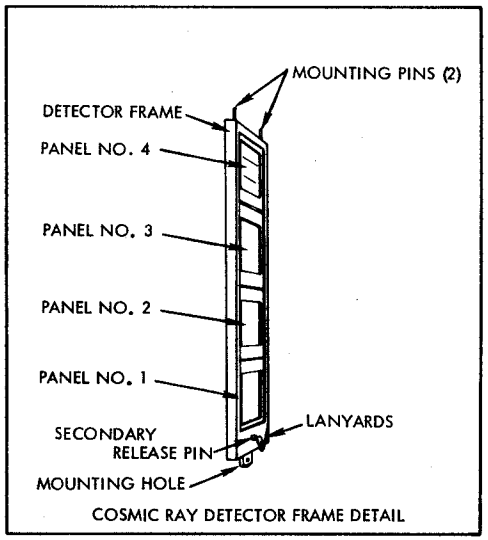


LM ORIENTATION OF COSMIC RAY DETECTOR PANELS

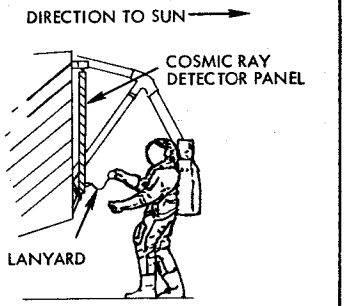


LM DESCENT STAGE MOUNTING OF COSMIC RAY DETECTOR PANELS

Figure 2-32(a). Cosmic Ray Detector Experiment - LM Descent Stage Mounting

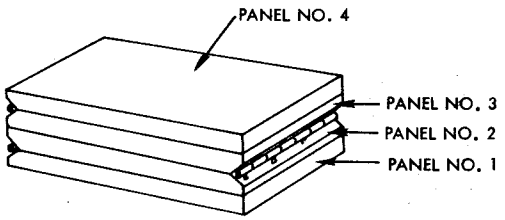


COSMIC RAY DETECTOR FRAME DETAIL



ASTRONAUT PULLING LANYARD TO EXPOSE A PREVIOUSLY UNEXPOSED SURFACE OF PANEL NO. 4 PRIOR TO BEGINING SURFACE ACTIVITIES (FIRST EVA)

EVA 1 ACTIVITY



COSMIC RAY DETECTOR PANELS FOLDED FOR STOWAGE AFTER RETRIEVAL FROM LM (FOLDING ALSO TRANSLATES SHEETS FOR PARTICLE DETECTION ON RETURN LEG)

EVA 3 ACTIVITY

Figure 2-32(b). Cosmic Ray Detector Experiment - EVA Activities and Detector Frame Detail

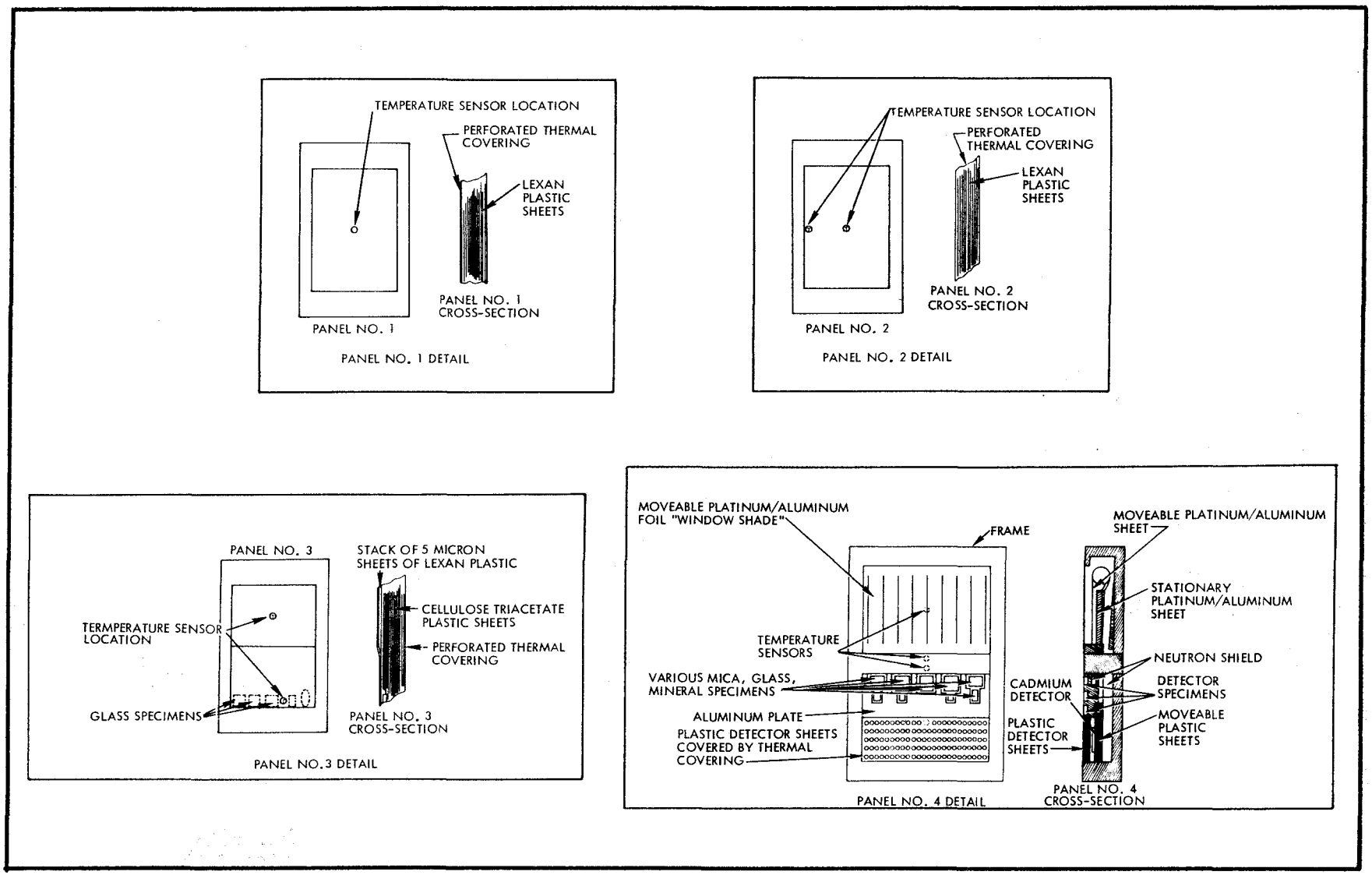


Figure 2-32(c). Cosmic Ray Detector Experiment - Individual Detector Panel Details

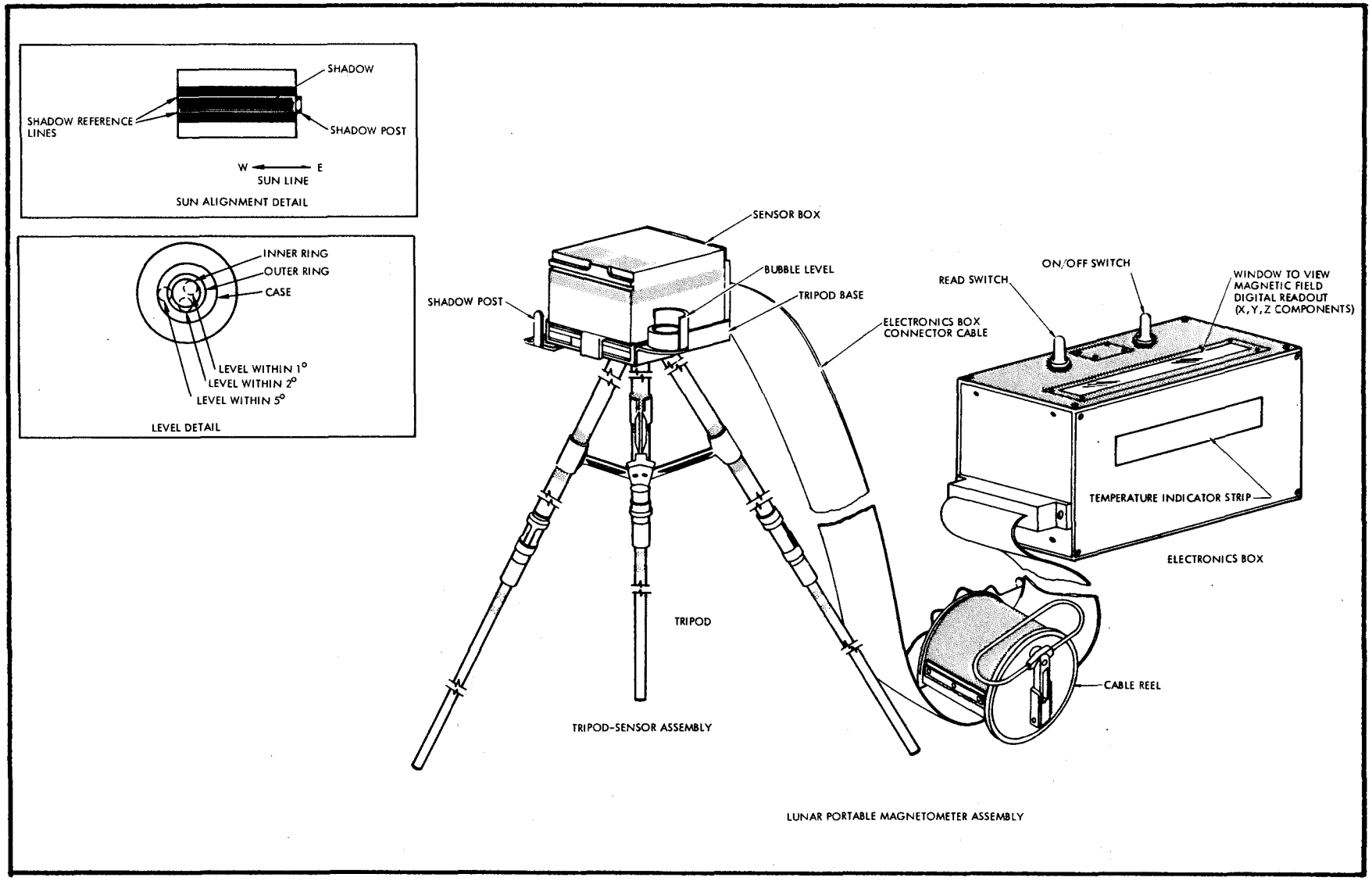


Figure 2-33(a). Portable Magnetometer Experiment - Equipment Components

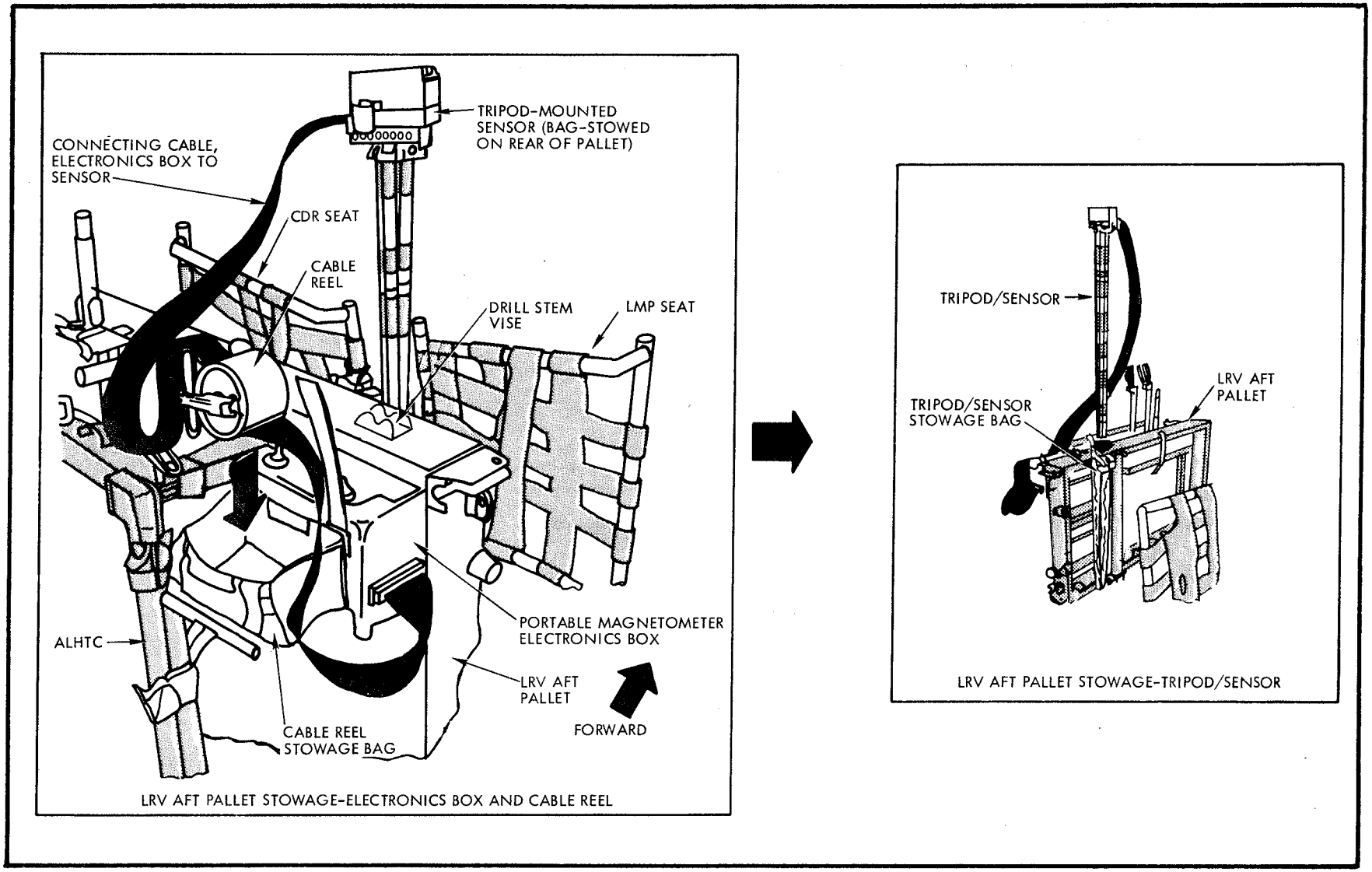


Figure 2-33(b). Portable Magnetometer Experiment - LRV Aft Pallet Mounting

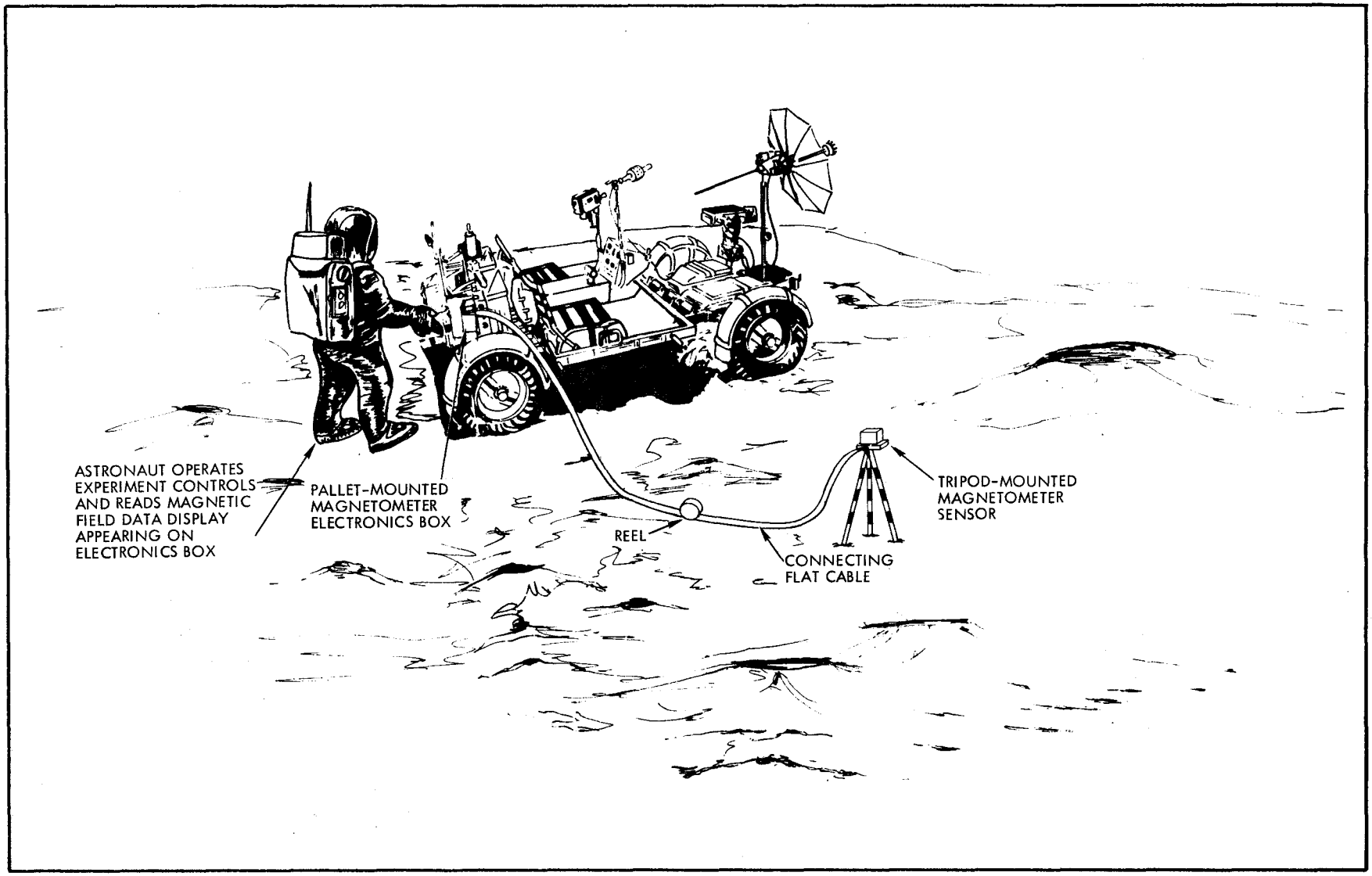


Figure 2-33(c). Portable Magnetometer Experiment - Operational Implementation

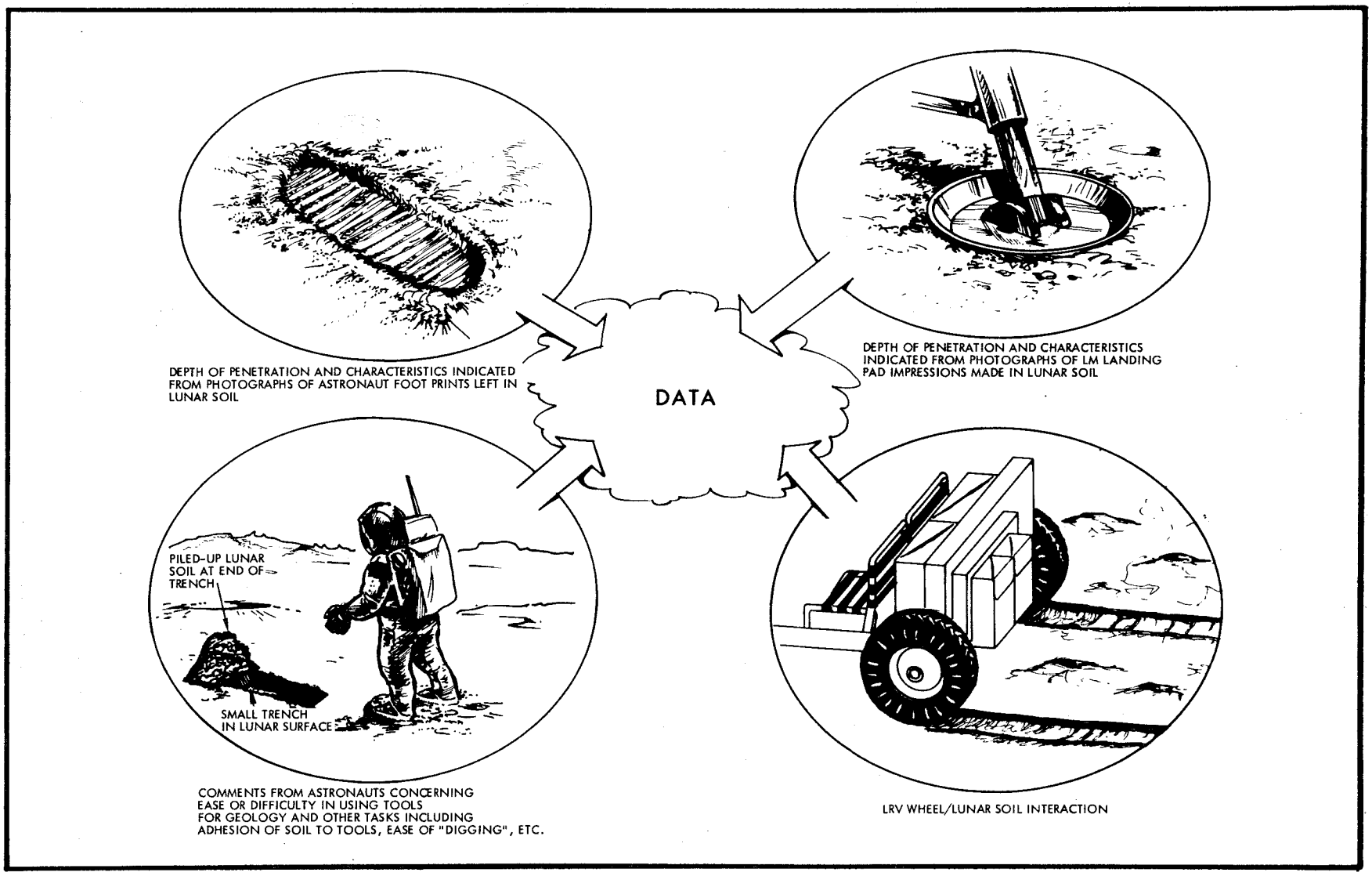


Figure 2-34(a). Soil Mechanics Experiment - Qualitative Data Source Examples

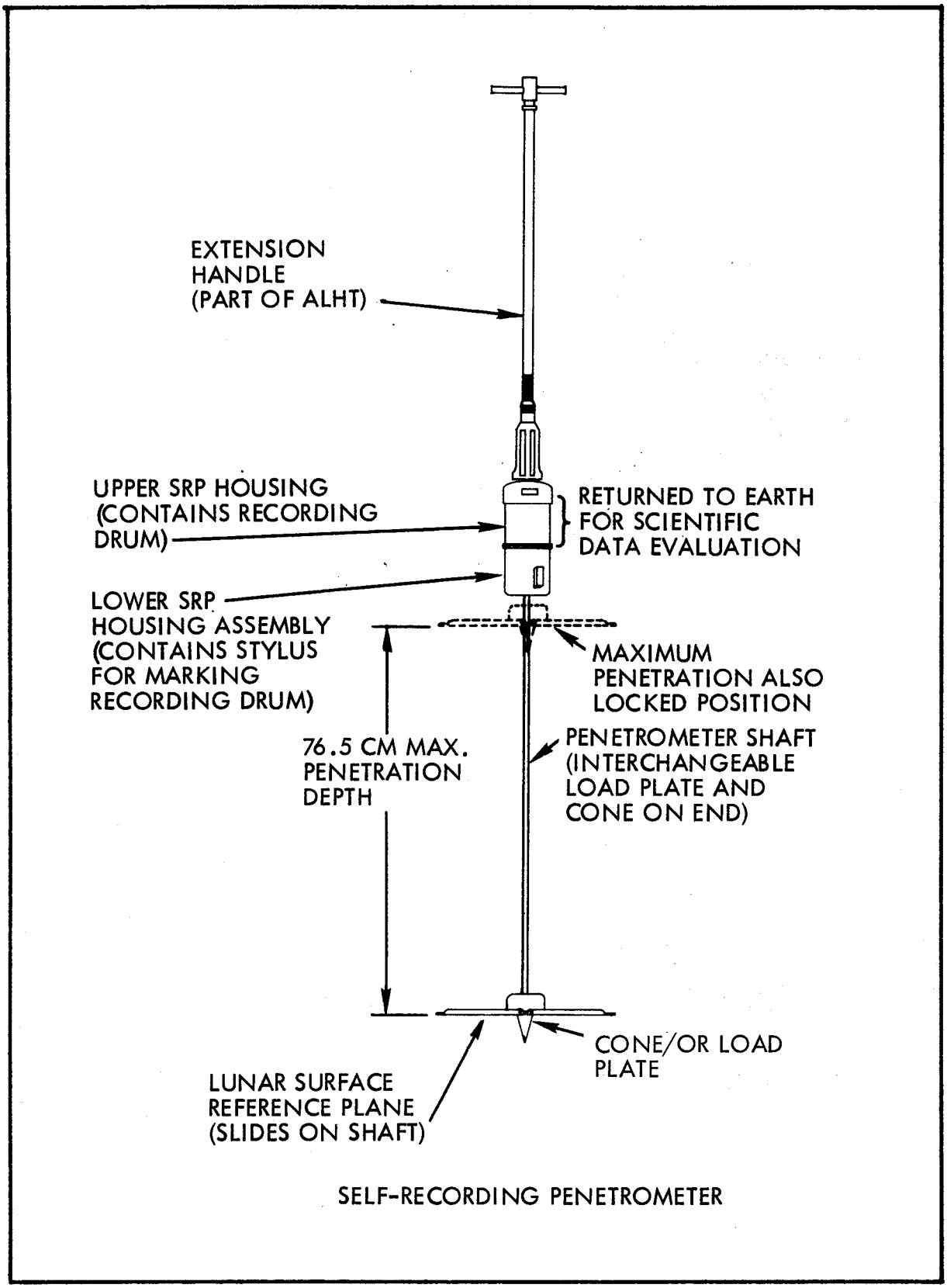
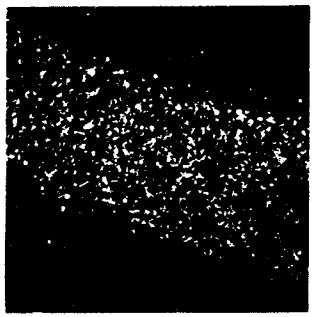


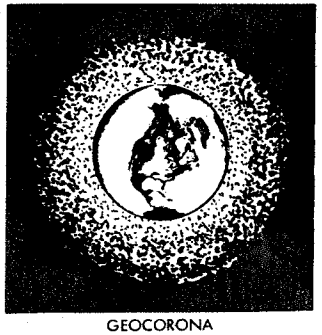
Figure 2-34(b). Soil Mechanics Experiment - Quantitative Data Source (Penetrometer/Load Plate Data)

SKY BACKGROUND



MILKY WAY STAR CLOUDS

NEARBY GALAXIE



GEOCORONA

Figure 2-35(a). Far UV Camera/Spectroscope Experiment - Representative Celestial Targets of Interest

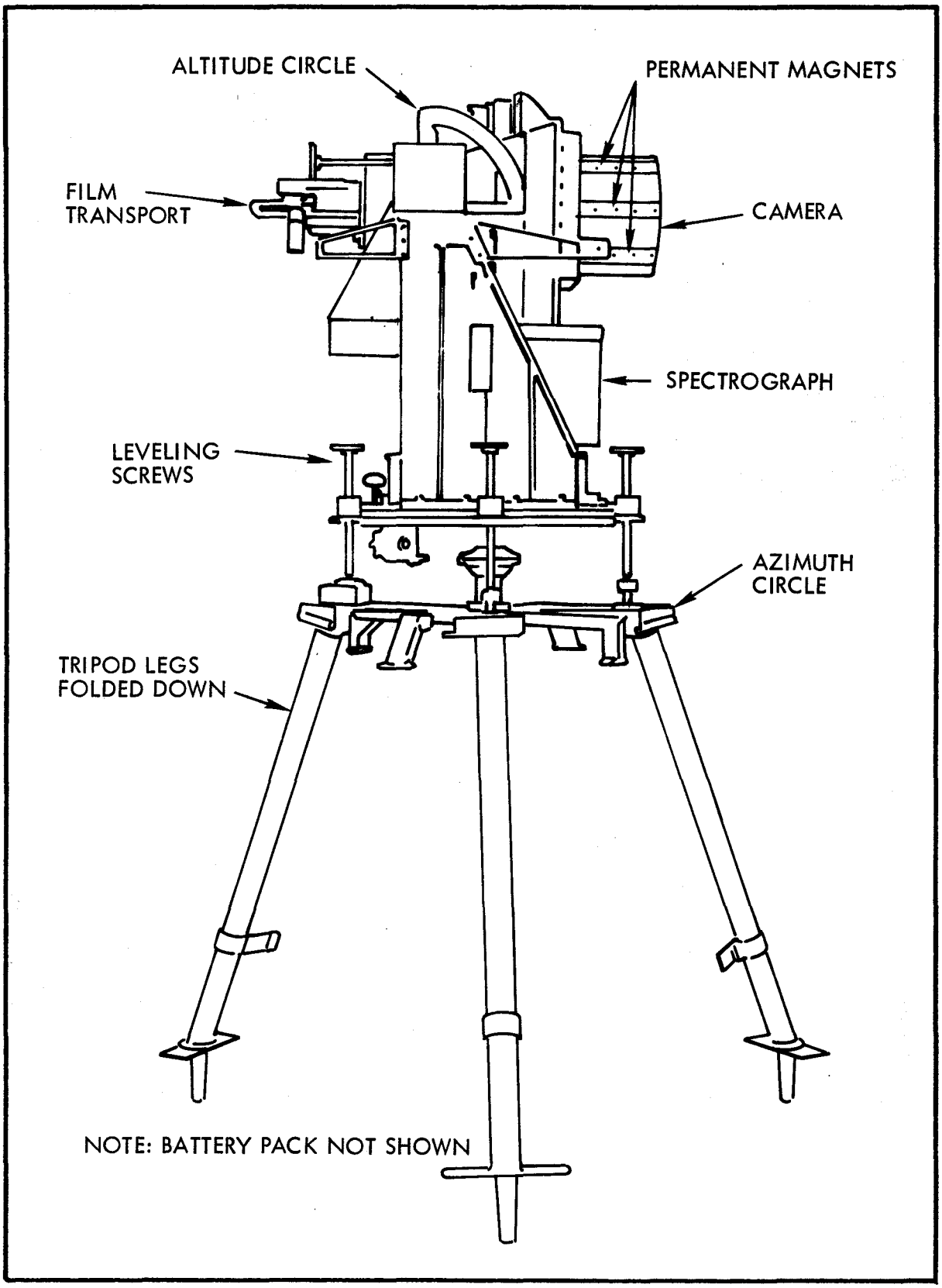


Figure 2-35(b). Far UV Camera/Spectroscope Experiment - Camera Component Identification

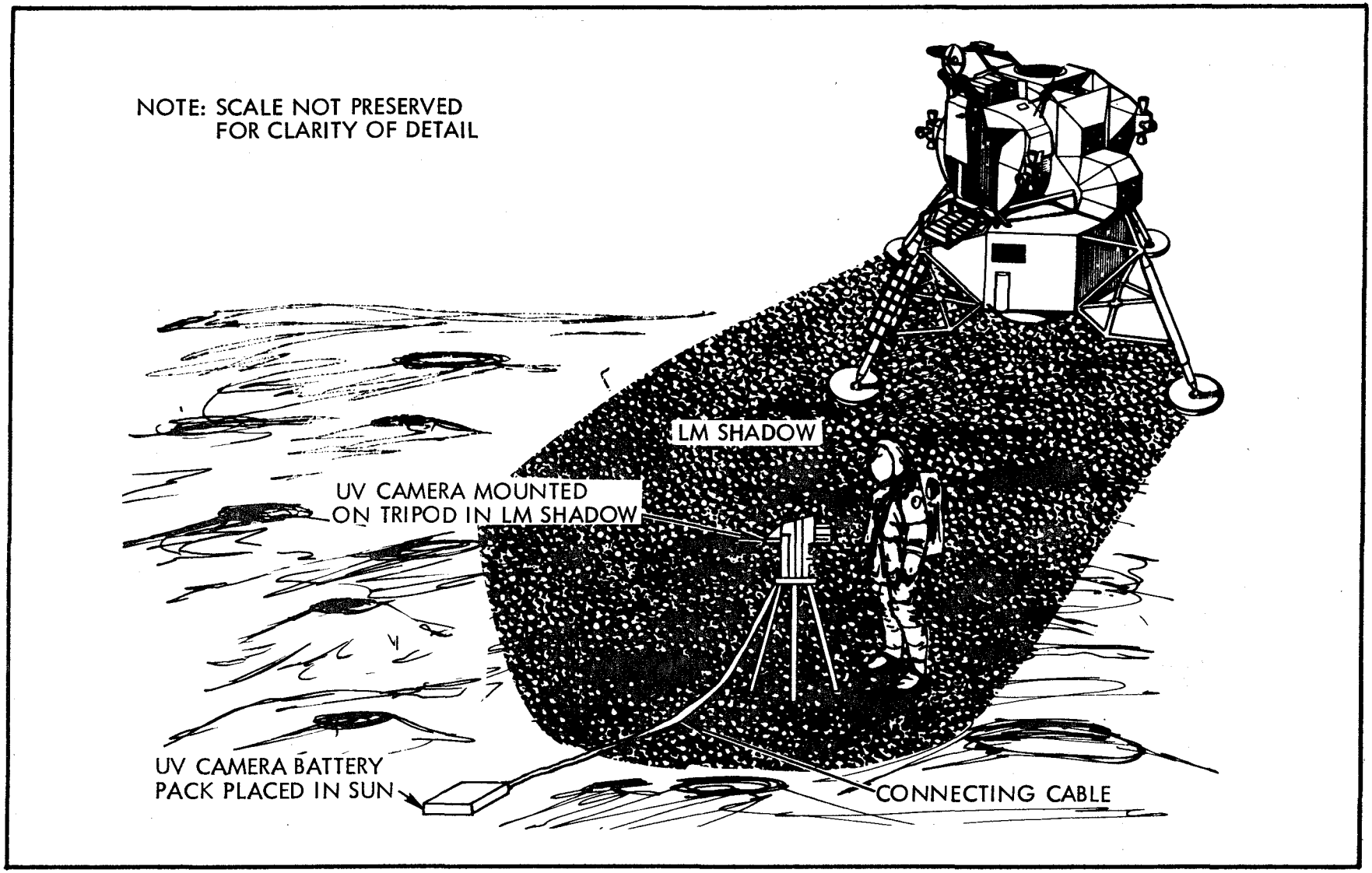


Figure 2-35(c). Far UV Camera/Spectroscope Experiment - Operational Implementation

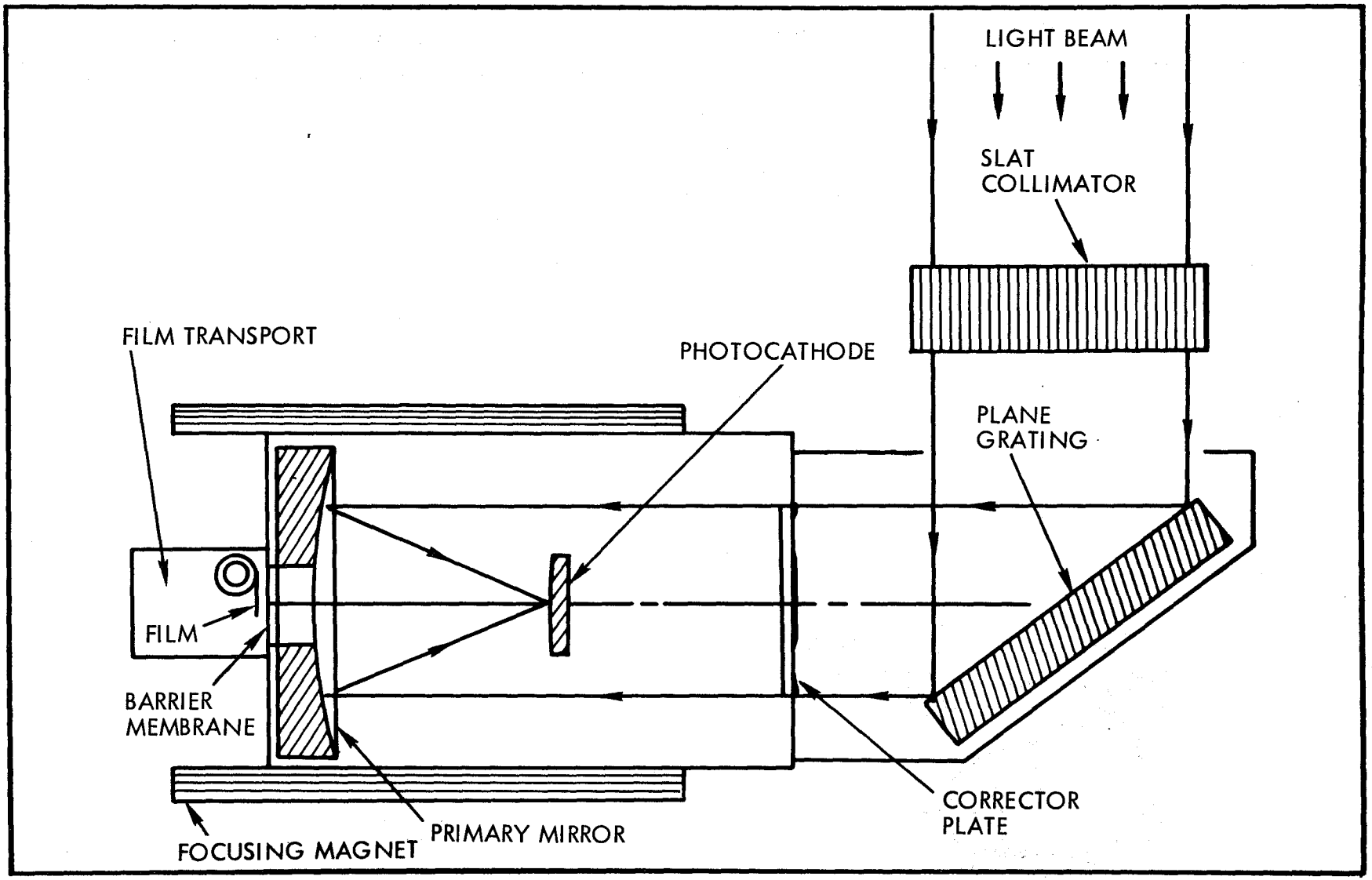


Figure 2-35(d). Far UV Camera/Spectroscope Experiment - Optics Detail

SECTION III

PHOTOGRAPHIC PLAN

3.1 GENERAL

Data in this section were provided by the Science Requirements and Operations Branch/TD5, Mapping Sciences Branch/TF5, and Photographic Technology Division/JL. This section identifies and describes the types of photographic films which will be flown on Apollo Mission J-2, correlates photographic requirements to planned science experiments and science-related detailed objectives, and specifies photographic film reproduction requirements.

Detailed photographic data in this section are provided for experiment Principal Investigators, members of the scientific community, and personnel responsible for planning science photographic activities. These data are intended for use in implementing the photographic requirements related to science activities as presented in the MSC-controlled J-2 Mission Requirements Document (Reference 1) until such data are published in other MSC-controlled documents. These documents include the Apollo 16 Flight Plan (Reference 2) and the Apollo 16 Lunar Surface Procedures (Reference 3).

3.2 SUMMARY OF FILM TYPES

Table 3-1 lists the film types that will fly on Apollo Mission J-2, and a brief description of each. Detailed information on these films, presented in Appendix E, includes film characteristics, suggested exposure indexes, image-structure properties, emulsion characteristics, and typical density-log exposure curves. These data are the result of processing tests performed mostly by the film supplier, and reflect averages based on many different samples of the same film type. Thus, the data are accurate as to reflecting general film and emulsion characteristics, but should not be used for precise sensitometric comparisons with any single sample of film. The detailed film descriptions presented should serve to indicate the film processing capabilities of the Photographic Technology Division (PTD) at

the Manned Spacecraft Center (MSC), and aid in the selection of film types and processing techniques for the fulfilling of science-related, mission photographic requirements.

3.3 PHOTOGRAPHIC/SCIENCE REQUIREMENTS CORRELATION

Tables 3-2 and 3-3 present detailed photographic requirements for lunar orbital and lunar surface science activities, respectively. A listing of photographic equipment and film codes is given with each table. Entries in the "exposure parameters" column refer to aperture stop, duration of exposure (seconds), and focus distance (feet), respectively. Film processing requirements are referenced to the appropriate page of Appendix E on which that particular film is described.

The PTD performs sensitometric exposures of each film-type scheduled to be used on a particular mission for comparison with the manufacturer's sensitometric standards and to establish film processing controls. The Film Sensitometric Calibration, Processing, Handling, and Equipment Capabilities Document (Reference 16) provides detailed information on these sensitometric calibrations, and describes a procedure for the coordination of special photographic requirements with the PTD.

3.4 PHOTOGRAPHIC REPRODUCTION REQUIREMENTS

Table 3-4 presents the postmission reproduction requirements for imagery obtained from science-related photography to be performed on the J-2 Mission.

Table 3-1. Apollo Mission J-2 Flight Films

NUMBER	CHARACTERISTIC	TYPICAL FLIGHT APPLICATION
2485	Very high-speed BW	Low light level astronomy
3400	Intermediate-speed aerial BW	Lunar surface photography from lunar orbit
3401	Medium-speed, fine grain aerial BW	Documentation photography of geological samples
3414*	Low-speed BW	Lunar surface photography from lunar orbit and transearth coast
SO-164	Medium-speed BW	Photography of the mass spectrometer and its boom
SO-168 (ASA 160)	High-speed color exterior	Photography of the deployed Apollo Lunar Surface Experiments Package (ALSEP)
SO-368	Medium-speed color exterior	Color photography performed of the lunar surface
IIa-0	Ultraviolet Spectroscopic	UV photography of the earth and moon
NTB-3	Far Ultraviolet Spectroscopic	Far UV imagery and spectra of celestial objects obtained from the lunar surface

*Previously designated SO-349 and 3404

Table 3-2. Lunar Orbit Science Photographic Requirements

Notes: The following notes apply to all pages of Table 3-2.

Camera Nomenclature:

DAC - 16-mm data acquisition camera
HEC - 70-mm Hasselblad electric camera
35 - 35-mm Nikon camera
MC - 3-Inch mapping camera
SC - 3-Inch stellar camera
PC - 24-Inch panoramic camera

Film Nomenclature:

CEX - Color exterior (SO-368)
BW - Black and white (3400, 3401, and SO-164)
LBW - Low-speed black and white (3414, formerly SO-349 and 3404)
VHBW - Very high-speed black and white (2485)
IIa-O- Ultraviolet (UV) spectroscopic

All photographs are mandatory except those designated as highly desirable (HD) or otherwise qualified.

Film type processing is specified by reference to the page number in Appendix E (e.g.,E-8) for that film.

Exposure parameters are preliminary and based on previous mission photography where possible. Final values are subject to change by the Crew Procedures Division and the Photographic Technology Division. The parameters are listed sequentially as aperture stop (including f- and T-stop), exposure time in seconds, and focus distance in feet.

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
SM Orbital Photographic Tasks (Detailed Objective)	High-resolution photographs with stereo coverage (25-degree convergence angle) and limited monoscopic coverage of potential landing sites and exploration areas on the moon*	PC/24-Inch Lens**	LBW(3414, formerly SO-349 and 3404)/E-4	Automatic Exposure Control
	High-quality metric photographs of the lunar surface, based on 78 percent forward overlap between successive frames and 55 percent sidelap between consecutive photographic revolutions	MC/3-Inch Lens**	BW(3400)/E-2	Automatic Exposure Control
	Stellar photographs time-correlated with the metric photographs of the lunar surface	SC/3-Inch Lens	BW(3401)/E-3	f/2.8, 1.5 sec, ∞

*For photographic sequences see Section IV of the J-2 Mission Requirements Document.

**The 24-Inch Panoramic Camera has automatic V/h compensation from 45 to 80 NM and a manual override for 55 and 60 NM settings. V/h compensation altitude range for the 3-Inch Mapping Camera is ±10 NM from a nominal altitude of 60 NM, manually adjustable by crew. Prelaunch adjustment provides operation from 40 to 80 NM.

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Mass Spectrometer (S-165)	Sequence photographs during one complete sunlit pass (including 2 minutes prior to solar illumination of the spacecraft and extending to, at least, 2 minutes after cessation of solar illumination of the spacecraft) while the mass spectrometer is fully extended and collecting data	DAC/18-mm Lens/ Window mounting bracket, RH side window	BW(SO-164)/ E-2	f/8, 1/250, 20, frame cycle rate of 1 frame per second
UV Photography-Earth and Moon (S-177)	13 sets of 5 photographs as follows: One sunlit photograph with each of three UV filters and one photograph with a visual range filter (a second photograph with each filter is HD)	HEC/105-mm UV transmitting lens/UV bandpass filters centered at 3750 Å, 3050 Å, and 2600 Å, visual range filter above 4000 Å/ring slide for filters and window mounting bracket	IIa-0/E-8	All photographs will be focused at ∞. Exposure times and aperture settings are as follows, with values corresponding to each of the four filters listed in the order shown on this page

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
UV Photography-Earth and Moon (S-177) (Continued)	One color photograph of approximately the same scene as taken with UV filters (HD)*	HEC/105-mm UV transmitting lens/visual range filter	CEX (SO-368)/ E-7	f/8, 1/250,∞
	During translunar coast (TLC):			
	4 sets of the earth disc at the following ground elapsed times (GET):			
	7:20			(f/4.3,1/250),(f/4.3,1/125), (f/4.3,20),(f/8,1/500)
	12:30			(f/5.6,1/250),(f/5.6,1/125), (f/5.6,20),(f/8,1/500)
	29:30			(f/4.3,1/250),(f/4.3,1/125), (f/4.3,20),(f/8,1/500)
	52:30			(f/5.6,1/250),(f/5.6,1/125), (f/5.6,20),(f/8,1/500)
	2 sets of the lunar disc taken in close time sequence at approximately 68:00 GET:			

*No color photographs are required of lunar maria and lunar terra.

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
UV Photography-Earth and Moon (S-177) (Continued)	Set 1			(f/4.3,1/60),(f/4.3,1/60), (f/4.3,1/15),(f/4.3,1/250)
	Set 2			(f/5.6,1/60),(f/5.6,1/60), (f/5.6,1/15),(f/5.6,1/250)
	In lunar orbit:			
	1 set of the earth disc			(f/5.6,1/250),(f/5.6,1/125), (f/5.6,20),(f/8,1/500)
	1 set of earth and lunar horizon			(f/4.3,1/250),(f/4.3,1/60), (f/4.3,20),(f/8,1/500)
	1 set of lunar terra			(f/5.6,1/60),(f/5.6,1/60), (f/4.3,1/15),(f/4.3,1/250)
	1 set of lunar maria			(f/4.3,1/60),(f/4.3,1/60), (f/4.3,1/15),(f/4.3,1/250)
	During transearth coast (TEC):			
	2 sets of the lunar disc taken in close time sequence at approximately 223:00 GET:			
	Set 1			(f/4.3,1/60),(f/4.3,1/60), (f/4.3,1/15),(f/4.3,1/250)

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
UV Photography-Earth and Moon (S-177) (Continued)	Set 2 1 set of the earth disc taken at approximately 288:00 GET			(f/5.6,1/60),(f/5.6,1/60), (f/5.6,1/15),(f/5.6,1/250) (f/5.6,1/250),(f/5.6,1/125), (f/5.6,20),(f/8,1/500)
Gegenschein from Lunar Orbit (S-178)	6 photographs: 2 in the antisolar direction, 2 in the direction of the Moulton point, and 2 in the direction midway between the antisolar direction and the direction of the Moulton point. The photographs are to be taken while the spacecraft is in the lunar double umbra	35/55-mm Lens (fixed)/window mounting bracket, light shield	VHBW (2485)/ E-7	f/1.2, (3 min, 1 min)*, ∞
	6 additional photographs the same as specified above (HD)	35/55-mm Lens (fixed)/window mounting bracket, light shield	VHBW (2485)/ E-7	f/1.2, (3 min, 1 min)*, ∞

*These two exposures in each direction

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Gegenschein from Lunar Orbit (S-178) (Continued)	2 photographs in the direction midway between the antisolar direction and the direction of the Moulton point, photographs to be taken through the RH side window for calibration of light intensity (HD)	35/55-mm Lens (fixed)/window mounting bracket, light shield	VHBW (2485)/ E-7	f/1.2, (3 min, 1 min), ∞
CM Photographic Tasks (Detailed Objective)	10 photographs taken of the following celestial targets Target (R. Asc./Decl.) NGC 4472 (Virgo Cluster) (12^h31^m/+7.3°) NGC 5128 (Centaurus A) (13^h24^m/-42.0°)	35/55-mm Lens (fixed)/window mounting bracket*, light shield	VHBW (2485)/ E-7	f/1.2, (as indicated below), ∞ 5 minutes 5 minutes

*Bracket has 2 positions: the CSM +X direction and a direction pitched up 30 degrees (+X into -Z).

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
CM Photographic Tasks (Continued)	North Ecliptic Pole ($18^h0^m/+66.5°$)			300, 60
	Gum Nebula			
	Region 1 ($7^h30^m/-32.0°$)			240, 60, 240, 60*
	Region 2 ($8^h40^m/-50.0°$)			240, 60, 240, 60*
	Region 3 ($9^h0^m/-33.0°$)			240, 60, 240, 60*

*First pair of exposures is through a red color filter; the second pair is through a blue color filter.

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
CM Photographic Tasks (Continued)	Deleted			

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
CM Photographic Tasks (Continued)	4 series of solar corona photographs: 1 series after CSM sunset and 1 series prior to CSM sunrise** early in lunar orbit; two similar series late in lunar orbit			

**For sunrise photographs the CSM attitude rate will be matched to the lunar orbital rate, holding the +X axis aligned near the forward-looking horizontal such that a small portion of the camera's field-of-view is fixed on the lunar surface.

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
CM Photographic Tasks (Continued)	Each solar corona series to consist of:			
	(a) Seven photographs taken at the following times: From CSM Sunset (Sec) / Prior to CSM Sunrise (Sec) 10 / -10 20 / -20 30 / -30 40 / -40 50 / -50 60 / -60 75 / -75	HEC/80-mm Lens/ window mounting bracket	VHBW (2485)/ E-1	Aperture of f/2.8 and focus of ∞ for all photographs, shutter speeds variable with times of photographs as follows (in sec): 1/60 1/30 1/8 1/2 1 4 10
	(b) approximately 120 frames, during the following intervals: (HD) 5 sec after to 120 sec after CSM sunset; 120 sec before to 5 sec before CSM sunrise	DAC/18-mm Lens/ window mounting bracket	VHBW (2485)/ E-1	T/1.0 (f/.95), 1/60, ∞ frame cycle rate of 1 frame per second

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
CM Photographic Tasks (Continued)	Four photographs of the moon through the CM RH rendezvous window, for calibration purposes*	HEC/80-mm Lens/ window mounting bracket	VHBW (2485)/ E-1	f/2.8, (1/500, 1/250, 1/125, 1/60), ∞
	Three photographs of a comet, if one is in a favorable position	DAC/18-mm Lens/ optical adapter to the CSM sextant	VHBW (2485)/ E-1	T/1.0 (f/.95), (60, 20, 5), ∞
	28 photographs of zodiacal light taken at the following times** Time Prior to CSM Sunrise (Min:Sec) -14:00 -10:00 - 7:00 - 5:00 - 3:30 - 2:00 - 1:30	35/55-mm Lens/ window bracket, polarizing filter Note: One pair of photographs with indicated identical shutter speeds will be taken, one each at the 0- and 90-degree settings of the polarizing filter	VHBW (2485)/ E-1	f/1.2, (as shown below), ∞ 90, 90 60, 60 30, 30 20, 20 10, 10 5, 5 3, 3

*Photographs to be taken during transearth coast prior to the CSM EVA.

**For these photographs the CSM attitude rate will be matched to the lunar orbital rate holding the +X axis aligned near the forward-looking local horizontal such that a small portion of the camera's field-of-view is fixed on the lunar surface.

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
CM Photographic Tasks (Continued)	-1:10 -1:00 -0:50 -0:40 -0:30 -0:20 -0:10			1, 1 1/2, 1/2 1/4, 1/4 1/8, 1/8 1/15, 1/15 1/30, 1/30 1/60, 1/60
	Six photographs each of specific areas in low light levels near the terminator*	HEC/250-mm Lens	VHBW (2485)/ E-1	f/5.6, 1/125, ∞
	Photographs of the following lunar surface areas in earthshine, at approximately 30-second intervals: 1. Fra Mauro/S-IVB Impact Areas, photographed between 30°W, 4°S and 35°W, 2°S. 2. Reiner Gamma area, photographed between 50°W, 7°N and 65°W, 9°N.	35/55-mm Lens (fixed)	VHBW (3485)/ E-1	f/1.2, 1/8, ∞

*Photographs of 10 terminator crossings mandatory and an additional 10 crossings HD. For specific terminator targets, refer to Section IV of the J-2 Mission Requirements Document.

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
CM Photographic Tasks (Continued)	Photographs of specific* areas of the lunar surface, providing 60 percent forward overlap	HEC/250-mm Lens	CEX (SO-368)/ E-7	
Gamma-Ray Spectrometer (S-160)	**	PC/24-Inch Lens	LBW (3414, formerly SO-349 and 3404)/E-4	Automatic Exposure Control
X-Ray Fluorescence (S-161)	**	MC/3-Inch Lens	BW (3400)/E-2	Automatic Exposure Control
Alpha Particle Spectrometer (S-162)	**	SC/3-Inch Lens	BW (3401)/E-3	f/2.8, 1.5 sec, ∞
Mass Spectrometer (S-165)	**			
S-Band Transponder (CSM/LM) (S-164)	**			

*For identification of photographic targets and exposure parameters, refer to Section IV of the J-2 Mission Requirements Document.

**Copies of appropriate Mapping Camera and/or Panoramic Camera photographs taken of the ground track overflown during periods of experiment operation.

Table 3-2. Lunar Orbit Science Photographic Requirements (Continued)

EXPERIMENT OR OBJECTIVE	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Bistatic Radar (S-170)	*			
Subsatellite (S-164, S-173, S-174)	*			

*Copies of appropriate Mapping Camera and/or Panoramic Camera photographs taken of the ground track overflown during periods of experiment operation.

Table 3-3. Lunar Surface Science Photographic Requirements

Notes: The following notes apply to all pages of Table 3-3.

Camera Nomenclature:

DAC	-	16-mm data acquisition camera
LDAC	-	Lunar surface 16-mm data acquisition camera (battery-operated)
HEDC	-	70-mm Hasselblad electric data camera (with reseau)
LSUV	-	Lunar Surface UV camera
LFLC	-	Long focal length camera (HEDC specially adapted for use with a 500-mm lens, permanently focused at 1 kilometer)

Film Nomenclature:

CEX	-	Color exterior (SO-368)
HCEX	-	High-speed color exterior (SO-168) (ASA 160)
BW	-	Medium-speed black and white (3401)
NTB-3	-	Far UV spectroscopic

All photographs are mandatory except those designated as highly desirable (HD) or otherwise noted.

Film type processing is specified by reference to the page number in Appendix E (e.g., E-5) for that film.

Exposure parameters are preliminary based on previous mission photography. Final values are subject to change by the Crew Procedures Division and the Photographic Technology Division. The parameters are listed sequentially as aperture stop (including f- and T-stop), exposure time in seconds, and focus distance in feet. DECAL refers to a decal on the camera showing aperture stops for different viewing angles relative to the sun.

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
ALSEP/Central Station (C/S)*	One photograph of the C/S, taken from 7 feet behind the C/S looking south	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 7
	One photograph of the C/S, taken from 7 feet looking north to show the positions of the switches	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 7
	Panoramic photographs (as required) from the vicinity of the C/S to show entire ALSEP deployed	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 11
Radioisotope Thermoelectric Generator (RTG) (ALSEP)*	One photograph of the RTG on its pallet, taken 7 feet from the RTG	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 7

*Photographs desired but not listed as a science requirement in the J-2 Mission Requirements Document. The C/S and RTG are not experiments or DO's but provide only subsystems support to the Apollo 16 ALSEP array.

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Passive Seismic (S-031) (ALSEP)	One photograph cross-sun from 3 feet of the deployed PSE, showing position of bubble and gnomon shadow on compass rose (HD)	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 3
	One photograph showing C/S in background, taken 7 feet from PSE (HD)	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 7
Active Seismic (S-033) (ALSEP)	One photograph of the mortar package taken cross-sun from 15 feet and showing the C/S in the background (HD)*	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 74
	Three photographs of mortar package, one each looking down-sun, looking southeast, and looking southwest, each from 7 feet	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 7

*Any photograph (e.g., from a panoramic sequence) which shows the C/S and mortar package will suffice.

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Active Seismic (S-033) (ALSEP) (Continued)	Television coverage of one geophone deployment (HD) Television coverage showing use of the thumper (HD) Television coverage showing deployment of mortar package and pallet (HD)	GCTA/12.5-to 75-mm zoom lens	N/A	f/2.2 to f/22 by manual control, 30 frames per second video format
Lunar Surface Magnetometer (S-034) (ALSEP)	One photograph, taken 3 feet from the LSM and focused on shadowgraph, prior to sunshade deployment (HD)	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 3
	One photograph, taken 7 feet from the LSM, showing the three sensor heads and, if possible, the C/S in the background (HD)	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 7

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Heat Flow (S-037) (ALSEP)	One photograph of each bore stem with probe emplaced, taken down-sun from 11 feet	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 11
	One photograph of HFE electronics package looking north from 7 feet (HD)	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 7
	One stereo pair of each bore stem with probe emplaced, taken from 7 feet looking north	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 7
Lunar Geology Investigation (S-059)	For each documented geological sample including the comprehensive sample and the 1-kilogram soil sample, the following 5 photographs:			

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Lunar Geology Investigation (S-059) (Continued)	Before Sampling:			
	One down-sun from 11 feet, including gnomon with photometric chart	HEDC/60-mm Lens	BW (3401)/E-3	f/11, 1/250, 11
	One stereo pair cross-sun from 7 feet, including gnomon with photometric chart	HEDC/60-mm Lens	BW (3401)/E-3	f/8, 1/250, 7
	After Sampling:			
	One cross-sun from 7 feet	HEDC/60-mm Lens	BW (3401)/E-3	f/5.6, 1/250, 7
	One location photograph cross-sun from 15 feet, including the LRV or LM, to be taken before or after sampling	HEDC/60-mm Lens	BW (3401)/E-3	f/5.6, 1/250, 74

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Lunar Geology Investigation (S-059) (Continued)	For radial sampling of a fresh crater; one stereoscopic partial panorama covering the sampling area	HEDC/60-mm Lens	BW (3401)/E-3	DECAL, 1/250, 74
	For sample from rim of fresh crater:			
	Documented sample photographs (5)			
	Partial panorama	HEDC/60-mm Lens	BW(3401)/E-3	DECAL, 1/250, 74
	For sample of ray material from distant crater: partial stereo pan along ray in both directions	HEDC/60-mm Lens	BW(3401)/E-3	DECAL, 1/250, 74
	For secondary crater with impacting projectile: documented sample photographs of crater and projectile			

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Lunar Geology Investigation (S-059) (Continued)	Panoramic photographs, each set containing 15 to 20 overlapped photographs for 360-degree coverage, taken with horizon near top of the picture - sets to be taken from: a) Three positions approximately 20 feet from the LM and 120 degrees apart b) At each station on the traverse c) Geological features of interest along traverse d) High elevation points e) Points with items of crew interest f) 2.6-meter drill core site	HEDC/60-mm Lens	BW (3401)/E-3	DECAL, 1/250, 74

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Lunar Geology Investigation (S-059) (Continued)	For near-field polarimetric measurement:			
	One photograph down-sun (10-degree phase angle), from 11 feet, taken of a rock sample area, including gnomon with photometric chart	HEDC/60-mm Lens	BW (3401)/E-3	f/11, 1/125, 11
	Three photographs of area from 7 feet, one at each of three positions of the polarizing filter, at a phase angle of 90 degrees	HEDC/60-mm Lens/ polarizing filter	BW (3401)/E-3	f/5.6, 1/125, 7
	Same 3 photographs at phase angle of 110 degrees			
	Same 3 photographs at phase angle of 130 degrees			

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Lunar Geology Investigation (S-059) (Continued)	One location and one after-sample photograph as described for documented geological samples			
	For distant polarimetric measurements:			
	Three photographs from at least 12 meters, approximately cross-sun, one each at the left, center, and right settings of the polarizing filter	HEDC/60-mm Lens/ polarizing filter	BW (3401)/E-3	f/5.6, 1/125, 74
	Three photographs as before, but up to 20 degrees down-sun from first position	HEDC/60-mm Lens/ polarizing filter	BW (3401)/E-3	f/5.6, 1/125, 74
	Distant photographs of the following:	LFLC/500-mm Lens	BW (3401)/E-3	f/11 (down-sun) and f/8 (cross-sun), 1/250, 1 kilometer

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Lunar Geology Investigation (S-059) (Continued)	(1) Opposite walls of North Crater from station stops on rim (2) Inaccessible regions of Smoky and Stone Mountains as well as South Ray and Stubby Craters, etc. (3) Mounds in floor of Palmetto Crater and Ravine Crater			
	For each core tube sample: one stereo pair cross-sun of core tube in contact with surface, from 7 feet (HD)	HEDC/60-mm Lens	BW (3401)/E-3	f/5.6, 1/250, 7
	One location photograph of core tube and horizon, from 15 feet after tube is emplaced	HEDC/60-mm Lens	BW (3401)/E-3	DECAL, 1/250, 74

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Lunar Geology Investigation (S-059) (Continued)	Following each small trench sample:			
	A stereo pair of any interesting features, cross-sun from 7 feet (HD)	HEDC/60-mm Lens	BW (3401)/E-3	f/5.6, 1/250, 7
	A location photograph approximately cross-sun from 15 feet, taken any time in the above trench procedure (HD)	HEDC/60-mm Lens	BW (3401)/E-3	f/5.6, 1/250, 74
	For trench in level area suitable for Soil Mechanics:	HEDC/60-mm Lens	BW (3401)/E-3	
	Stereo pair after each skim of the surface, cross-sun from 7 feet			f/5.6, 1/250, 7
	Location photograph of completed trench, approximately cross-sun from 15 feet			f/5.6, 1/250, 74

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Lunar Geology Investigation (S-059) (Continued)	For each large rock sample: same as for documented geological samples	-	-	-
	For large igneous boulder:			
	Documented sample photographs (5)			
	One close-up photograph before and after each chip	HEDC/60-mm Lens	BW (3401)/E-3	DECAL, 1/250, 27 inches
	For largest overturnable boulder:	HEDC/60-mm Lens	BW (3401)/E-3	
	Before rocking stability check:			
	One photograph down-sun from 11 feet			f/11, 1/250, 11
	Stereo pair cross-sun from 7 feet			f/8, 1/250, 7

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Lunar Geology Investigation (S-059) (Continued)	After rocking stability check:			
	One close-up photograph before and after each chip			DECAL, 1/250, 27 inches
	After overturning boulder:			
	One photograph cross-sun from 7 feet after each soil sample			f/5.6, 1/250, 7
	One location photo-graph cross-sun from 15 feet			f/5.6, 1/250, 74
	For vertically split boulder:			
	Documented sample photographs (5)			
	One close-up photograph before and after chipping	HEDC/60-mm Lens	BW (3401)/E-3	DECAL, 1/250, 27 inches

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Lunar Geology Investigation (S-059) (Continued)	For fillet samples: same as for documented geological samples	-	-	-
	For special surface top layer samples: after sample photograph as described for documented geological samples	-	-	-
	For the lunar environment soil samples: trench photographs will suffice	-	-	-
Solar Wind Composition (S-080)	One cross-sun stereo pair of the SWC showing the staff in the lunar surface, with the entire foil and staff filling the field-of-view (HD)	HEDC/60-mm Lens	BW (3401)/E-3	f/11, 1/250, FOCUS

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Solar Wind Composition (S-080) (Continued)	Two photographs of the upper part of the deployed SWC from 7 feet, showing the red marking on the reel and the upper part of the foil and staff: a) One photograph taken immediately after deployment b) One photograph taken just prior to retrieval of the foil and reel at the end of the foil exposure period (HD)	HEDC/60-mm Lens	BW (2401)/E-3	f/11, 1/250, 7
Cosmic Ray Detector (Sheets) (S-152)	One photograph of the detector panels taken prior to pulling the red ring, lanyard No. 1, of the panel array, down-sun from 7 feet	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 7

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Cosmic Ray Detector (Sheets) (S-152) (Continued)	One similar photograph taken immediately after pulling the red ring, lanyard No. 1 (HD)	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	f/11, 1/250, 7
Portable Magnetometer (S-198)	One photograph of each measurement site, to include the sensor head and the LRV and/or a distinguishable surface feature	HEDC/60-mm Lens	BW (3401)/E-3	f/11, 1/250, FOCUS
	Stereo pair, cross-sun from 3 feet, of igneous rock sample on sensor head	-	-	f/11, 1/250, 3
Soil Mechanics (S-200)	One photograph of the lunar surface showing DPS exhaust impingement erosive craters taken cross-sun at 11 feet from the center of the LM	HEDC/60-mm Lens	BW (3401)/E-3	f/5.6, 1/250, 11

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Soil Mechanics (S-200) (Continued)	The following photographs of the excavated trench:	HEDC/60-mm Lens	BW (3401)/E-3	
	a) One location photograph of trench site from 15 feet	-	-	DECAL, 1/250, 74
	b) A stereo pair of the trench, down-sun from 7 feet	-	-	f/11, 1/250, 7
	The following photographs after the trench wall has been collapsed, to include adjacent plate load test:			
	a) A stereo pair from 7 feet oriented perpendicular to the wall	-	-	f/5.6, 1/250, 7
	b) A stereo pair from 7 feet parallel to the wall, generally down-sun	-	-	f/11, 1/250, 7

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Soil Mechanics (S-200) (Continued)	Sequence photographs* cross-sun during excavation and use of the penetrometer with cones	LDAC/10-mm Lens	CEX (SO-368)/ E-7	f/8, 1/250, ∞, 6 frames per second
	For each plate load test:			
	a) A cross-sun stereo pair of the test surface after plate is removed, from 7 feet	HEDC/60-mm Lens	BW (3401)/E-3	f/5.6, 1/250, 7
	b) A location photograph taken from 15 feet	HEDC/60-mm Lens	BW (3401)/E-3	DECAL, 1/250, 74
	Photographs of the course traversed before and after traverses for ALSEP deployment (HD)	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	**
	Photographs of an astronaut's footprint during traverse for ALSEP deployment (HD)	HEDC/60-mm Lens	HCEX (SO-168)/ E-5	**

*Television coverage is an acceptable alternate.

**Soil Mechanics photographs designated as HD, and with no exposure parameters indicated, require no specific crew tasks. Copies are to be provided only if such photographs are obtained in support of other operational tasks.

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Soil Mechanics (S-200) (Continued)	A stereo pair of the LRV tracks taken from 7 feet parallel to the tracks, at each of a minimum of three locations other than those where penetrometer tasks were performed (HD)	HEDC/60-mm Lens	BW (3401)/E-3	*
	Photographs of the LM exterior showing any soil accumulation on the vertical surfaces (HD)	HEDC/60-mm Lens	BW (3401)/E-3	*
	Photographs of natural slopes, boulders, ridges, crater walls, and embankments in the vicinity of the landing site (HD)	HEDC/60-mm Lens	BW (3401)/E-3	*
	Photographs of the lunar soil-LRV interactions (HD)	HEDC/60-mm Lens	BW (3401)/E-3	*

*Soil Mechanics photographs designated as HD, and with no exposure parameters indicated, require no specific crew tasks. Copies are to be provided only if such photographs are obtained in support of other operational tasks.

Table 3-3. Lunar Surface Science Photographic Requirements (Continued)

EXPERIMENT	PHOTOGRAPHIC SUBJECT/ DESIRED VIEWS	CAMERA/LENS/FILTER AUXILIARY EQUIPMENT	FILM TYPE/ PROCESSING	EXPOSURE PARAMETERS
Soil Mechanics (S-200) (Continued)	Photographs of the LRV in motion (HD)	LDAC/10-mm Lens	CEX (SO-368)/ E-7	*
Far UV Camera/ Spectroscope (S-201)	Photographic imagery and spectra of specific celestial targets**	LSUV/Schmidt Electronographic Lens	NTB-3/E-9	Automatic exposure control
	One photograph of deployed instrument from approximately 20 feet, showing LM and edge of LM shadow	HEDC/60-mm Lens	BW (3401)/E-3	f/5.6, 1/60, 74
	One photograph downsun from 3 feet, showing the azimuth circle of instrument and the horizon	HEDC/60-mm Lens	BW (3401)/E-3	f/5.6, 1/60, 3

*Soil Mechanics photographs designated as HD, and with no exposure parameters indicated, require no specific crew tasks. Copies are to be provided only if such photographs are obtained in support of other operational tasks.

**For identification of celestial targets, refer to Section V of the J-2 Mission Requirements Document.

Table 3-4. Photographic Reproduction Requirements

ITEM	LUNAR SURFACE ONLY	ORBITAL AND LUNAR SURFACE	ORBITAL ONLY	TOTAL
70-mm Photography				
Positive Transparencies (Rolls)	6	16	3	25
Masters (Rolls) - From Original Onboard Film	8	7	3	18
Duplicate Negatives	1	0	0	1
8 x 10 In. Prints (Color and BW) -				
Full Sets	12	16	5	33
Partial Sets	6	0	0	6
Proof Books (Set)	4	9	1	14
BW Strip Prints (2X)	4	0	0	4
70-mm VHBW (Mags SS, TT)				
Masters (Rolls) From Original Onboard Film	0	0	3	3
Positive Transparencies (Rolls)	0	0	15	15
Duplicate Negatives	0	0	11	11
8 x 10 In. Prints	0	0	12	12
Proof Books (Near Terminator Exposures)	0	0	6	6
Masters (Rolls) - From Original Onboard Film (Near-Terminator Exposures)	0	0	9	9

Table 3-4. Photographic Reproduction Requirements (Continued)

ITEM	LUNAR SURFACE ONLY	ORBITAL AND LUNAR SURFACE	ORBITAL ONLY	TOTAL
70-mm UV (Mag. 00)				
Masters (Rolls) - From Original Onboard Film	0	0	4	4
Positive Transparencies (Rolls)	0	0	5	5
Duplicate Negatives	0	0	2	2
8 x 10 In. Prints	0	0	7	7
16-mm Photography				
16-mm Optical Masters	0	5	0	5
16-mm Working Prints (Set)	9	11	0	20
16-mm Working Prints (VHBW)	0	0	5	5
Duplicate Negatives (VHBW)	0	0	5	5
35-mm Nikon Orbital Photography				
Positive Transparencies (Rolls)	0	0	12	12
Masters (Rolls) - From Original Onboard Film	0	0	5	5
8 x 10 In. Prints	0	0	9	9
Proof Books (Set)	0	0	7	7
Duplicate Negatives	0	0	7	7

Table 3-4. Photographic Reproduction Requirements (Continued)

ITEM	LUNAR SURFACE ONLY	ORBITAL AND LUNAR SURFACE	ORBITAL ONLY	TOTAL
24-In. Panoramic Camera				
Positive Transparencies (Rolls)	0	0	7	7
Masters (Rolls) - From Original Onboard Film	0	0	9	9
Duplicate Negatives	0	0	2	2
Direct Negatives	0	0	7	7
Prints 4 1/2 x 47 In.	0	0	5	5
3-In. Mapping Camera				
Positive Transparencies (Rolls)	0	0	12	12
Masters (Rolls) - From Original Onboard Film	0	0	7	7
Contact Strip Prints	0	0	7	7
Duplicate Negatives	0	0	3	3
Direct Negatives	0	0	9	9
BW Strip Prints (2X)	0	0	2	2
35-mm				
Positive Transparencies (From 3-In. Stellar Camera)	0	0	5	5
Masters (Rolls) - From Original Onboard Film	0	0	5	5
Duplicate Negatives	0	0	1	1
Direct Negatives	0	0	1	1

Table 3-4. Photographic Reproduction Requirements (Continued)

ITEM	LUNAR SURFACE ONLY	ORBITAL AND LUNAR SURFACE	ORBITAL ONLY	TOTAL
Far UV Camera/Spectroscope				
Duplicate Negatives	4	0	0	4
8 x 10 In. Negative Prints	2	0	0	2
AGFA Contour Copies	2	0	0	2

Quantities in this table refer to the number of copies (transparencies, masters, etc.) made from all film of the indicated type. For example, of the 25 recipients of 70-mm positive transparencies, 16 will receive positive transparencies of all 70-mm magazines to be exposed both in lunar orbit and on the lunar surface, and 6 will receive positive transparencies of all 70-mm magazines to be exposed on the lunar surface only. Magazines of all orbital exposures only are required by 3 recipients.

SECTION IV

LUNAR SURFACE SCIENCE PLAN

4.1 GENERAL

This section defines the lunar surface activities planned for the Apollo Mission J-2. Included are descriptions of the landing site and rationale for its selection, identification of lunar surface science experiments, and listings of lunar surface activities.

Detailed data contained in this section are provided for experiment Principal Investigators, members of the scientific community, and personnel responsible for planning science activities on the lunar surface. These data are intended for use in implementing the lunar surface science requirements presented in the MSC-controlled J-2 Mission Requirements Document (Reference 1) until such data are published in other MSC-controlled documents. Such documents include the Apollo 16 Flight Plan (Reference 2), Apollo 16 Lunar Surface Procedures (Reference 3), and Apollo 16 Flight Mission Rules (Reference 17).

4.2 LANDING SITE GEOLOGICAL RATIONALE

4.2.1 INTRODUCTION

The landing site for the J-2 Mission is the Descartes area of the moon. The relationship between the Descartes region and previous Apollo landing sites is shown in Figure 4-1. A more detailed, regional view of the Descartes region with the indicated landing site is shown in Figure 4-2. The Descartes region lies in the lunar southern highlands and is unique in that it is the highest topographic region on the near side of the moon. Since no recognizable gravity anomalies are associated with this region, this mountainous plateau apparently must extend to a great depth to be in isostatic equilibrium.

The portion of the Descartes region which has been selected for the LM touchdown point and, correspondingly, the synthesis of traverse routes and activities is shown in Figure 4-3. A topographic map of the same area with the planned LRV traverse routes is depicted in Figure 4-4. The landing point, which was determined to best provide for the accomplishment

of objectives associated with the Descartes landing site, is located at the coordinates of 15°30'59" E and 9°00'01" S (Reference 5). The geological rationale for selection of this landing site (Reference 4) is presented in the following paragraphs.

4.2.2 GEOLOGICAL RATIONALE

The lunar highlands appear to consist of three major types of deposits: (1) undivided pre-Imbrium materials and older degraded crater materials, (2) ejecta blankets composed of material ejected by the major basin-forming events, (e.g., Mare Imbrium formation) that are typified by the Apollo 14 Fra Mauro and Apollo 15 Apennine Mountains highland areas, and (3) volcanic constructional materials that are exemplified by the Descartes highland region, the Apollo 16 lunar landing site.

The Descartes area is an outstanding location to sample and study the petrochemistry of two volcanic constructional units of the lunar highlands: the Cayley formation unit* and the Descartes formation (a derivative of the Kant Plateau unit), of which two separate and distant portions are present.

Fresh craters of various sizes, also present within the candidate landing area, allow sampling of these highland units to varying depths. The mounded floors of craters within this landing area, up to 1 kilometer in diameter, suggest that a lower layer of unknown origin has been penetrated.

The Cayley formation unit is highland plains material consisting mostly of smooth to undulating terrain probably resulting from fluid volcanic flow rock and pyroclastic detritus. This unit is the largest single identifiable rock unit on the near side of the moon (covers 7 percent of near side surface) except for mare regions. The Descartes formation (located at the edge of the larger Kant Plateau unit) is composed of hilly and furrowed highland plateau material that is probably the product of more viscous volcanic flow rock, pyroclastics, and their associated cones.

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*The Cayley formation unit and Cayley Plains are used as interchangeable terms in this section. Cayley formation is a general geological term whereas Cayley Plains is associated with the Cayley formation unit peculiar to the Descartes landing site.

The Kant Plateau unit covers 4.3 percent of the near side of the moon. This landing site also provides a unique opportunity to accomplish dating and other studies of the morphological evolution of the young, bright-rayed craters. The geological information obtained can be applied to infer ages of other visible craters of apparently similar construction.

The geological units to be sampled in the proposed landing area (Figure 4-5*) are

a) Cayley Plains which include two young and prominent bright-rayed craters (North Ray and South Ray Craters)

b) South Descartes Formation (Stone Mountain)

c) North Descartes Formation (Smoky Mountain)

d) Subdued craters and crater chains

4.2.2.1 Cayley Plains (North Ray and South Ray Craters)

Since the proposed landing area is on the smooth phase of this unit, LM vicinity samples will provide material of this unit. Bright-rayed craters of sizes up to 1 kilometer in diameter (e.g., North Ray and South Ray Craters) penetrate this unit. Radial sampling of the bright rays emanating from these craters will permit selective sampling of stratigraphic history to a depth of about 200 meters.

Exposed in the east wall of the bright-rayed North Ray Crater (Figure 4-3) and recognizable as a scarp-forming unit to the south and east of the crater is the youngest stratigraphic unit of the Cayley formation. In addition, a lower stratigraphic layer lying approximately 150 to 200 meters below the present surface is indicated by mounds in the floor of this and South Ray craters. Speculations as to the origin of this lower layer include: another type of Cayley constructional unit; Imbrium basin ejecta; Nectaris basin ejecta; or pre-Imbrium local source material. Detailed sampling should provide the correct answer. Crater rim sampling alone of North Ray Crater should determine if pre-Imbrium material is present or not (traverse limitations will preclude crew access to the rim of South Ray Crater). Investigations are also to be made of the seemingly rimless craters in this area and of the one very dark crater (Flag Crater) west of the selected landing point.

*Reference 18.

4.2.2.2 South Descartes Formation (Stone Mountain)

These hills form the north edge of a bright, hilly, and furrowed unit that extends southward 100 kilometers to the crater Descartes and eastward 50 kilometers across the Kant Plateau. The Kant Plateau unit, of which the Descartes formation is a derivative, is recognizable at several highland areas on the near side of the moon and becomes more prevalent on the far side. This unit appears to have been formed of very viscous lava, morphologically the opposite of mare lava. Samples from these hills will provide material from a large regional highland volcanic unit, the Kant Plateau (Descartes formation).

4.2.2.3 North Descartes Formation (Smoky Mountain)

This feature might be a pre-Imbrium crater wall although it is more probably a volcanic constructional form. Sampling would establish whether ancient breccias are present from a different region of the moon or if these hills are just another area of highland volcanics. Samples supporting either hypothesis would afford valuable data. This unit will be sampled at a large crater (Ravine Crater) at the south base of these hills.

4.2.2.4 Subdued Craters and Crater Chains

A number of craters and crater chains, marginally accessible from the proposed landing area, appear to be the result of ejecta from the crater Theophilus (or possibly Cyrillus). The largest group close to the landing area is west of the North Ray Crater. The morphology of this crater-type will aid in understanding the details of formation of large secondary craters and their rate of degradation. The deepest samples of Cayley formation might be collected from the rim. Palmetto Crater is representative of this group.

A small group of irregular craters east of North Ray Crater and against the base of the North Descartes Formation are either primary impact craters or a secondary crater chain similar to those father west. These craters will be observed but not sampled because of the previously mentioned geological unit priorities and surface timeline/traverse constraints.

4.3 LUNAR SURFACE PLANNING DATA

4.3.1 EXPERIMENTS IDENTIFICATION

Table 4-1 lists detailed activities for implementing the lunar surface science requirements presented in Reference 1. Data listed in each column are described below. These data are for use only until crew surface procedures/timelines and photographic activities are published in Reference 3.

a) Experiment (Number) and Activity (Priority). Includes each activity and its priority. The priorities assigned to each activity are based on the following definitions presented in the J-2 Mission Requirements Document (Reference 1).

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

2) 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 alternative sources or which is not required for evaluation of essential parts of the objective or experiment.

b) Astronaut Activities. Lists activities required by the astronauts to support the experiment activity. The "Sample ID" in the column indicates that an astronaut voice comment is required to identify the prenumbered bag used, the serial number and order of the multiple core tubes used, and the type of sample (e.g., "small rocks showing erosion"). This information is for postmission correlation with samples and sample photography. A description of the hand tools and equipment used to accomplish these activities appears in Section II of this document.

c) Photographs. Indicates the general photographic activity required. Detailed photographic requirements are defined in Section III of this document.

d) Stowage. Indicates the container provided for stowage of the desired sample. Containers are described in Section II of this document and are further identified in Reference 3.

e) Remarks. Provides additional information pertinent to the development of detailed timelines and procedures.

4.3.2 PRIORITY FOR GEOLOGICAL INVESTIGATIONS

The priorities of the major geological features of the landing site are as follows:

1) Descartes Formation (Kant Plateau) - rugged volcanic forms of the lunar highlands. Consist of cones, shield volcanoes, fissure eruptions, and composite volcanoes. Material was viscous which resulted in the bulbous, lobate, and steep margins to the volcanic units. Rounding of some areas indicates that pyroclastic rocks blanket local regions. Nearest representatives are south and north of the landing point and are within reach of either LRV or walking traverses.

2) Cayley Plains - rolling to smooth volcanic forms of the lunar highlands. Unit fills crater floors, basins, and other low-lying areas. Highlands equivalent of the mare fill. Widespread unit in the highlands (about 7 percent of the near side of the moon) that is older than mare volcanism and, in part, may be older than Imbrium basin formation. The landing point is on these plains and can be explored extensively between the North and South Ray Craters, each located about 5 kilometers, respectively, from the landing point.

4.3.3 LRV TRAVERSE ROUTE TERRAIN PROFILES

These data are presented in Figure 4-6.

4.3.4 TRAVERSE PLANNING GUIDELINES AND CONSTRAINTS

The guidelines and constraints listed below are taken from Lunar Surface EVA Planning Guidelines, Apollo J-Missions (Reference 19) and the Minutes of the 37th Lunar Surface Operations Planning Meeting (Reference 20). These guidelines and constraints will be used in the development of the mission traverses.

a) Lunar Surface Stay-Time: 72.8 hours. (Reference 19)

b) EVA Durations: Three extravehicular activities (EVA) of duration up to 7 hours each.

c) LRV Mobility Rate: 7.3 kilometers per hour, average, over uncorrected map distance.

d) Walking Speed: 2.5 kilometers per hour, average, over uncorrected map distance.

e) BSLSS Ride-/Walk-Back Limit: If a Portable Life Support System (PLSS) failure should occur during a traverse, the Buddy Secondary Life Support System (BSLSS) will be used to provide the capability of returning to the LM. The BSLSS can provide 52.5 minutes of LRV ride time. With the LRV, an emergency return speed of 9.2 kilometers per hour is considered realistic. Hence, the maximum return distance to the LM on any LRV traverse is 8.1 kilometers.

For a walking traverse, the map distance limit is 3.6 kilometers, corresponding to an emergency walking speed of 3.6 kilometers per hour and use of the BSLSS.

f) PLSS Walk-Back Limit: Failure of the LRV during a traverse requires that the crew have the capability to walk back to the LM. The PLSS walk-back capability is defined by the consumables remaining and the walk-back speed (3.6 kilometers per hour at a metabolic rate of 1560 BTU per hour for up to 1 hour return time and 2.7 kilometers per hour at a metabolic rate of 1290 BTU per hour for a return requiring over 1 hour).

g) LRV Total Distance Capability: 76 kilometers, based on battery capability.

h) Overhead Times for Traverse Station Stops:

LRV Traverses: Stops $\geq$15 minutes - 6.8 minutes
Stops <15 minutes - 3 minutes

Walking Traverses: All stops - 3 minutes

4.4 LUNAR SURFACE ACTIVITIES

4.4.1 LANDING SITE EXPERIMENTS

Apollo Lunar Surface Experiments Package (ALSEP), Far UV Camera/ Spectroscope, Cosmic Ray Detector (Sheets), and Solar Wind Composition experiments are accomplished or deployed in the area near the landing point. The Portable Magnetometer measurements are taken both near the landing point and on the traverse routes. Figure 4-7 shows the nominal ALSEP deployment scheme.

4.4.2 NOMINAL TRAVERSES

The Lunar Geology Investigation and Soil Mechanics experiments are conducted during lunar surface traverse activities. Detailed traverse plans were presented at the February 1972 SWP meeting (Reference 21), and have subsequently been slightly modified.

4.4.2.1 LRV Traverses

The current version of the LRV traverses is presented in Figures 4-3 and 4-4. Table 4-2 contains supplementary data described below for use with the traverse map. These data are still subject to further minor revisions as the planning cycle matures.

a) Station or Travel: Indicates the traverse station number or that the crew is traveling, as appropriate.

b) Distance: Shows the actual traverse distance between the two stations and the cumulative total of these distances.

c) Station Stop or Travel Time: Indicates the travel time between individual stations and the cumulative travel time, or the individual station stop time and the cumulative station stop time, as appropriate.

d) Station Science Time: Indicates the time at each station devoted to scientific activities, i.e., station stop time minus stop overhead. The cumulative total is also shown.

e) EVA Time After Event: Shows the time, since beginning the EVA, at the end of each station stop or travel sequence, as appropriate.

f) Geological Features/Observations and Activities: Describes the surface feature at the traverse station or along the traveled route, as appropriate. A listing is also provided of the crew observations and scientific activities considered appropriate for the particular traverse station or route traveled.

4.4.2.2 Walking Traverses

The current version of the walking traverses to be used in the event that the LRV cannot be deployed or becomes inoperable is presented in Figures 4-8 and 4-9. Table 4-3 contains similar information for use with

the walking traverse maps in the same manner as Table 4-2 is used for the LRV traverse maps. As for the LRV traverses, the walking traverse data are subject to further minor changes as mission planning progresses.

Table 4-1. Experiment Activities

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
LUNAR GEOLOGY INVESTIGATION (S-059) FTO 1) CRATER SAMPLING a. Regular 1. Rim Sampling (soil and rocks) (M) 20-50 m diam craters	Scoop soil and collect rock samples from crater rim.	Documented Sample Photography* and partial pan from crater rim. (M)	In individual prenumbered bags	The material from the rim of a crater will provide samples from the deepest part of the crater.
2. Distant crater ray samples (M) Large Craters	Scoop soil and collect rock samples from recognizable rays.	Documented Sample Photography Stereo partial pan along ray in both directions. (Station pan may satisfy) (M)	In individual prenumbered bags	Provide material for dating from deep within the crater from which the ray originates.
3. Fresh secondary crater soil and rocks (HD) Crater with clearly associated remnants of impacting projectile. Projectile preferably 10-20 sq. cm, glass-coated, non-vesicular.	Scoop soil and collect rocks from crater. Collect impacting projectile or chip.	Documented Sample Photography (HD)	In individual prenumbered bags	Samples from crater soil and chips from rock(s) producing the crater will provide data on contemporary exposure histories.
*If only one crew member is collecting samples and performing Documented Sample Photography, the documentary photography procedure shall be to point the gnomon leg with photometric chart toward the sample to be collected and take only the cross-sun stereo pair before sampling and the after-sampling photograph.				

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
b. Special 4. Radial sampling of a fresh crater (M3) and diametric sampling (HD) 20-50 m diam craters in bedrock	Collect 3 rake/soil 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 diameter outward from this crater rim; d) one crater diameter from this center rim. If time limited, rake/soil samples can be replaced by 2 scoops of soil and several documented rocks at each site.	Documented Sample Photography 1 partial stereo pan 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).
FTO 2) BOULDER SAMPLING a. Special 5. Vertical split boulder chips (M, if encountered) Boulder >1 m diam 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.	Documented Sample Photography (M) Close-up stereo after each chip (M)	In prenumbered bag in SRC	Chips from fracture surface and boulder top/bottom provide data on radiation history and long cosmic ray tracks.

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
6. Chips and soil from overturnable boulder (M1, if encountered) Chips from other sides (HD)	Take chip from top, turn rock over, take chip from bottom center. Collect soil from under boulder and 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, if split)	Cross-sun stereo pair before stability check (M) If assessment positive, stereo pair of each of 3 other faces (M) Down-sun and location photos (M) Close-up stereo pair of chipped area (M) Cross-sun stereo pair of overturned boulder (M) Documented Sample Photography of reference soil. (M)	In prenumbered bag in SRC	Chips and samples from soil underneath and adjacent to boulder provide data on surface radiation history.
7. Boulder top dust and chip (M1, if encountered)	Collect dust from top of boulder and chip from under deposit	Adequate to show arrangement (M)	In prenumbered bag in SRC	Dust and chip samples from under dust may concurrently establish erosional processes with dust representing erosional products.
8. Boulder with overhang-chip and soil (M1 or M7, if encountered) >1 km from LM (permanent shadow) Boulder with N-S split may meet requirement for shadow.	Collect soil from permanently shadowed area beneath boulder overhang and chip from shadowed rock surface. Fill SESC to near capacity. Collect reference soil 1 m away in open area	Adequate to permit calculation of shadow pattern on soil. (M) Documented Sample Photography on reference sample. (M)	In SESC and prenumbered bag in SRC	SESC sample of soil under overhang will be used for analysis of volatile substances.
9. East-West split boulder soil (M1 or M8, if encountered) >1 km from LM Width of split $\leq$ height of split, i.e. $\overline{45}°$ shielding angle	Collect soil sample from between split halves and from unshielded surface east or west of rock. Split should be narrow but wide enough to permit sample collection.	Flightline pan (3-5 frames) (M) Close-up stereo pair of each chip (M) Documented Sample Photography of reference soil sample (M)	Individual prenumbered bags	East-West split chips have been shielded from direct cosmic radiation.

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
10. Large igneous boulder (M2, if encountered) Boulder >5 m diam	Collect two widely separated samples. Take reference soil sample	Flightline pan (3-5 frames) (M) Close-up stereo pair of each chip (M) Documented Sample Photography of reference soil sample (M)	Individual pre-numbered bags	Can be used for crater dating if boulders are unambiguously related to crater of interest. Radiation history and variation in lithology and rock structure.
FTO 3) SOIL AND ROCK SAMPLING a. Regular 11. Contingency sample (M, if circumstances arise)	In event of actual contingency collect loose sample of lunar material	Location photo (HD) Photo through LM window satisfactory if sample area in view	Suitable return container	Lunar surface material to provide a "sure" lunar sample for earth return only if the lunar stay is terminated early in the EVA period. The first lunar sample obtained will suffice.
12. Documented samples (M) and (HD) Rake/soil samples at: LM/ALSEP area Smoky Mt. Stone Mt. South Ray Crater ejecta North Ray Crater Cayley Plains near rim of large old crater.	Scoop 100-200 gm of soil and rocks at each major geological site on traverses and from each geological unit. Where rocks are too large, chips will be obtained. (M) Collect rake/soil sample including 1-kg rocks from 1-4 cm diameter and 1-kg soil sample from each rake/soil area. (M) Collect samples of local bedrock from around blocky-rimmed craters. (M) Collect several, roughly equidimensional rocks of 1-3 kg mass. (M) Select different types showing variations in color, texture, shape, degree of rounding, and mineral composition.	For each sample, the following Documented Sample Photography (M) 5 photographs: 3 before sampling (1 plus a stereo pair) 1 location (before or after sampling) 1 after sampling	In prenumbered 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. 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.

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
12. Documented samples (Continued)	Samples from each accessible layer of bedrock exposure. (M, if encountered) Samples from top, middle, and bottom of each bedrock layer greater than 10 m in thickness. (HD)			
13. Sampling profile (M)	Collect soil/rock samples along traverses crossing major contacts	At least one after photo (M)	In individual prenumbered bags	Important traverses are between S. Descartes Mountains, LM/ALSEP area, and south rim of North Ray Crater
14. Padded sample bags (M) Rocks 5-15 cm Site >500 m from LM	Collect dense, hard, nonfriable igneous rocks with varying degrees of roundness. Minimize handling. Avoid dusting.	Documented Sample Photography (M)	PSB's stored in LM Ascent Stage	Padded bags protect crystalline rock samples from fracture and surface abrasion thus preserving surface properties of samples.
15. Additional samples to maximize amount of material returned (M)	Collect samples of particular interest in order of priority in SRC: a) small rocks, b) soil in SCB's a) 15-20 cm equidimensional rock, b) 5-15 cm equidimensional rocks, c) soil Collect near end of available sampling time on each EVA.	Documented Sample Photography (M)	Loose in an SRC or SCB	15-20 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. 5-15 cm diameter: Similar to above. Several small rocks may be more valuable than one large rock because of higher statistical significance of more samples.

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
FTO 3) SOIL AND ROCK SAMPLING b. Special 16. 1 fillet sample - fillets around most of rock base Rock >30 cm In leval area (M1 or M6, if encountered) Rock preferably crystalline or tough breccia.	Scoop fillet material before taking chip from rock. Scoop nearby typical soil sample for reference.	Down-sun, location, and cross-sun stereo pair (M) Cross-sun stereo pair after sample (M) Close-up stereo pair after chip (M) Documented Sample Photography for reference soil (M)	Rock, fillet material, and nearby 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.
17. 2 lunar environment soil samples (M4) CSVC >1 km from LM SESC at North Ray Crater only if shadowed soil sample not previously collected. (Reference Activity 8)	Collect single core tube sample to be sealed in CSVC. Collect soil sample from bottom of trench at least 10 cm deep to be sealed in SESC. Fill SESC to near capacity.	Documented Sample Photography (M) Small exploratory trench photographs will suffice. (M)	CSVC in an SRC SESC	These samples will be the only truly virgin vacuum samples from the moon; provide biologically pure samples for gas analysis and for chemical and microphysical analyses.
18. Surface Sampler Device (SSD) Sample (M5) >1 km from LM/ALSEP, on Cayley but not on ray or near crater On side of rock shielded from LM.	Obtain two adjacent samples from undisturbed lunar surface. Precautions necessary to avoid kicking up dust or otherwise disturbing sample area. Take minimum-depth layer sample first. Second sample ~30 cm away.	No before photos If skim sample not taken, after sampling stereo pair is required (M)	Any container other than SRC	Taken with special surface sampler which collects very top layer of soil and rock grains for studies of soil particles, their effects, and for accurate microcrater counting. Top surface layers in previously returned core tube samples have been disarranged to the extent that such studies cannot be performed.

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
18. Surface Sampler Device (SSD) (Continued)				Knowledge of interaction of solar wind and cosmic radiation with lunar surface will yield better understanding of solar and galactic radiation and small scale lunar surface processes.
19. Surface skim sample (M5) Subsurface sample (HD) <1 m from SSD site	Scoop top few mm of regolith by skimming surface. Collect second soil sample from beneath skimmed area.	Documented Sample Photography (M) Cross-sun stereo pair after first skim (M)	In individual prenumbered bags	Samples and photos will provide data on radiation history of soil surface and soil mechanics.
Cores and Trenches 20. 1 double core tube sample (M) Equidistant between LM and ALSEP sites but not on ejecta blanket	Obtain core tube sample. Report number and order of multiple core tubes.	Standard Core Tube Photography(M) 3 photographs: 1 stereo pair 1 location (1 showing core tube embedded in surface)	In an SRC or sample collection bag	This activity provides 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.
21. 1 double core tube sample (M) Highest station on Stone Mt. Remote from fresh craters near rake/soil sample	Obtain core tube sample Report number and order of multiple core tubes.	Standard Core Tube Photography (M)	In an SRC or sample collection bag	

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
22. 1 double core tube sample (M) On ray from South Ray Crater	Obtain core tube sample.	Standard Core Tube Photography (M)	In an SRC or sample collection bag	
23. 1 double or single core tube sample (M) Highest station on Smoky Mt. Remote from fresh craters near rake/soil sample.	Obtain core tube sample. Report number and order of multiple core tubes.	Standard Core Tube Photography (M)	In an SRC or sample collection bag	
24. Any remaining core tube samples 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	
25. 2.6-meter drill core (M) On flat surface <20-30 m from HFE No crater >5 m between HFE and drill site.	Obtain sample using Apollo lunar surface drill	Standard Core Tube Photography (M)	Stow 2 drill stem sections in Beta cloth bag	This core provides the only certain deep sample of regolith which will help to determine stratigraphy in the sample area.

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
26. Small exploratory trenches (M) The following sites will be considered for trenching: a) near rim of small crater. In center (HD) b) Slopes of Stone and Smoky Mts. c) in a mound d) in an area where there is a change in surface characteristics such as color surface patterns, or mechanical properties e) in a distant crater ray	Dig trenches 20 degrees 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.	1 stereo pair (M) (after trenching) 1 location (M) (before or after sampling; after photo, if sample collected) Photos at crew's discretion if interesting features observed. (HD)	In prenumbered bag in an SRC or SCB	The intention is to determine the character of regolith down to 5 to 25 centimeters 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 provides opportunity to assess effect of surface erosion when compared with exposed rocks.
27. Separate soil/small rock samples (M) At S-200 trench or at least 50 m from LM.	Scoop samples from a trench; from bottom, side, top, and all discernible layers. Samples should include both soil and small rocks.	Photographs taken in support of S-200 (M) will suffice.	In prenumbered bags in an SRC.	Additional information on Soil Mechanics (S-200).

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
FTO 4) LUNAR FIELD RELATIONSHIPS				
28. Lunar surface features and field relationships (M) 500-mm lens will be used to photograph distant targets, e.g., North Ray Crater (M, if visited) HD Stone Mt. Smoky Mt. South Ray Crater exterior and interior (if visible) Baby Ray Crater Wreck Crater Stubby Crater Major boulder fields, rock ledges in outcrops Palmetto Crater Ravine Crater	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 of two sides; e) boundary zone between hillside and relatively level ground at its base; f) disturbed (footprints, wheeltracks, trenches) and undisturbed surface material.	Features and field relationships will be photographed at crew discretion. (HD) Short base stereo pair of targets of opportunity (HD). Include scale in photo when possible.	N/A	Geologic feature color and texture differences, infers age, origin, and composition of features. Undisturbed surface samples provide statistically unbiased sample of local regolith.
29. Panoramic Photographic sequences (M) Large areas of landing site. Areas of interest and distant features.	Take photographs based on following criteria: a) geological features of interest along traverse; b) from high elevation points from which unobstructed horizon can be seen; c) items of crew interest; d) one set per traverse station e) second pan with as wide a stereo base as practical within sampling area	15 photographs [20 (HD)] to provide 360-degree, overlapped coverage	N/A	These photographs, when joined as mosaics, provide accurate map control data.

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
30. 3 panoramic photograph sequences at LM (M) one set per EVA	Take photographs 6 m from LM at three positions approximately 120 degrees apart	15 (M) photographs [20 (HD)] to provide 360-degree, overlapped coverage	N/A	
31. Near-field polarimetric measurement photographs (M) At least 4 rock samples (M) 4 rock samples will be collected near North Ray Crater	Take photographs in area of rocks. If sampling photographs are taken between near- and far-field polarimetric measurements, filter may be left on in horizontal position. Collect samples in area where the near-field polarimetric measurement is taken. No soil in bags.	10 photographs (M) Down-sun photo plus 3 sets at 90°, 110° and 130° phase angles. Each set will include 3 different filter positions. 1 location photo and after photos (M)	N/A In documented prenumbered bags in an SRC or SCB	Comparison of polarimetric signatures with those of known materials will allow classification and correlation of lunar material even though textures are not resolvable.
32. Far-field polarimetric measurement photographs (M) Rim of North Ray Crater or, sample area of near-field photos.	Photos of inner wall across crater. Move at least 50 m down-sun from first position to view same area from different phase angle	Partial pans at two different phase angles between 50° - 130° (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) ORGANIC CONTROL SAMPLE 33. 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	
FTO 6) REMNANT MAGNETISM SAMPLES (2) 34. Passive Sample	None required	None required	Suitable bag- to remain in LM	Determine if magnetism of returned lunar samples is of moon origin or LM induced
35. In Situ Magnetic Measurement Sample	Ref: Lunar Portable Magnetometer Experiment	Ref: Lunar Portable Magnetometer Experiment	DSB	

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	TRAVERSE/ STATION NO.	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
Soil Mechanics (S-200)					
Trench (M)	Excavate a narrow trench immediately adjacent to a penetrometer test location; sunlit wall should be vertical and smooth. Comment on any layers (or strata) detected while excavating the trench. Describe excavation; estimate depth and time required to complete as well as natural slope of excavated material	Trench excavation site corresponding to double core tube site, midway between LM and ALSEP site	1) Location photograph (M) 2) After excavation, stereo pair down-sun (M) 3) After wall collapse, stereo pair of sunlit face perpendicular to wall and stereo pair down-sun (M) parallel to wall 4) Television coverage of trench operation (M)	N/A	Equidistant between LM and ALSEP sites; a minimum of 8 cm wide and, at least, 30 cm long aligned 20 degrees off the sun line, to a depth of 15 cm
5 penetrometer tests (M)	Perform tests following trench excavation: 4 tests - 0.2 $in.^2$ cone 1 test - 0.5 $in.^2$ cone	Trench excavation site - 2 tests (0.2 $in.^2$ cone and 0.5 $in.^2$ cone); 2/3 distance to ALSEP site-1 test (0.2 $in.^2$ cone); 1/3 distance to ALSEP site-1 test (0.2 $in.^2$ cone); At ALSEP site-1 test (0.2 $in.^2$ cone)	Each penetrometer test will be documented by television coverage(M) Photos of penetrometer test sites (HD)	N/A	Final test performed near drill core sample location at ALSEP site. For each test, astronaut should apply a smooth, even force when using the penetrometer and should comment on penetration number as read from self-recording penetrometer indexing system, on smoothness of application of pressure upon the penetrometer and any abrupt changes in force applied, and on abrupt changes in resistance to penetration of the cone penetrometer as would indicate the presence of hard subsurface layers, rock fragments, or very soft substrata or cavities

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	TRAVERSE/ STATION NO.	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
1 plate load test (M)	Perform test at top of trench with 1 in. x 5 in. plate	Trench excavation site	Plate load tests will be documented by trench photographs after wall collapse (M)	N/A	5 in. side of plate should be parallel to and one-third trench depth from the smooth vertical wall. Test not performed if trench wall collapses during excavation
1 plate load test (M)	Perform test adjacent to double core tube site in region of trench excavation using 1 in. x 5 in. plate		Plate load test will be documented by trench photographs after wall collapse (either natural collapse or collapse induced by first load plate test) (M)	N/A	
4 penetrometer tests (M)	Perform tests adjacent to planned core tube site on Stone Mt. using 0.5 $in.^2$ cone or 0.2 $in.^2$ cone	Stone Mt.	Photos of penetrometer test sites (HD)	N/A	
Photographs of LM, lunar surface, etc. (M and HD)	Take photographs				See Photographic Plan, Section III, Table 3-3, for details
Solar Wind Composition (S-080) (M)	Remove experiment from LM MESA and deploy it on the lunar surface. Retrieve the reel and foil, place in teflon bag, store in LM. Comment on location of experiment with respect to LM, attitude of foil with respect to sun, and total time foil was deployed	At LM	4 photographs:(HD) One stereo pair cross-sun showing staff and entire foil. One of upper part of deployed SWC showing reel and marks immediately after deployment. One like the previous one, just before retrieval of foil	Teflon bag in LM	Deployed during the first EVA Retrieval should be as late as possible during last EVA

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	TRAVERSE/ STATION NO.	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
Apollo 16 ALSEP Array					
Central Station (C/S) and Radioisotope Thermoelectric Generator (RTG) (M)	Deploy and activate the C/S and RTG: Subpackages 1 and 2 and the radioisotope fuel source will be removed from the LM; the fuel source will be placed in the RTG on subpackage 2; subpackages 1 and 2 will be attached to the antenna mast and carried barbell style to the deployment site; the lunar surface drill will be transported on the LRV; the experiments will be removed from the subpackages, assembled, and cables connected at the deployment site; the antenna from subpackage 1 will be erected on the C/S and pointed toward earth; the transmitter will be turned on.	ALSEP site	4 photographs(HD): 2 of the C/S 1 of the RTG 1 of the entire deployed ALSEP	N/A	≥92 m from LM; during the first EVA. The astronaut pushes a switch which removes the shorting plug and reports this action to the MCC. After sufficient time for safe power build-up, the MCC requests the astronaut to put switch 1 in the ON position. This applies power to the C/S and the transmitter is turned ON automatically if it was in the ON condition at launch; if not, the ground will command transmitter ON. The ground will command individual experiments ON; if this fails, or if the transmitter fails to go ON by ground command, the astronauts will manually activate the appropriate switches on the C/S.
Passive Seismic (S-031) (M)	Deploy, coarse level, and rough align the sensor assembly. Deploy the thermal shroud. Perform a fine leveling and report azimuth readings to MCC.	ALSEP site	2 photographs(HD): 1 showing bubble level and gnomon shadow on compass rose; 1 with C/S in background.	N/A	Part of Apollo 16 ALSEP Array.

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	TRAVERSE/ STATION NO.	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
Active Seismic (S-033) (M)	Deploy, level, and align mortar package 16.8 m away from C/S. Deploy geophone cable in same direction as mortar flight azimuth with geophones in a straight line at distances of 3, 49, and 95 m from the mortar package. Activate 19 ASI changes at marked intervals along geophone cable	ALSEP site	1 photograph of the mortar package, taken from 15 feet and showing the central station in the background (HD) 1 photograph of the mortar package, taken from 7 feet and looking down-sun toward grenade impact area (HD) Television coverage of one geophone deployment and one thumper activation (HD)	N/A	Part of Apollo 16 ALSEP Array
Lunar Surface Magnetometer (S-034) (M)	Deploy, level, and align the sensor assembly. Report shadowgraph readings to MCC and put sun shield on top	ALSEP site	2 photographs(HD): 1 of shadowgraph 1 of sensor heads with C/S in background	N/A	Part of Apollo 16 ALSEP Array
Heat Flow (S-037) (M)	Deploy, level, and align the electronics package. Drill 2 holes, 2.6 m deep and 9.1 m apart, with lunar surface drill; insert 1 sensor probe into each emplaced bore stem with probe tool and report the appropriate marking to determine the probe depth	ALSEP site	7 photographs(HD): 1 of each drilled hole with probes inserted; 1 of the electronics package; 1 stereo pair of each bore stem	N/A	Part of Apollo 16 ALSEP Array

Table 4-1. Experiment Activities (Continued)

EXPERIMENT (NUMBER) ACTIVITY (PRIORITY)	ASTRONAUT ACTIVITIES	TRAVERSE/ STATION NO.	PHOTOGRAPHS	STOWAGE	RATIONALE/REMARKS
Cosmic Ray Detector (Sheets) (S-152) (M)	Pull "red" lanyard to completely expose hidden detector surfaces. Record and report time of lanyard pulling and amount of dust on the visible surfaces. Remove, fold, and stow detector panels; report time of removal	At LM	2 photographs: 1 of detector panels before (M) and 1 after (HD) pulling lanyard No. 1. ("red" lanyard)	In detector panel stowage bag in LM	Remove detector panels at end of last EVA; record temperature indicator data
Portable Magnetometer (S-198) (M)	Take a site point measurement at least 76 m from the LM (at Station 2)	At LM	1 of sensor head at each measurement site (HD)	N/A	Traverse measurements at four major crater stops (Stations 2, 15, 16, and 17)
	Take at least one measurement on each of two planned LRV traverses	Traverse Station			
	Take measurement of local igneous rock sample placed on sensor head following normal traverse measurement (M); report measurement with sample removed (HD)	Last LPM traverse station	1 of igneous sample on sensor head (HD). Documented Sample Photography of selected sample (M)	Stow sample in DSB	To be performed at Station 17
Far UV Camera/Spectroscope (S-201) (M)	Remove lunar surface UV camera and set it up in the shadow of LM with battery pack in sun. Level and zero-align camera, turn power on, point camera at each target, and initiate automatic exposure sequence. Remove and stow film	In LM shadow	2 photographs (HD): 1 of deployed instrument 1 of azimuth circle	In the film transport stowage bag	Remove film transport device with film at end of last EVA

Table 4-2(a). LRV Traverse Data - Traverse I

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE			
LM	-	-	97	97	N/A	N/A	1:37	Cayley Plains	Egress and EVA preparation.
Travel	0.10	0.10	01	98	-	-	1:38	Cayley Plains	Travel to ALSEP location.
ALSEP	-	-	144	242	N/A	N/A	4:02	Cayley Plains	ALSEP deployment.
Travel	1.5	1.60	12	254	-	-	4:14	Across Cayley Plains and Rays	Observe Station 2 area and distribution of ray material.
1 (Flag Crater)	-	-	43	297	36	36	4:57	Flag Crater, about 300 meters in diameter in Caylay Plains; adjacent ray from South Ray Crater	Exploration of crater and observations of adjacent ray: • Pan; Take 2nd Pan if time permits • Crater sampling (use padded bags here) • Rake/Soil Sample
Travel	0.65	2.25	5	302	-	-	5:02	Across Cayley Plains and Rays	Assess Station 2 region for best sampling area.

2 (Spook Crater locale)	-	-	56	358	49	85	5:58	Spook Crater (about 300-m diameter) and small blocky crater to the north	Assess site geology and, based on this and results from Flag Crater, divide time between Spook and small blocky crater:
									• Pan
									• Documented sampling
									  • Spook Crater rim
									  • Blocks associated with small crater
									• 500-mm photography of outlying areas
									• LPM Site Measurement

Travel	0.85	3.10	7	365	-	-	6:05	Cayley Plains	Observe ray patterns and terrain of EVA II route to Stone Mountain.

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

Table 4-2(a). LRV Traverse Data - Traverse I (Continued)

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE			
3 (LM/ ALSEP Vicinity)	-	-	14	379	11	96	6:19	Cayley Plains between LM and ALSEP	• LRV Grand Prix • Retrieve 2.6m Core Sample • Arm Mortar Package
Travel	0.05	3.15	1	380	-	-	6:20		Travel to LM.
LM	-	-	40	420	NAP	NAP	7:00	Cayley Plains	EVA closeout.

Table 4-2(b). LRV Traverse Data - Traverse II

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE			
LM	-	-	50	50	N/A	N/A	0:50	Cayley Plains	Egress and EVA preparation.
Travel	4.20	4.20	35	85	-	-	1:25	Across Cayley Plains and rays from South Ray Crater and up on Stone Mountain	Observe distribution of rays, abundance of blocks, and secondary craters. Observe any changes of regolith characteristics upon approach to and on Stone Mountain slope.
4 (Stone Mt. Highest Traverse Elevation)	-	-	58	143	51	51	2:23	Small craters at base of terrace in Descartes Formation. The highest point reached in the Descartes Formation on Stone Mountain.	Observation and sampling of Descartes formation: • Pan; Take 2nd Pan at end of stop, time permitting • Penetrometer Tests • Documented Sampling • Rake/Soil Samples • Double Core Sample • 500-mm Photography
Travel	0.80	5.00	7	150	-	-	2:30	Descartes Formation (Stone Mountain Slope)	Observe any changes of regolith characteristics upon descent from Stone Mountain. Note slope characteristics on Stone Mountain.
5 (Stone Mt-Midway down slope)	-	-	40	190	33	84	3:10	Intermediate area in cratered and terraced region of Descartes Formation.	• Pan; Take 2nd Pan at end of stop, time permitting • Documented Sampling
Travel	0.40	5.40	3	193	-	-	3:13	Descartes Formation to base of Stone Mountain	Observe terraces and any bedrock/regolith changes.
6 (Stone Mt. - Base)	-	-	20	213	17	101	3:33	Descartes Formation at base of Stone Mountain	Observation and sampling of Descartes Formation: • Pan • Documented Sampling

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

Table 4-2(b) LRV Traverse Data - Traverse II (Continued)

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE			
Travel	0.40	5.80	3	216	-	-	3:36	Descartes Formation	Observe terraces and any bedrock/regolith changes.

7 (Stone Mt. Base and Stubby Crater Locale)	-	-	15	231	8	110	3:51	In Descartes Formation at base of Stone Mountain near Stubby Crater	Observe relations between Cayley and Descartes Formation in Stubby Crater area:
									• Pan
									• Documented Sampling
									  • Stubby Rim
									• 500-mm photography
									  • South wall of Stubby Crater
									  • Other targets

Travel	0.60	6.40	5	236	-	-	3:56	Across Cayley Formation to rays from South Ray Crater	Observe changes in regolith and note characteristics of rays.
8 (South Ray Rays and Stubby Crater Locale)	-	-	60	296	53	163	4:56	In rays from South Ray Crater overlying Cayley and Stubby Crater rim	In blocky ray area: • Pan; Take 2nd Pan, time permitting • Documented Sampling • Rake/Soil Sample • Double Core Sample • Boulder Sampling Operations
Travel	0.45	6.85	4	300	-	-	5:00	Across Cayley Formation	Observe changes in regolith and note characteristics of rays
9 (Cayley Plains)	-	-	25	325	18	181	5:25	Cayley Plains area	• Pan • Documented Sampling • CSVC • Top Surface Layer Samples

Table 4-2(b). LRV Traverse Data - Traverse II (Continued)

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE			
Travel	2.60	9.45	21	346	-	-	5:46	Across Cayley Plains	Observe ray and block distribution, compare to other rays and regolith.
10 (LM/ ALSEP Area-Station 3 Locale)	-	-	33	379	26	207	6:19	Cayley Plains between LM and ALSEP	• Double Core Sample • Soil Mechanics Trench • Trench Samples • Penetrometer Tests • Brief Documented Sampling Period
Travel	0.05	9.50	1	380	-	-	6:20	Cayley Plains	Characteristics of Cayley and Rays.
LM	-	-	40	420	N/A	N/A	7:00	Cayley Plains	Closeout.

Table 4-2(c). LRV Traverse Data - Traverse III

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE			
LM	-	-	45	45	N/A	N/A	0:45	Cayley Plains	Egress and prepare for traverse
Travel	5.50	5.50	44	89	-	-	1:29	Across Cayley to North Ray Crater	Observe Cayley and Rays from North Ray Crater Observe block distribution and variety while maneuvering through outer ejecta blanket
11 (North Ray Crater Rim)	-	-	55	144	48	48	2:24	South rim of North Ray Crater	• Pan; Take 2nd Pan prior to leaving station • 500-mm photography of north crater rim and interior • Documented Sampling • Near field and far field polarimetric photography and near field polarimetry sampling • 2nd far field polarimetric photography before leaving station
Travel	0.35	5.85	3	147	-	-	2:27	Around rim of North Ray Crater	Observe rays and approach to ejecta blanket - Note block variety and distribution
12 (North Ray Crater Rim)	-	-	55	202	48	96	3:22	Area of very large blocks on southeast rim of North Ray Crater	• Pan; Take 2nd Pan before leaving, time permitting • Documented Sampling • Rake/Soil Sample • 500-mm photography of far crater rim and interior
Travel	0.65	6.50	5	207	-	-	3:27	Down slope and outer ejecta blanket of North Ray Crater	Observe block distribution and variety
13 (North Ray Crater Ejecta Blanket)	-		10	217	7	103	3:37	Area near outer ejecta blanket of North Ray Crater	Examine Ejecta: • Pan • Rock/Soil Sample

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

Table 4-2(c). LRV Traverse Data - Traverse III (Continued)

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE			
Travel	0.85	7.13	7	224	-	-	3:44	From North Ray blanket ejecta to base of Smoky Mountain (Descartes Formation) near Ravine Crater	Observe transition with Smoky Mountain.
14 (Smoky Mountain Base)	-	-	40	264	33	136	4:24	Crater cluster at base of Smoky Mountain near Ravine Crater	In Descartes Formation • Pan; Take 2nd Pan before leaving, time permitting • 500-mm photography of Smoky Mountain • Documented Sampling • Rake/Soil Sample • Double Core Sample
Travel	1.35	8.70	11	275	-	-	4:35	From base of Smoky Mountain (Descartes Formation) To Dog Leg Crater in the Cayley Formation	Observe transition with Smoky Mountain.
15 (Dog Leg Crater)	-	-	10	285	7	143	4:45	Small crater in the Cayley Formation	In Cayley Plains: • Pan • LPM measurement • Rock/Soil Sample
Travel	1.10	9.80	9	294	-	-	4:54	South across Cayley Plains to Dot Crater	Observe Cayley formation and rays emanating from North Ray Crater.
16 (Dot Crater)	-	-	10	304	7	150	5:04	Dot Crater, Blocky-Rimmed, possibly concentric crater	• Pan • Rock/Soil Sample • LPM measurement

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Table 4-2(c). LRV Traverse Data - Traverse III (Continued)

STATION OR TRAVEL	DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES	OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE			
Travel	0.55	10.35	5	309	-	-	5:09	Across Cayley Plains to Palmetto Crater	Observe lateral changes in Cayley characteristics.
17 (Pal-metto Crater)	-	-	38	347	31	181	5:47	Cayley Plains near Palmetto Crater	• Pan; Take 2nd Pan at end of stay, time permitting • Documented Sampling • Rake/Soil Sample • LPM site measurement • LPM igneous sample measurement
Travel	2.25	12.60	18	365	-	-	6:05	Across Cayley Plains toward LM	Observe characteristics of Cayley Plains.
LM	-	-	55	420	N/A	N/A	7:00	Cayley Plains	LRV Grand Prix No. 2 Closeout

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Table 4-3(a). Walking Traverse Data - Traverse I

STATION OR TRAVEL	ACTUAL DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES/OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULATIVE	INDIVIDUAL	CUMULATIVE	INDIVIDUAL	CUMULATIVE		
LM	-	-	97	97	N/A	N/A	1:37	Cayley Plains - Rolling to smooth volcanic forms of the lunar highlands. Egress LM ALSEP, Science Equipment unloading
Travel	0:10	0:10	2	99	-	-	1:39	Across Cayley Plains to ALSEP deployment area.
ALSEP Site	-	-	144	243	N/A	N/A	4:03	ALSEP Deployment
Travel	0:85	0:95	21	264	-	-	4:24	Across Cayley Plains and large crater rays to vicinity of Spook Crater and small blocky crater to the north of Spook.
A (Spook Crater Locale)	-	-	60	324	57	57	5:24	Exploration of crater, assess geology • Pan • Crater sampling (padded bags) of Spook Crater Rim and blocks associated with small crater • 500-mm photography
Travel	0:90	1:85	22	346	-	-	5:46	Cayley Plains Observe ray patterns and terrain of EVA II route
B (Midway Between LM and ALSEP Site)	-	-	39	385	36	93	6:25	Cayley Plains - Midway between LM and ALSEP site • Pan • Soil/Rake Sample • Double Core Tube • Trench and Penetrometer Measurements • Soil Samples from Trench
Travel	0:05	1:90	1	386	-	-	6:26	Travel to LM
LM	-	-	35	421	N/A	N/A	7:01	EVA closeout

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

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Table 4-3(b). Walking Traverse Data - Traverse II

STATION OR TRAVEL	ACTUAL DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES/OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE		
LM	-	-	45	45	N/A	N/A	0:45	Cayley Plains - Egress & EVA preparation
Travel	2.9	2.9	70	115	-	-	1:55	Across Cayley Plains to base of terrace in Descartes formation. Observe terraces and any bedrock/regolith changes.
C (Base of Stone Mountain)	-	-	75	190	72	72	3:10	Small craters at base of terrace in Descartes formation (Stone Mt.). Note characteristics of Descartes formation and local geology - compare to Cayley, assess terraces. • Pan • Documented Sampling Surface Sampler Rake/Soil Sample • 500-mm Photography
Travel	0.8	3.7	19	209	-	-	3:29	Descartes Formation - Observe Craters/Blocks
D (Base of Stone Mountain)	-	-	71	280	68	140	4:40	Stone Mountain/Stubby Crater vicinity - Descartes Formation at base of Stone Mountain. Observe relations between Cayley and Descartes Formation in this area. • Pan • Documented Sampling of Stubby Rim • 500-mm Photography
Travel	3.0	6.7	72	352	-	-	5:52	Across Cayley to area midway between ALSEP site and LM
E	-	-	32	384	29	169	6:24	• Pan • Documented Sampling • Special Surface Sampler • Rake/Soil Sample • CSVC Single Core

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

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Table 4-3(b). Walking Traverse Data - Traverse II (Continued)

STATION OR TRAVEL	ACTUAL DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES/OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE		
Travel	0.05	6.8	1	385	-	-	6:25	Return to LM across Cayley Plains.
LM	-	-	35	420	N/A	N/A	7:00	EVA closeout.

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Table 4-3(c). Walking Traverse Data - Traverse III

STATION OR TRAVEL	ACTUAL DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)*		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES/OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE		
LM	-	-	40	40	N/A	N/A	0:40	Egress and prepare for traverse
Travel	2.10	2.10	50	90	-	-	1:30	Across Cayley skirting subdued crater (Palmetto) stopping slightly north and east of this crater.
F (NE Rim of Palmetto Crater)	-	-	75	165	72	72	2:45	Rim of subdued crater-Palmetto Crater - in Cayley Plains • Pan • Documented samples of crater rim • Soil/Rake Samples • 500-mm Photography
Travel	0.25	2.35	6	171	-	-	2:51	Across Cayley Plains near rim of Palmetto Crater Observe lateral changes in Cayley characteristics.
G (East Rim of Palmetto Crater)	-	-	50	221	47	119	3:41	• Documented Sampling • Double Core Sample • Soil/Rock Sample
Travel	0.8	3.15	19	241	-	-	4:01	Around SE rim of Palmetto Crater Observe lateral changes in Cayley characteristics
H (South Rim of Palmetto Crater)	-	-	26	267	23	142	4:27	• Pan • Documented Sampling of Palmetto Crater rim • Soil/Rake Sample
Travel	0.80	3.95	19	286	-	-	4:46	Across Cayley Plains - south of Palmetto Crater - toward LM.

*Station Science Time equals Station Stop Time minus Station Stop Overhead.

Table 4-3(c). Walking Traverse Data - Traverse III (Continued)

STATION OR TRAVEL	ACTUAL DISTANCE (km)		STATION STOP OR TRAVEL TIME (min)		STATION SCIENCE TIME (min)		EVA TIME AFTER EVENT (hr:min)	GEOLOGICAL FEATURES/OBSERVATIONS AND ACTIVITIES
	TO STATION	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE	INDIVID-UAL	CUMULA-TIVE		
I (Volcanic Region N of LM)	-	-	50	336	47	189	5:36	Investigate small volcanic area Documented Sampling
Travel	0.60	4.55	14	346	-	-	5:50	Across Cayley Plains to the LM
LM	-	-	65	411	N/A	N/A	6:55	EVA closeout.

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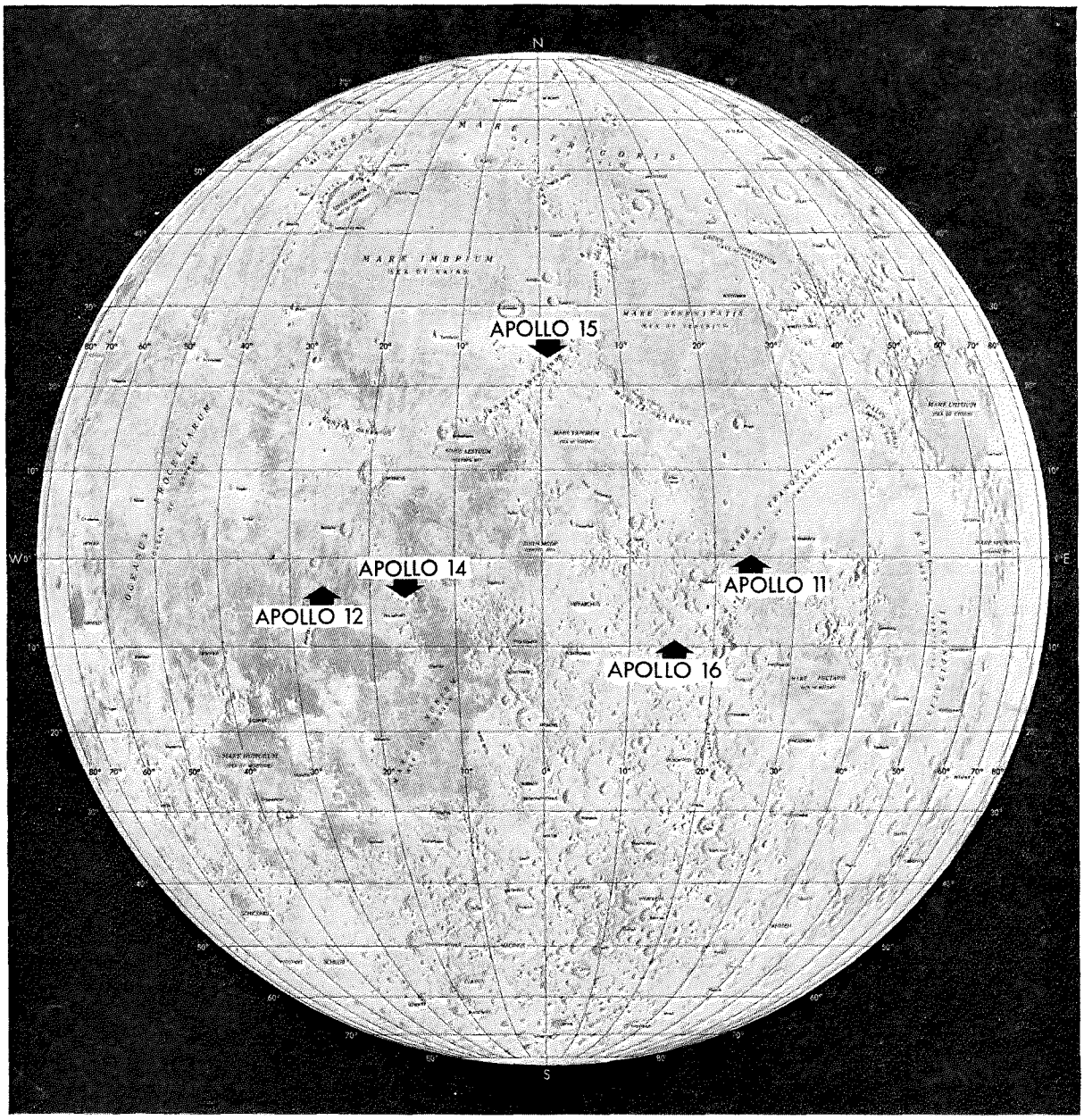

Figure 4-1. Apollo 16 Landing Site (Descartes) Relationship to Previous Lunar Landing Sites

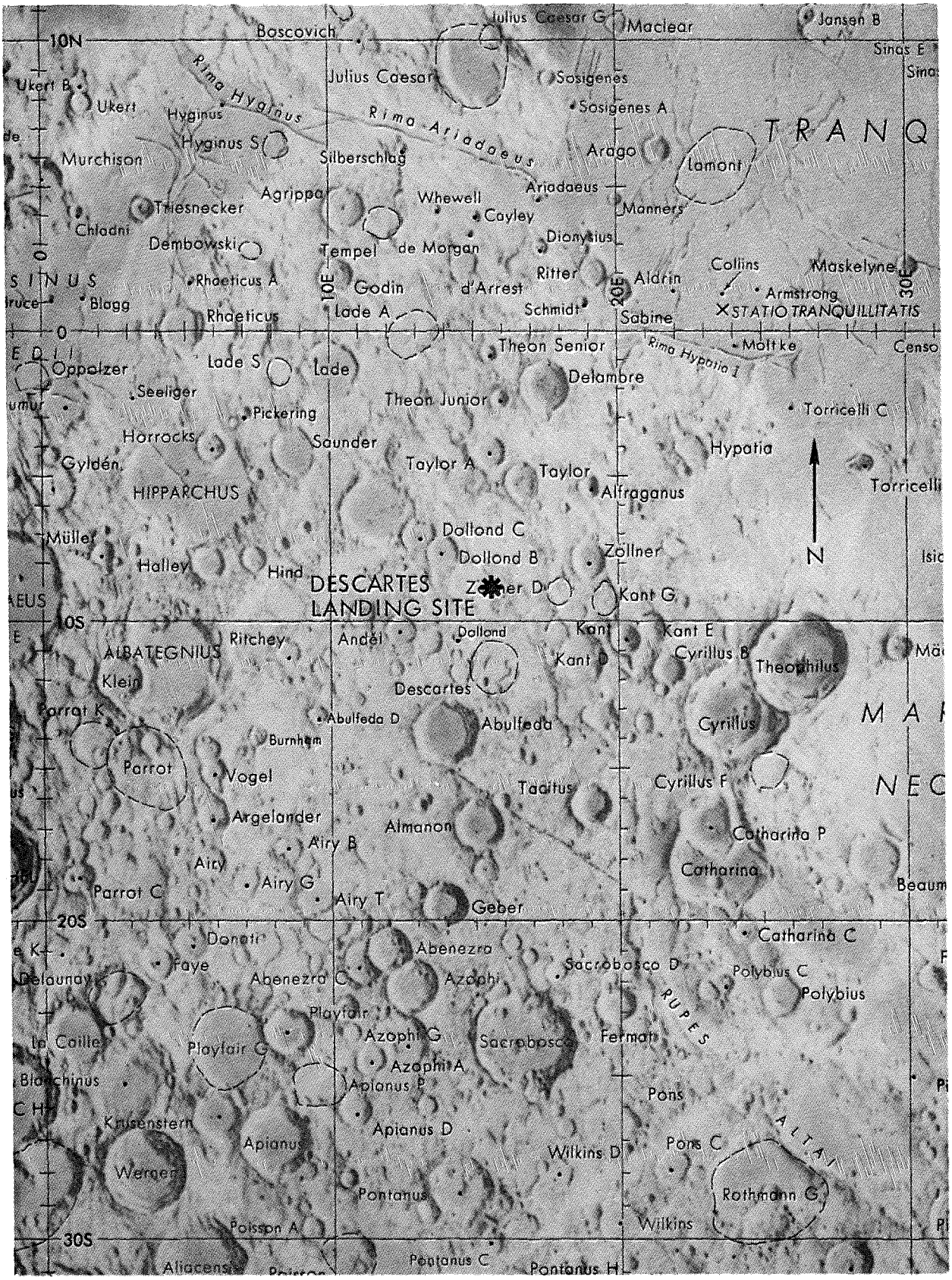

Figure 4-2. LM Landing Site in the Descartes Area

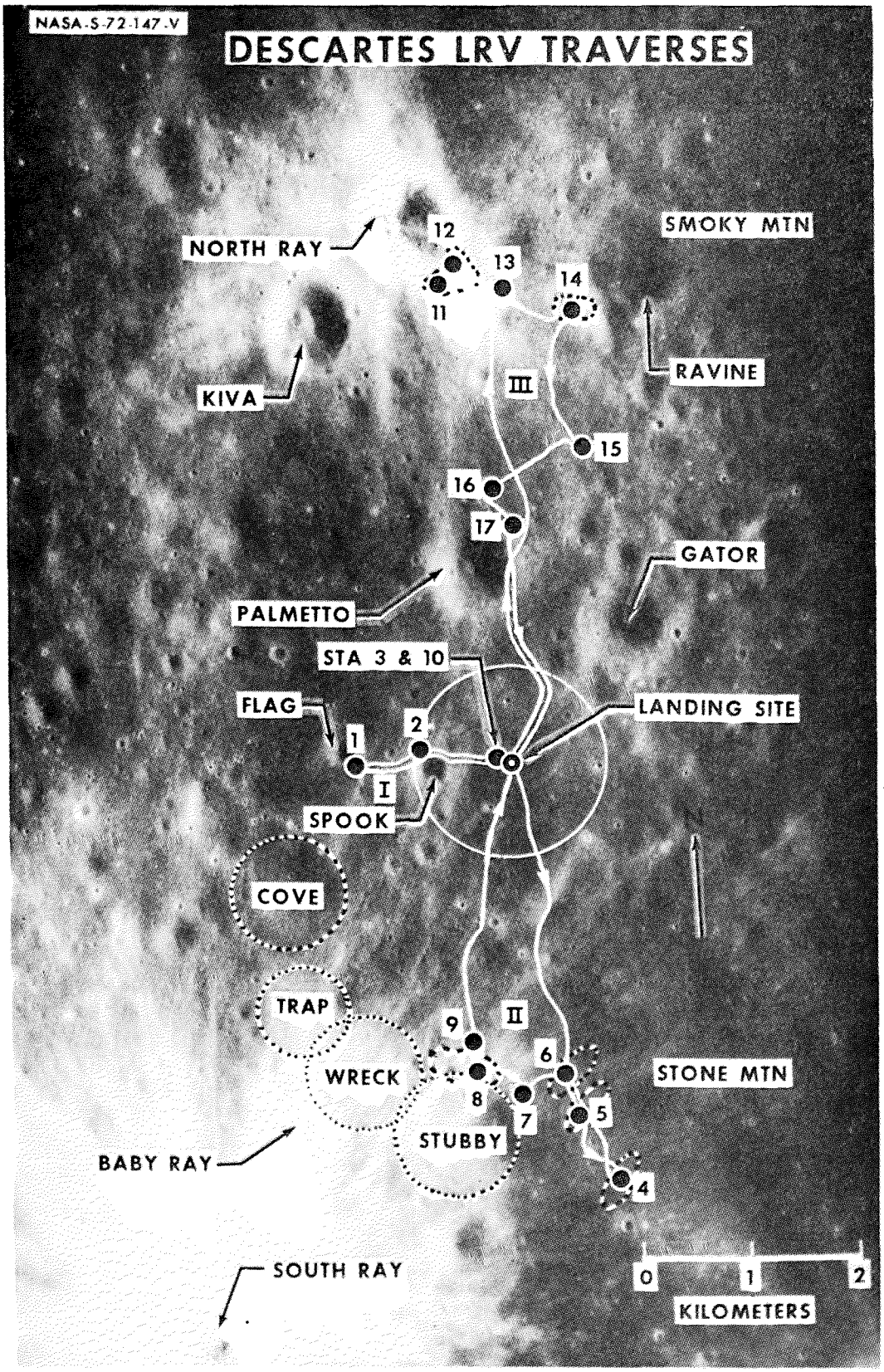

Figure 4-3. Descartes Landing Area and LRV Traverse Routes

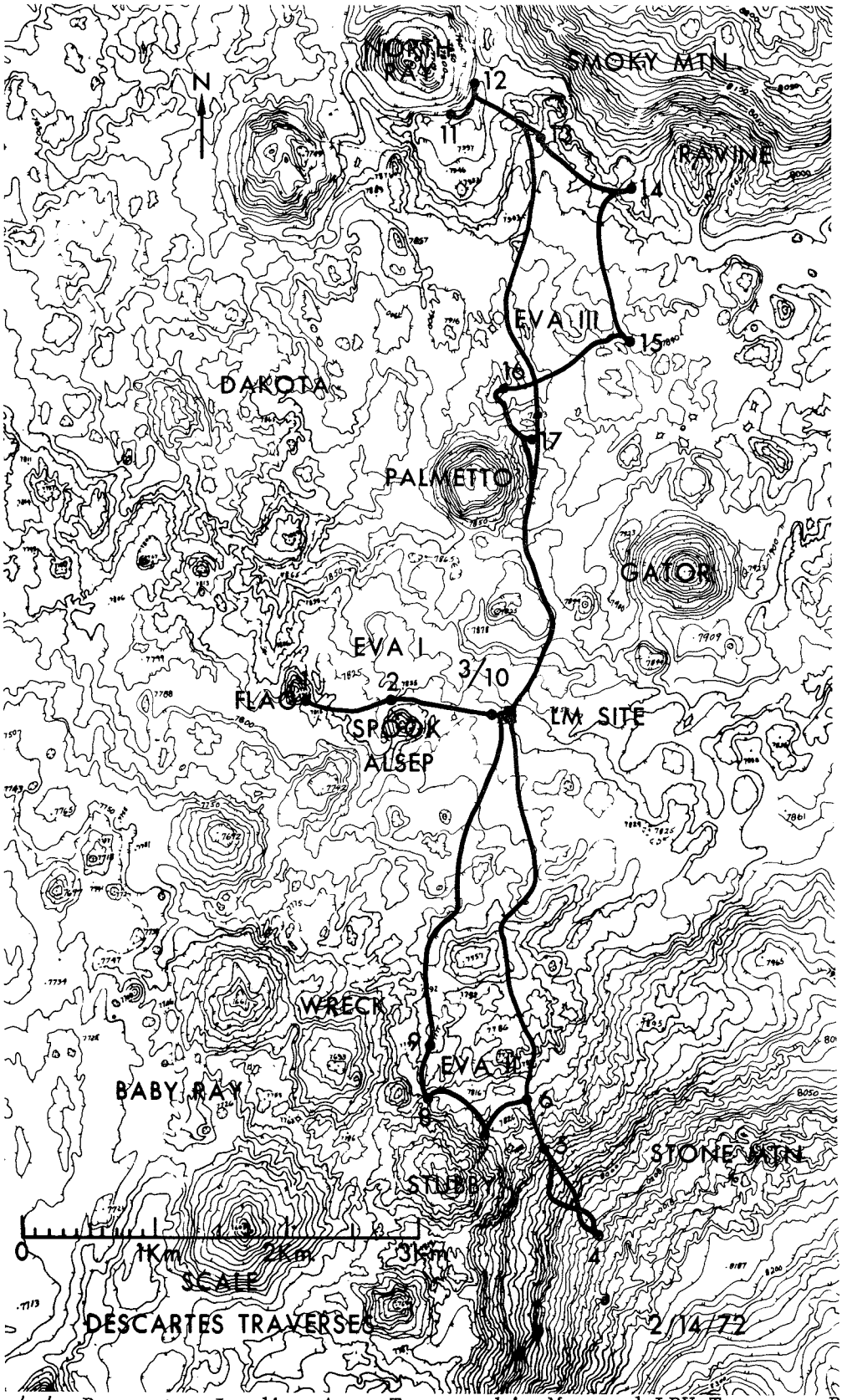

Figure 4-4. Descartes Landing Area Topographic Map and LRV Traverse Routes

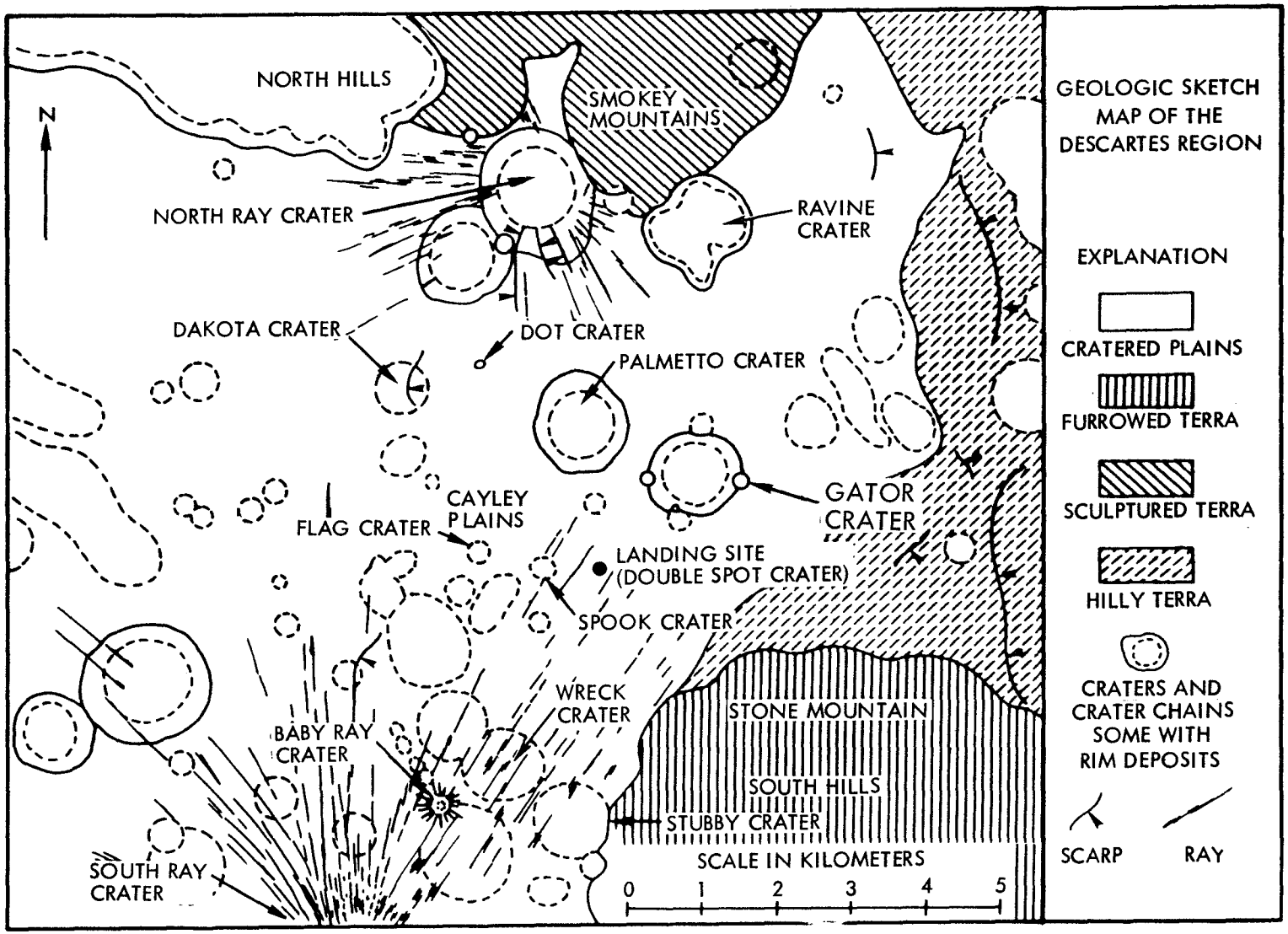

Figure 4-5. Geologic Units of the Selected Descartes Landing Area

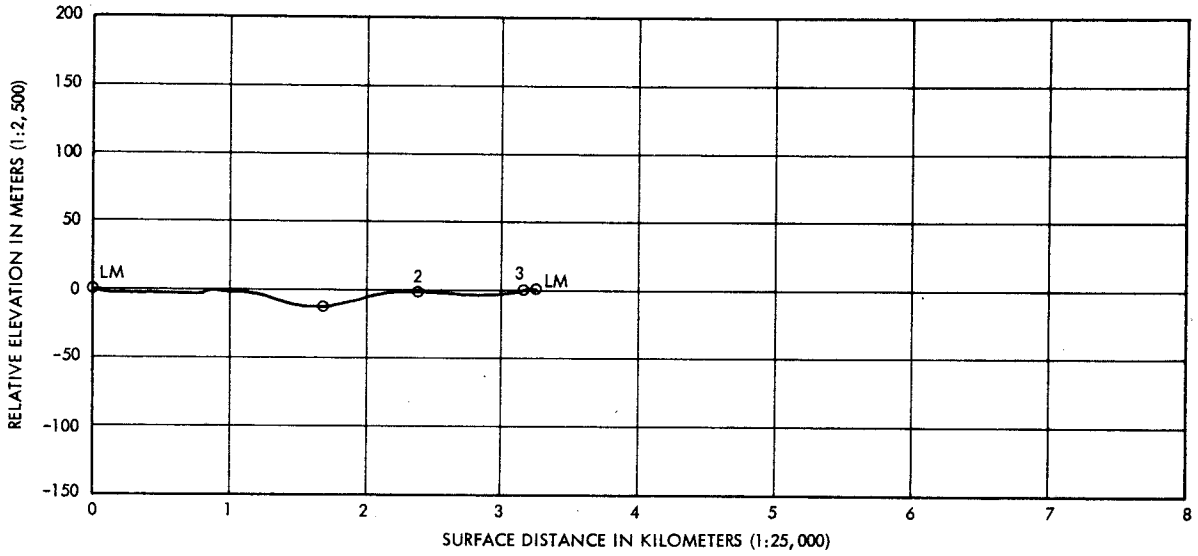

Figure 4-6(a). Descartes LRV Traverse Elevation Profile - Traverse I

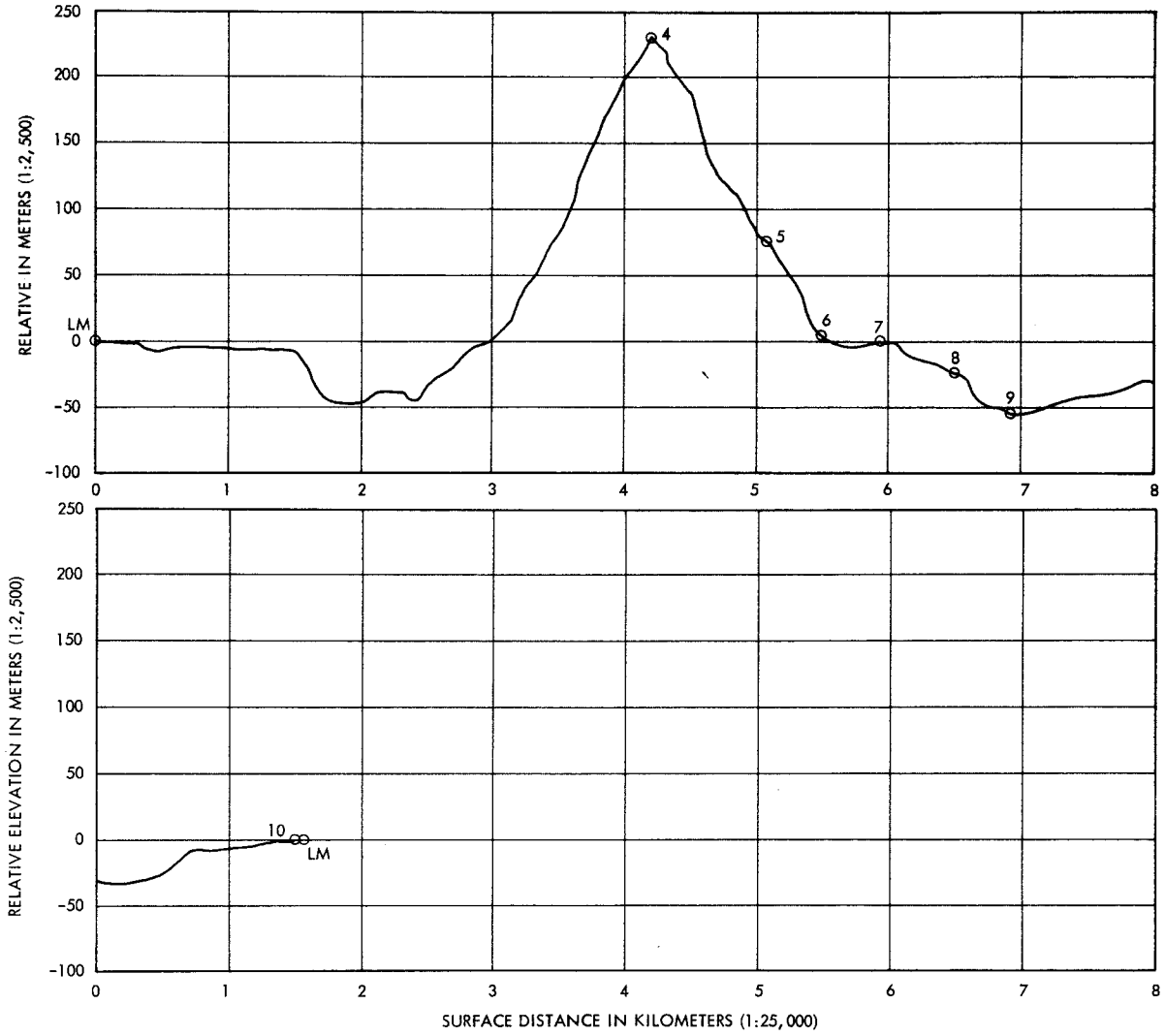

Figure 4-6(b). Descartes LRV Traverse Elevation Profile - Traverse II

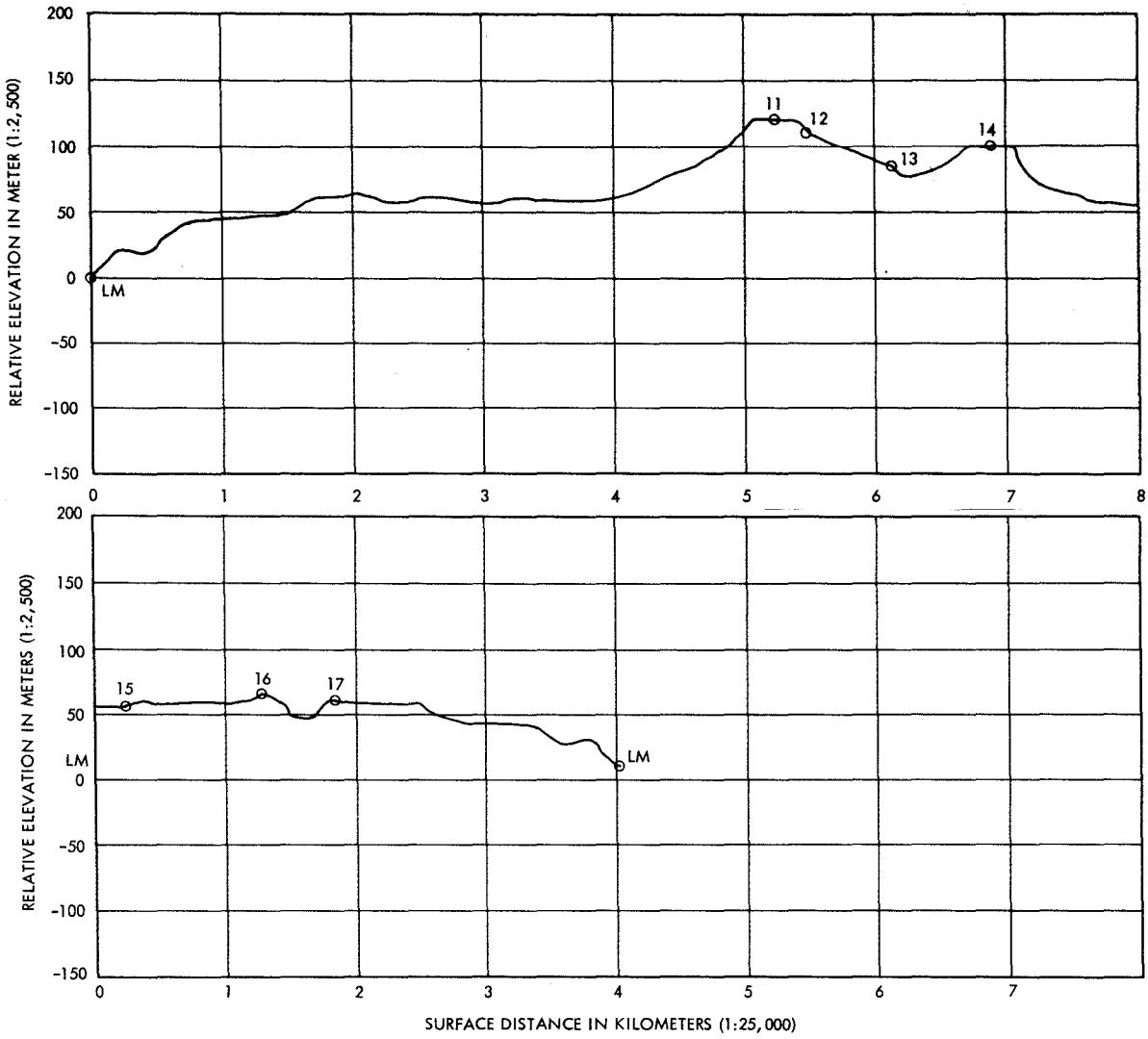

Figure 4-6(c). Descartes LRV Traverse Elevation Profile - Traverse III

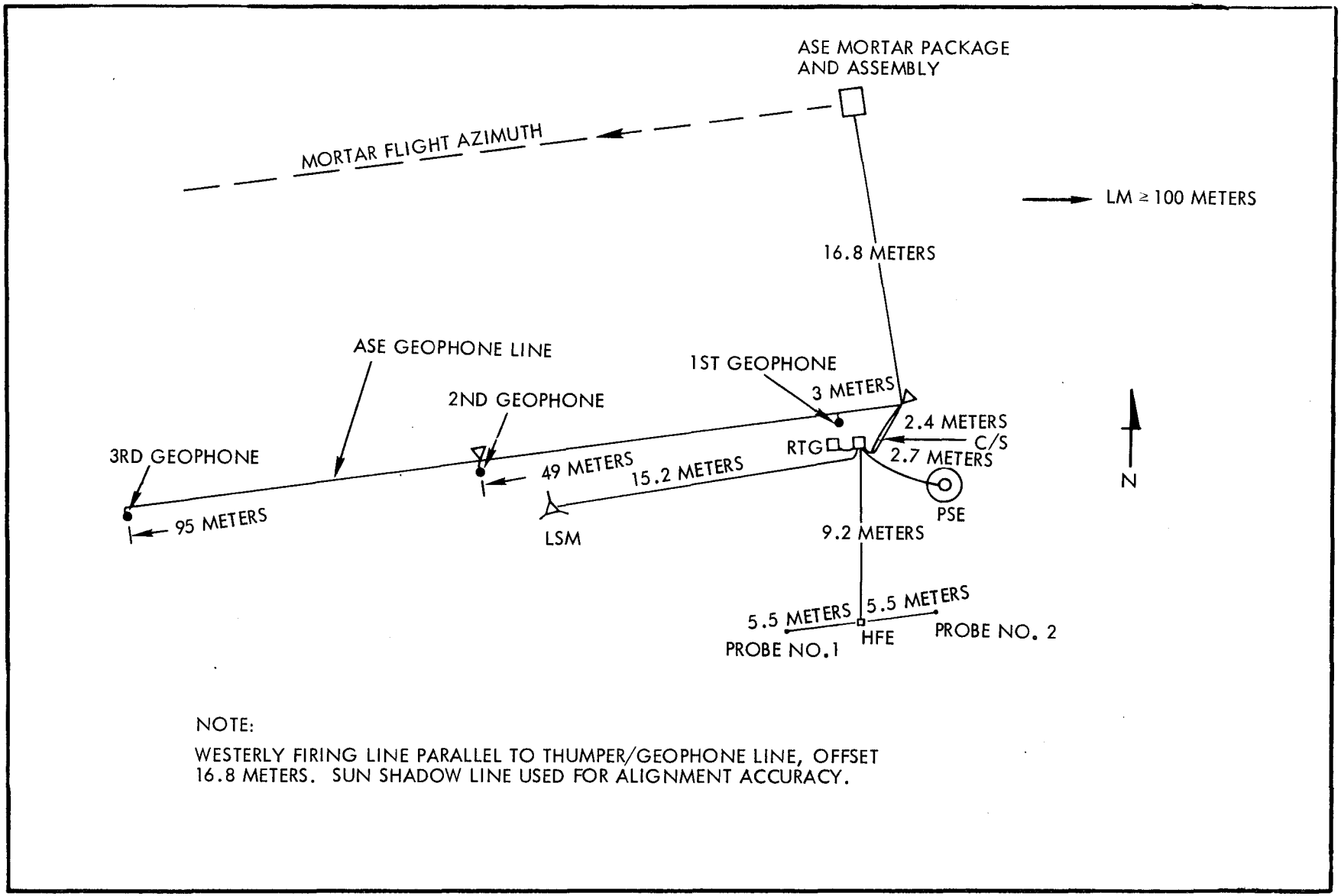

Figure 4-7. Apollo 16 ALSEP Nominal Deployment

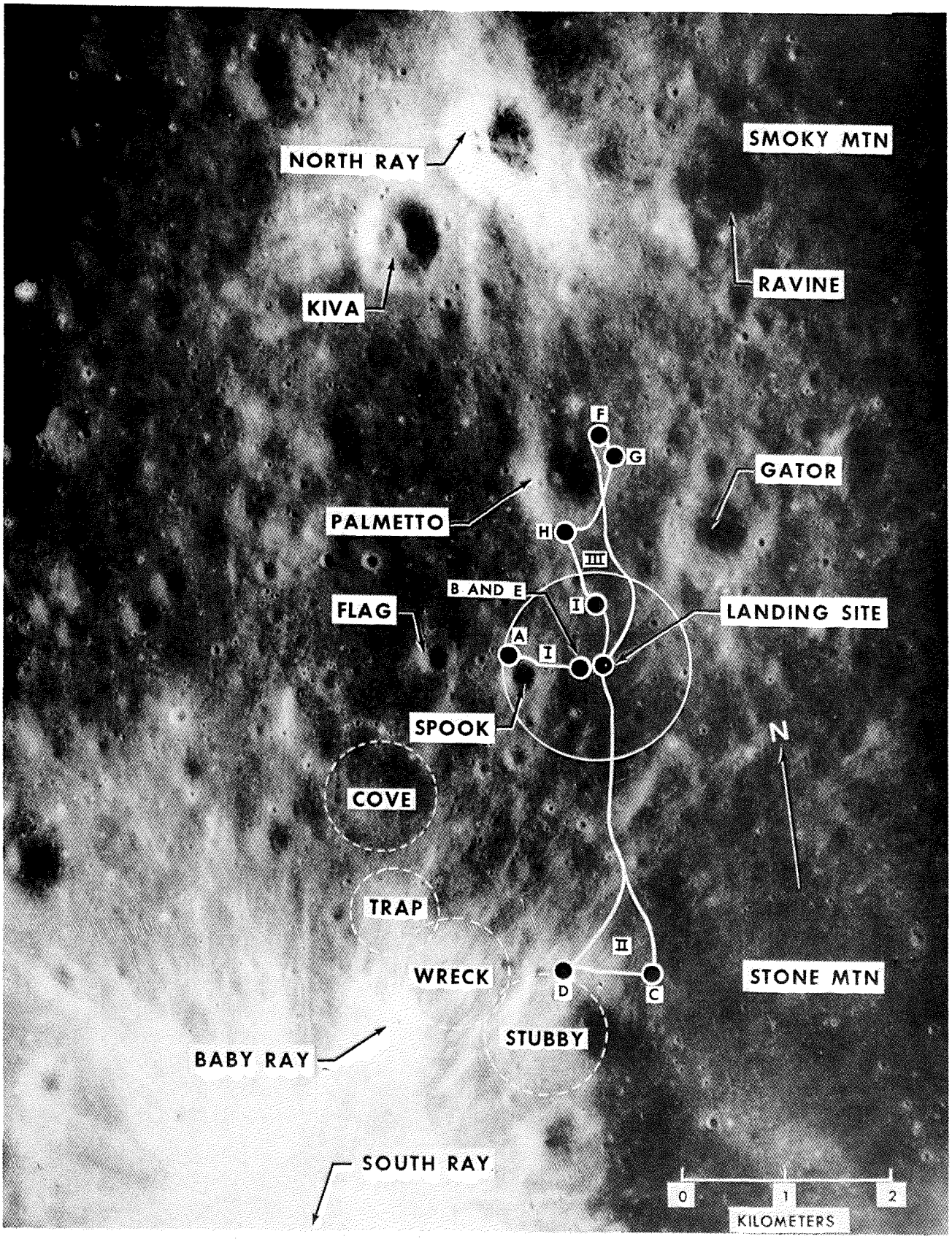

Figure 4-8. Descartes Landing Area and Walking Traverse Routes

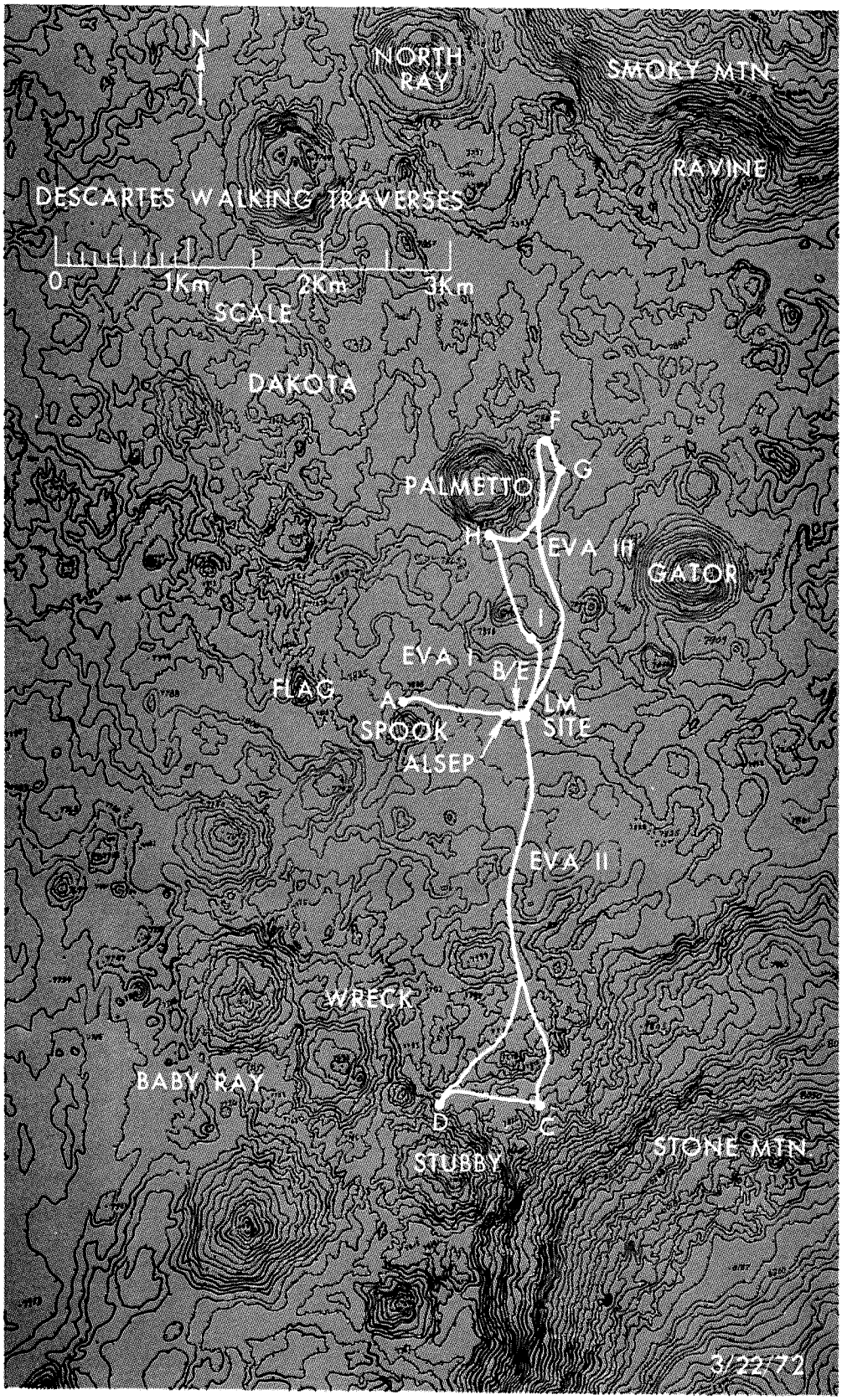

Figure 4-9. Descartes Landing Area Topographic Map and Walking Traverse Routes

SECTION V

SCIENCE ACTIVITIES RATIONALE

5.1 GENERAL

This section contains the rationale for science experiments and each science-related detailed objective (DO) assigned to Apollo Mission J-2. These rationale give the reasons for each unique science activity (such as collecting a particular lunar geology sample) and thus serve as a basis for selection of alternate activities if deviation from the nominal timeline becomes necessary.

Data presented in this section are intended for use by experiment Principal Investigators, members of the scientific community, and personnel involved in planning and implementing mission science activities. For details pertaining to activities covered in this section, reference should be made to other sections in this document, to the Science Operations Support Plan, Mission J-2/Apollo 16 (Reference 22), and to MSC-controlled documents which include the J-2 Mission Requirements Document (Reference 1), Apollo 16 Flight Plan (Reference 2), and the Apollo 16 Lunar Surface Procedures (Reference 3).

5.2 RATIONALE

Rationale for lunar orbit science experiments and DO's are presented in Tables 5-1 and 5-2; those for lunar surface science experiments are presented in Table 5-3.

Table 5-1. Rationale for Lunar Orbit Science Experiments and Science-Related Detailed Objectives

EXPERIMENT/DETAILED OBJECTIVE		OPERATING TIME REQUIRED	MEASUREMENT AND CONSIDERATIONS	RATIONALE
TITLE	NO.			
Gamma-Ray Spectrometer	S-160	Lunar Orbit 10 hrs. minimum, >60 hrs. desirable. Transearth Coast 32 hrs. minimum, 6 hrs. partial boom extension.	Gamma-ray radiation flux in the 0.2 to 10 MeV range. This is a mapping-type experiment. Therefore, the scientific gain is proportional to the surface seen by the spectrometer. In addition, extended operation is almost imperative due mainly to the high background-to-data ratio. The improvement in resolution of the data is proportional to the square root of operating time.	Obtain evidence on the origin and evolution of the moon by determining the degree of chemical differentiation the moon has undergone during its development and in conjunction with the other geochemical experiments (X-Ray Fluorescence and Alpha Particle Spectrometer) to determine the composition of the lunar surface. The gamma-ray spectrometer measures the radiation flux from the surface of the moon while in orbit around the moon. This flux has two components. One is the decay of natural radioactivity mixed in lunar surface material, the principal contributors to which are isotopes of potassium, uranium, and thorium plus radioactive daughters of the latter two. The intensity of these contributors is a sensitive function of the degree of differentiation. Gamma radiation is also produced by the interaction of cosmic-ray particles with the nuclei of chemical elements making up the lunar surface. Analysis of the data taken in the Apollo 15 Mission from lunar orbit shows a strong contrast in gamma-ray count rates over different regions of the moon. Specifically, the regions of highest activity are the western maria, followed by Mare Tranquillitatis and Mare Serenitatis. Considerably lower activity is found in the highlands of the far side, with the eastern portion containing nearly an order of magnitude less gamma-ray activity than that found in Oceanus Procellarum and Mare Imbrium. The data shows intensity peaks that correspond to the characteristic energies of the isotopes of iron, aluminum, uranium, potassium, and thorium. Spectra during transearth coast provide measurements of the total cosmic-ray background of energies up to 27 MeV. Most components of the spectrum measured are factors of 3 to 7 below the components measured during lunar orbit and when the boom was retracted. It has been concluded that the secondary radiation produced by interaction of cosmic rays and the spacecraft can be controlled through boom extension to the degree necessary to permit gamma-ray astronomy during TEC on the J-2 Mission.

Table 5-1. Rationale for Lunar Orbit Science Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		OPERATING TIME REQUIRED	MEASUREMENT AND CONSIDERATIONS	RATIONALE
TITLE	NO.			
X-Ray Fluorescence	S-161	Lunar Orbit 10 hrs. minimum, more is desirable. Transearth Coast 4 hrs. minimum, 20 hrs. desirable. Data from selected galactic objects.	The K-line radiation yield of Na, Mg, Al, and Si from the sunlit lunar surface is measured during the quiet, active, and flare periods of the sun as occurs during the experiment operation period. Similarly, the instantaneous solar X-ray spectrum is measured for background information and to determine the excitation conditions. The measured energy range is from 0.75 to 6 keV. This experiment is a mapping-type experiment like the Gamma-Ray Spectrometer and has the same operating times and relationships with the surface overflown. Constant operation is desirable to obtain data from as much of the lunar surface as possible. Measurements will be made on two galactic objects while in transearth coast. Measurements on one of the objects will be repeated on the following day. Ground-based astronomical observatories will make simultaneous measurements in the optical and radio bands.	Perform a compositional survey of the lunar surface. Solar X-rays should interact with the lunar surface to produce characteristic fluorescent X-rays. The measurement of these X-rays should yield the following information about the lunar surface. a) The nature of surface material. b) A measure of the homogeneity of the surface as one sweeps around the moon. c) By comparison with the gamma-ray results, some idea of the extent of gardening and whether or not the composition of the surface is like that of the subsurface. Detailed analyses are currently being performed on Apollo 15 data. The sharply varying aluminum-to-silicon ratio measured in the Apollo 15 Mission confirms that the maria and the highlands are indeed chemically different, and the distinguishing albedo differences between these major features must be, in part, the signature of this difference. The anorthositic component of the returned lunar samples is certainly related to the high aluminum content measured in the highland regions, and the correspondingly low aluminum content of the returned mare basalts is consistent with the low measurement values over the maria. The experiment X-ray data, thus, further support the theory that the moon, shortly after formation, developed a differentiated, aluminum-rich crust. The sharp change in the aluminum-to-silicon intensity ratio between the highland and mare areas places stringent limitations on the amount of horizontal displacement of the aluminum-rich material after the mare flooding. Indications definitely exist in the more gradual data trends that the circular maria have a lower aluminum content than the irregular maria, and within particular maria (for example, Crisium and Serenitatis), the centers have a lower aluminum content than the edges. Finally, the large ejecta blankets, such as the Fra Mauro formation, seem to be chemically different from the unmantled highlands. Conduct a long-term X-ray flux survey of two galactic sources.

Table 5-1. Rationale for Lunar Orbit Science Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		OPERATING TIME REQUIRED	MEASUREMENT AND CONSIDERATIONS	RATIONALE
TITLE	NO.			
Alpha Particle Spectrometer	S-162	Lunar Orbit 10 hrs. minimum, more is desirable. Transearth Coast Operation is concurrent with the X-Ray Fluorescence Experiment.	Alpha particles in the energy range from 3.5 to 7.5 MeV. This experiment is also a mapping-type with the same relationships to surface overflown and operation time. The search for localized sources of radon makes constant operation desirable. The transearth coast data is used for background and engineering evaluation of the Alpha Particle and X-Ray Spectrometers.	The primary objectives are the determination of lunar surface radon evolution which assists the other geochemical experiments (Gamma-Ray Spectrometer and X-Ray Fluorescence) in determining lunar surface composition and identifying localized sources of enhanced radon emission. There are several reasons for a study of radon evolution from the moon. Perhaps the most important is that the concentrations of uranium and thorium in different lunar regions can be directly compared when the alpha particle and gamma-ray results are correlated. With information from a gamma-ray sensor, the concentration of uranium can be determined so that it is possible to determine the diffusion characteristics of the soil. In turn, the diffusion properties are related to the porosity and quantity of absorbed gases in the lunar soil. If there is significant diffusion of radon to the surface, then the active deposit from the radon decay will increase the gamma activity of the surface (for terrestrial rates of radon evolution, the gamma emission would be increased by a factor of three, thus making the surface appear considerably more granitic). Hence, the alpha measurement is needed in order to subtract the effect of surface deposits. The location of regions with enhanced radon emission is an indication of one or more of the following interesting features: the occurrence of crevices or fissures on the lunar surface; areas which release volatiles generally; or, possibly, regions with unusual concentrations of thorium. The alpha particle emission of the moon in the energy band of 4.7 to 9.1 MeV is 0.004 counts per cm^2 per second per steradian. No statistically significant difference in count rates between lunar dark and light sides was observed. The alpha particle activity of the moon due to radon emission is less than 1/60 the value predicted by the terrestrial model of radon diffusion.

Table 5-1. Rationale for Lunar Orbit Science Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		OPERATING TIME REQUIRED	MEASUREMENT AND CONSIDERATIONS	RATIONALE
TITLE	NO.			
S-Band Transponder	S-164			
• CSM/LM		Front side passes, in order of science priority: CSM/LM 60 x 8 NM; LM descent; LM ascent stage to impact; CSM and CSM/LM 60 x 60 NM; CSM/LM 60 x 170 NM. (Unpowered flight)	Doppler tracking data of CSM, docked CSM/LM, LM, and subsatellite Tracking data below 16 NM altitude are most useful.	The objective of this experiment is to track the CSM, docked CSM/LM, LM, and/or a subsatellite in lunar orbit by means of S-band doppler measurements during periods when the spacecraft is unperturbed by maneuvers, attitude control, or astronaut activity, and then to reduce these data for an enhanced gravity field determination. Accurate measurement of a spacecraft's natural lunar orbit position over meaningful periods of time allows definition of a lunar mass model. Such a model, when correlated with lunar shape information, will enhance and support future lunar activities by permitting greater surface landing accuracy, backside landings, more accurate or alternate orbit determinations, and will give the scientific community a basic model for such considerations as lunar origin and subsurface structure.
• Subsatellite		Minimum requirements: Data for all frontside passes in order of science priority: when subsatellite is below 16 NM for two frontside passes, each for two equivalent ground tracks with subsatellite at two altitudes separated at least 10 NM, and two-station tracking four times per month. Data for all subsatellite passes below 30 NM are desired. Data for at least one frontside pass with subsatellite between 45-and 60-NM altitudes, and for another pass with subsatellite passing over ground track complementary to first.		The initial data indicate that the Apollo 15 Subsatellite is operating normally and, because the periapsis altitudes are following closely the predicted altitudes, suggest that the spacecraft will have an orbital lifetime of at least the planned 1 year. The Subsatellite transponder experiment should provide data for a detailed gravity map for the area between $\pm 95°$ longitude and $\pm 30°$ latitude. Excellent tracking data was collected on the Subsatellite from November 29 through December 19 when the Subsatellite dropped to an alititude as low as 38 km. Analyses of the low-altitude Apollo 15 CSM data have resulted in new gravity profiles of the Serenitatis and Crisium mascons; these results are in good agreement with the Apollo 14 data analysis and strongly suggest that the mascons are near-surface features with a mass distribution per unit area of approximately 800 kg/cm^2. The Apennine Mountains show a local gravity high of 85 mgal but have undergone partial isostatic compensation, and the Marius Hills likewise have a gravity high of 62 mgal.

Table 5-1. Rationale for Lunar Orbit Science Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		OPERATING TIME REQUIRED	MEASUREMENT AND CONSIDERATIONS	RATIONALE
TITLE	NO.			
Mass Spectrometer	S-165	Three 2-rev periods minimum. 5 revs per period are desirable -X direction attitude data collected in the 60 x 9 elliptical and 60 NM circular lunar orbits and during transearth coast. One or more revs for background data collection (with CSM +X axis pointed in the direction of velocity vector). -X data at 5 min. intervals at 5 different boom positions during lunar orbit. -X data at full boom extension during water dump and fuel cell purge in lunar orbit. Data at 25 min. intervals at 5 boom positions during TEC. TEC data at 3 boom positions for oxygen only purge. Fully extended boom for water dump and fuel cell purge data as well as RCS firing contamination data.	Measure the abundance of lunar atmosphere particles in the 12 to 66 AMU range. The sunrise and sunset terminators are the primary regions of interest as certain gases are predicted to be concentrated in these regions. Data collection over a complete orbit will provide data on the distribution of the gases. Experiment operation spread over the total lunar orbit period will provide maximum data coverage. The main objective of the transearth coast operation is obtaining data on contamination due to the CSM. Outgassing and data collection are desired in the early revs after each new orbit obtained as a result of SPS burns. This enables relatively unpolluted atmospheric data to be acquired prior to orbit contamination by CSM sources.	Obtain data on composition of lunar ambient atmosphere as an aid in understanding mechanisms of release of gases from the surface, as a tool to locate areas of volcanism, and for determining distribution of gases in lunar atmosphere. Study of the composition and distribution of gases in the lunar atmosphere is important to two current investigations. First is the understanding of the origin of the lunar atmosphere. Light gases, such as hydrogen, helium, and neon probably originate from neutralization of solar wind ions at the surface of the moon, while Ar^{40} is most likely due to radioactive decay of K^{40}. Ar^{36} and Ar^{38} may be expected as spallation products of cosmic ray interactions with surface materials. Molecular gases, such as carbon dioxide, carbon monoxide, hydrogen sulfide, ammonia, sulphur dioxide, and water vapor may be produced by lunar volcanism. The second investigation is related to transport processes in planetary exospheres. The exosphere of the earth, and that of almost any other planet, is bounded by a dense atmosphere in which hydrodynamic wind systems complicate the problem of specifying appropriate boundary conditions for exospheric transport. This contrasts sharply with the situation in the lunar atmosphere, which is entirely a classical exosphere, with its base the surface of the moon. The lunar exosphere should be amenable to accurate, analytical study. Hence, experimental determination of the global distribution of lunar gases can provide a reasonable check on theory, giving confidence to the application of theoretical techniques to transport problems in the terrestrial exosphere. Results from Apollo 15 show that a large number of sublimated gas molecules from frozen particles of water hydrocarbons, and RCS fuel combustion products exist in the vicinity of the spacecraft. This gas cloud seems to be moving with the CSM, since its measured density is largely independent of whether the SIM is in the +X or -X orientation, suggests that the CSM is its most probable source. During TEC the amplitudes of all peaks in the gas cloud spectra decreased by a factor of five to ten and a boom retraction test showed no increase in gas densities down to 1.25 meters from the CSM surface

Table 5-1. Rationale for Lunar Orbit Science Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		OPERATING TIME REQUIRED	MEASUREMENT AND CONSIDERATIONS	RATIONALE
TITLE	NO.			
Particle Shadows/Boundary Layer (Subsatellite)	S-173	Real-time mode data while in magneto-tail. Real-time mode data once per day for 4 lunations. Real time mode data twice a week after 4 lunations. All data (MRO mode) outside real-time support periods.	Electrons in the energy range from 20 to 320 keV and protons from 50 keV to 2.3 MeV. Electrons in selected bands from 0.58 to 15 keV. The unpredictability of the occurrence of solar flares and propagation of solar flare electrons requires that as much data be acquired as possible. Data passes should be evenly spaced in time to assure sampling of most solar flares. To maximize the scientific return from possible widely varying conditions, it is essential that the subsatellite be monitored and controlled continuously in the magnetotail. A polar sounding rocket program consisting of at least two launches will be conducted concurrently with the subsatellite experiment.	The objectives of this experiment are the study of the formation and dynamics of the earth's magnetosphere, the physics of solar flares, and the interaction of plasmas with the moon. The study of the interaction region will yield information on the external plasma, the interior of the moon, the surface, and the lunar ionosphere. The empirical study of the boundary layers and discontinuities in naturally-occurring plasmas is complicated by the motion of the layers. This problem has arisen, for example, in the studies of the bow shock and magnetopause at the earth. On the basis of present evidence, the interaction of the solar wind with the moon occurs very close to the lunar surface. The boundary layer for this interaction extends from the lunar surface outward to some distance which is as yet unknown, but which is estimated to be on the order of 100 kilometers. This results, then, in a boundary layer that is fixed in space, since the inner boundary is the lunar surface, and variable in thickness. Thus, in this particular boundary layer, complications due to the moon do not exist. The goal of this part of the experiment is to obtain data on the physics of this interaction region or boundary layer. The characteristics of the boundary layer are determined by the properties of the plasma as well as those of the moon. Recently a new method (particle shadows), complementary to the use of magnetometers, has been devised. This method is used to determine the large scale topology of field lines under certain conditions. It is essentially a particle-tracing technique which determines where particles have been and where they go on the particular field lines under study. The tracer particles are supplied by the sun. The method also requires the presence of a large absorber such as the moon. As a spacecraft orbits the moon, a pattern of varying solar electron intensity is experienced. The characteristics of the field lines are then deduced from the symmetry properties of these patterns. Analysis of initial Apollo 15 data from the plasma and energetic-particle experiment of the Particles

Table 5-1. Rationale for Lunar Orbit Science Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		OPERATING TIME REQUIRED	MEASUREMENT AND CONSIDERATIONS	RATIONALE
TITLE	NO.			
Particle Shadows/Boundary Layer (Subsatellite) (Continued)				and Fields Subsatellite has led to the following conclusions: 1. The cavity formed in the solar wind by the moon has been observed in the fast-electron component of the solar wind. When the interplanetary magnetic field is aligned approximately along the solar-wind flow, the electrons are almost completely excluded from the cavity. When the magnetic field is more nearly aligned perpendicular to the solar-wind flow, the shadow structure, as defined by the fast-electron component, of the solar-wind becomes extremely complex. The shadow structure becomes much broader than the lunar diameter and may become very shallow. (That is, a considerable fraction of the electrons is able to enter the cavity.) 2. A weak flux of electrons in the energy range of 25 to 300 keV was found to move predominantly in a sunward direction for a period of several days while the moon was upstream from the earth in interplanetary space. The intensity of this flux was approximately 20 electrons/cm^2-sr-sec for electrons in the 25- to 300-keV energy range. Whether these particles have a solar or terrestrial origin has not yet been determined. 3. Following an important solar flare on 1 September, a flux of solar electrons was measured at the subsatellite. The electron spectrum was determined for the energy range of 6 to 300 keV.
Magnetometer (Subsatellite)	S-174	Real-time mode data while in magnetotail and data provided by S-173. Real-time mode data once per day for 4 lunations.	Local magnetic field within range of $\pm$200 gamma. Due to unpredictable variations of the interplanetary medium, as much data as possible must be collected to minimize the statistical uncertainty of experiment conclusions and to improve the resolution of the	Measurements of magnetic fields in the transient and steady state boundary layers should provide indirect information on the lunar ionosphere and transient lunar atmosphere. It is estimated that the altitude of the top of the boundary layer at the surface, or the skin depth of the lunar perturbation in the solar wind plasma, will vary from 5 to 500 km. The dynamical processes, e.g., wave-particle and field-particle interactions, are probably very important in this

Table 5-1. Rationale for Lunar Orbit Science Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		OPERATING TIME REQUIRED	MEASUREMENT AND CONSIDERATIONS	RATIONALE
TITLE	NO.			
Magnetometer (Subsatellite) (Continued)		All data (MRO mode) outside real-time mode support periods. Real-time mode data while in magneto-sheath after 4 months.	data. High bit rate data must be collected to obtain the maximum resolution of electrical conductivity and thermal distribution information derived from the subsatellite magnetometer (S-174) and the lunar surface ALSEP magnetometer (S-034) and portable magnetometer (S-198) data, respectively.	region. Magnetic field measurements at the high data rate should provide exploratory data on such phenomena. In the cavity directly behind the moon, the properties of the plasma and magnetic field are very different from those of the solar wind flowing in the adjacent regions. At the boundary between this downstream cavity and the solar wind, there are strong gradients in the density and velocity of the plasma. The 60 NM lunar orbit will traverse this layer in two places. Thus, one of the main purposes of this experiment would be to obtain data on the microscopic behavior in this region. Initial Apollo 15 data from the two subsatellite fluxgate sensors indicate that detailed mapping of the remanent magnetization, although complex, is entirely feasible with the present experiment. For example, preliminary analysis shows a fine structure in the magnetic field associated with the large craters Hertzsprung, Korolev, Gagarin, Milne, Mare Smythii I, and, in particular, Van de Graaff, which produces a 1-gamma variation in the field measured by the subsatellite passing overhead. Furthermore, magnetic fields induced within the moon by externally imposed interplanetary magnetic fields are detectable at the subsatellite orbit. Estimated variations of lunar conductivity as a function of latitude and longitude will be possible from magnetometer data. Finally, the data show that the plasma void that forms behind the moon when it is in the solar wind extends probably to the lunar surface, and the flow of the solar wind is itself rather strongly disturbed near the limbs of the moon.
Bistatic Radar	S-170	Minimum: 1/2 front side pass for VHF and 1/2 front side pass for S-band. 1/2 pass beginning at either AOS or the earth/moon line of centers.	CSM Transmitters: S-band PM (2287.5 MHz) signal VHF band AM (259.7 MHz) signal S-band direct signal (CSM-to-earth) and caromed signal (CSM-to-lunar surface-to-earth) received and recorded at the MARS tracking station (210-ft. antenna).	This experiment will provide new scientific information on the upper few meters of the lunar surface by determining the surface roughness and dielectric constant at wavelengths of 13 cm and 1 m by the Brewster angle method. The experiment will also provide information on subsurface layering to a depth of approximately 20 m.

Table 5-1. Rationale for Lunar Orbit Science Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		OPERATING TIME REQUIRED	MEASUREMENT AND CONSIDERATIONS	RATIONALE
TITLE	NO.			
Bistatic Radar (Continued)			VHF band direct and caromed signals are received and recorded at the Stanford University tracking station (150-ft. antenna).	The VHF data obtained during the Apollo 15 Mission have approximately one order of magnitude higher signal-to-noise ratio than previously obtained, and the effects of the bulk electrical properties and slope statistics of the surface are clearly present in the data. The S-band data show the areas surveyed during the mission to be similar to those regions sampled at latitudes farther south during the Apollo 14 Mission. Distinct variations in the slopes of the lunar terrain were measured and subsurface rock fragments were detected.

Table 5-2. Rationale for Lunar Orbit Science Photographic Experiments and Science-Related Detailed Objectives

EXPERIMENT/DETAILED OBJECTIVE		PHOTOGRAPHIC SUBJECT AND CONSIDERATIONS	RATIONALE
TITLE	NO.		
24-Inch Panoramic Camera (Part of SM Orbital Photographic Tasks Detailed Objective)		Lunar surface. Concurrent operation of 3-Inch Mapping Camera is desired. Camera cassette contains 6500 ft. of film providing capability of 165 min. of operation. Film frame format is 5 ft. by 5 in.	Obtain 1- to 2-meter resolution photography of potential landing sites and exploration areas and provide selective detailed information to support the analysis of lunar mapping photographs. Lunar landing site analysis and selection well in advance of the mission can significantly improve the efficiency of activities on the lunar surface. Only a thorough analysis of high resolution photography (the resolution must be three to five times better than the sizes of potential topographic hazards for system under consideration) can provide high confidence in the operational suitability of landing sites or exploration areas. Identification and photogrammetric studies of features of high scientific interest in the vicinity of candidate landing sites can reduce the time needed for scientific activities during the lunar missions and also provide important inputs to the site selection process. Survey an area of several hundred square kilometers several times with 1- to 2-meter resolution orbital photography at 1- to 3-year intervals to extend measurements of lunar surface meteoroid flux to larger masses. Apollo 15 obtained Pan Camera coverage of approximately 12 percent of the lunar surface, including the Hadley Rille landing site, highlands between Mare Crisium and Mare Serenitatis, and the LM ascent stage impact point, pre- and post-impact.

Table 5-2. Rationale for Lunar Orbit Science Photographic Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		PHOTOGRAPHIC SUBJECT AND CONSIDERATIONS	RATIONALE
TITLE	NO.		
3-Inch Mapping Camera (Part of SM Orbital Photographic Tasks Detailed Objective)		Lunar surface with simultaneous stellar photography and frame-coupled laser altimeter measurements. Operation is desirable whenever panoramic camera operates. Camera cassette contains 1500 ft. of metric film and 510 ft. of stellar film providing capability of 25 hours of operation, or approximately 4200 frames of photography each. Metric film format is 4.5 in. by 4.5 in. Stellar film format is 35-mm.	Mapping camera photographs provide a means for establishing a selenodetic network. This network will provide positional reference on the moon. It will also form the basis for subsequent photogrammetric determination of the lunar gravitational field through resection of camera position with respect to the control network. The mapping camera photographs form the basis of specialized cartographic maps ranging from small-scale flight charts used for lunar orbit operations to medium-scale topographic charts used for planning lunar surface operations. These maps and photographs provide additional data on the form, distribution, and relative abundance of major lunar surface features, and provide terrain profile information required to plan subsequent and future lunar exploration missions. Stellar photographs provide precision camera inertial pointing information for post-flight imagery interpretation.
		Wide-angle photographs of the lunar surface following TEI.	The objective is to extend selenodetic control to greater areas of the moon by relating features near the eastern limb and features at high latitudes on the near side to features near the equator. Successive photographs on the same mission provide perspective changes, primarily in longitude. Photographs from different missions provide perspective changes, primarily in latitude, due to different selenodetic inclinations. Apollo 15 obtained excellent quality metric photographs of the lighted areas overflown by the CSM, including coverage following TEI. Simultaneous stellar camera photographs were of sufficient quality to determine attitudes for metric data reduction.

Table 5-2. Rationale for Lunar Orbit Science Photographic Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		PHOTOGRAPHIC SUBJECT AND CONSIDERATIONS	RATIONALE
TITLE	NO.		
Laser Altimeter (Part of SM Orbital Photographic Tasks Detailed Objective)		Range from CSM to lunar surface with 1-meter resolution. To be supported on the lunar darkside by stellar camera as film budget permits. Minimum operation: whenever mapping camera is operating.	Provide precise time-correlated altitude information for use in conjunction with tracking data and pictures taken by the mapping and panoramic cameras. The determination of the moon's gravitational field from analysis of lunar orbiter perturbations, of which the main result is the discovery of the mass concentrations, is of great importance to the study of the moon's structure and evolution. However, the lack of accurate topographic elevations makes it difficult to draw inferences as to internal structure because the contribution to the gravitational field of the visible topography cannot be subtracted out accurately. Also, the spectrum of the long wave variations in topography is of significance to lunar structure itself. This instrument yields data to help resolve this problem. The laser altitudes are used with MSFN tracking from the earth to determine improved orbits. The variations in topographic variations are then determined by subtracting the laser altitudes from the orbital radial coordinates. This procedure should give the topographic variations with an accuracy approaching that of the instrumentation. Limited laser altimeter data were obtained on Apollo 15 before hardware failure (through rev 24). Most significant of the altimetry data is the conclusion that the lunar nearside is approximately 2 kilometers below the mean lunar radius. Laser data correlated very well with S-band tracking data and with lunar surface terrain.

Table 5-2. Rationale for Lunar Orbit Science Photographic Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		PHOTOGRAPHIC SUBJECT AND CONSIDERATIONS	RATIONALE
TITLE	NO.		
Dim Light Photography (Part of CM Photographic Tasks Detailed Objective)			
a) Diffuse galactic light of celestial subjects		Photographs of the north galactic pole, north ecliptic pole, north celestial pole, and the Gum Nebula, taken in lunar double umbra (lunar umbra and no earthshine).	a) The objectives are to identify the extent, locations, configurations, and light levels of these astronomical sources, by photographing them while free of the masking effect of terrestrial scattered sunlight. Photographs taken in lunar double umbra can isolate each of these phenomena and can also take advantage of the increased parallax along the earth-moon baseline. Analysis of these photographs will have application to the study of the distribution of matter in the local region of our galaxy. The location of interplanetary and interstellar concentrations of matter is of importance to future long-range space flights.
b) Zodiacal light		Photographs of the zodiacal light as the CSM approaches sunrise in lunar orbit: outer zodiacal light (directions out of the ecliptic plane); inner zodiacal light (in ecliptic plane).	b)
c) Solar corona		Photographs of the solar corona taken in lunar orbit after CSM sunset and before CSM sunrise.	The objective is to study the pattern of energy outflow from the sun, by photographing its outermost region while the solar disc is occulted by the moon, and at several positions of solar rotation on its axis. Apollo 15 obtained good-quality photographs of the solar corona, zodiacal light, and lunar libration region L4.

Table 5-2. Rationale for Lunar Orbit Science Photographic Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		PHOTOGRAPHIC SUBJECT AND CONSIDERATIONS	RATIONALE
TITLE	NO.		
Lunar Surface Photography: (Part of CM Photographic Tasks Detailed Objective) a) In low light levels near the terminator b) In earthshine c) Of targets of scientific interest		Photographs of areas on the lunar surface taken from the CM in lunar orbit.	This photography will complement SIM bay photography by photographing specific targets at altitudes, attitudes, and sun incidence angles which are not feasible for the SIM cameras due to their own altitude and attitude constraints. Photographs of selected targets at different sun incidence angles, i.e., different illumination levels, will also provide information on the reflective properties of the lunar surface. Apollo 15 provided excellent quality photographs of science targets near the terminator regions and of surface areas in earthshine. Terminator photographs are a valuable source of data on crater density, and provide maximum detail of small surface features.
UV Photography - Earth and Moon	S-177	Earth and moon at different points during translunar coast, transearth coast, and in lunar orbit.	This experiment is an investigation of the terrestrial atmosphere by means of photographs of the earth obtained in ultraviolet light in order to aid in the interpretation of similar photographs of other planetary atmospheres. By photographing the earth in the same manner that is employed for planetary studies, one can use the detailed knowledge about the properties of the terrestrial atmosphere to interpret such planetary observations. Photographs of the moon at 2600 Å will be used to extend the wavelength coverage of ground-based colorimetric work and to search for possible fluorescence. Color differences on the moon that can be correlated with topographic features have been known for some time. By extending the wavelength range, it should be possible to improve the definition of features already recorded as well as to detect new colorimetric boundaries.

Table 5-2. Rationale for Lunar Orbit Science Photographic Experiments and Science-Related Detailed Objectives (Continued)

EXPERIMENT/DETAILED OBJECTIVE		PHOTOGRAPHIC SUBJECT AND CONSIDERATIONS	RATIONALE
TITLE	NO.		
UV Photography - Earth and Moon (Continued)			Apollo 15 obtained UV photographs of the earth and moon in pass bands centered at 3750 Å, at 3400 Å (effective wavelength of planned 2600 Å filter), and in the visible spectrum above 4000 Å. These photographs show that the earth is clearly visible at 3750 Å, fairly well defined at 3400 Å, and that no significant changes in the visibility of aerosols occurs at these pass bands.
Gegenschein from Lunar Orbit	S-178	Photographs in the antisolar direction, in the direction of the Moulton point, and in the direction midway between the Moulton point direction and the antisolar direction. Photographs are taken while the CSM is in lunar double umbra (lunar umbra and no earthshine).	The objective is to attempt to confirm the possible accumulation of matter at the Moulton point, which is the L1 libration point of the rotating sun-earth system. The photographs are intended to show differences in the distribution of reflected light from the vicinity of the Moulton point, and to help assess the contribution to the gegenschein of light that may be reflected from the region of the Moulton point. Photographs of the gegenschein/Moulton point regions were not obtained on Apollo 15 due to incorrect spacecraft pointing attitudes for the photography sequence.
Visual Observations from Lunar Orbit (Detailed Objective)		Observe specific lunar surface features and processes from the CM along the spacecraft ground-track.	These observations will supplement mapping and panoramic photography and other remotely-sensed data obtained of the lunar surface. The eye has a resolution of approximately 30 meters from the 60 NM circular orbit, which is adequate for problems related to regional distributions and tectonic trends. The eye also has an advantage because of its continuous viewing over a large field. In regards to color sensitivity, the eye represents a precision better than the most accurate photoelectric spectrophotometers. The capability is best utilized in deciphering color differences between lunar surface units under varying sun angles within what appears in photographs as "hard shadows" and "washout regions".

Table 5-3. Rationale for Lunar Surface Science Experiments

EXPERIMENT		RATIONALE
TITLE	NO.	
Apollo 16 Lunar Surface Experiment Package (ALSEP):		This collection of four lunar surface telemetered experiments is designed to obtain lunar seismic, thermal, and magnetic environment data over an extended period of time (from a full lunar day to one earth year or more). These data will be the bases of fundamental lunar, geophysical, and other investigations which will contribute to our knowledge and understanding of the moon and its magnetic environment. Data from ALSEP's at different locations on the moon are necessary to enable determination of directional, spatial, and temporal distributions of the measured phenomena. Therefore, it is planned to deploy an ALSEP during every lunar landing mission. ALSEP's were deployed and successfully operated during Apollo 11, 12, 14, and 15 and are planned for Apollo Missions J-2 and J-3. The Apollo 12, 14, and 15 ALSEP's are presently operating and simultaneously acquiring data from their respective locations on the moon. Individual ALSEP experiments are described below:
• Passive Seismic Experiment (PSE)	S-031	This experiment will determine the number, origin, and character of lunar seismic events, and obtain knowledge on the physical properties and general structure of the moon. The operating PSE's deployed during Apollo 12, 14, and 15 will monitor the seismic signals resulting from impact of the S-IVB stage during Apollo Mission J-2. The Apollo 12, 14, and 15 PSE's, in conjunction with the PSE that is planned to be deployed during Apollo Mission J-2, will monitor the

Table 5-3. Rationale for Lunar Surface Science Experiments (Continued)

EXPERIMENT		RATIONALE
TITLE	NO.	
Passive Seismic Experiment (Continued)	S-031	impact of the LM ascent stage during Apollo Mission J-2. The known location and energy of these impacts will enable more accurate interpretation of instrument measurements of natural lunar seismic phenomena. The PSE was also deployed and successfully operated during Apollo 11.
• Active Seismic Experiment (ASE)	S-033	This experiment is designed to generate and monitor artificial seismic waves in the 3 to 250 Hertz range, in the lunar surface and near subsurface. Natural seismic waves in the same frequency range will also be monitored on a limited basis. By varying the location and magnitude of the energy sources, wave velocities through several layers of subsurface materials can be investigated. Interpretation of the velocities of these waves, their frequency spectra, and rate of attenuation permits the type and character of lunar material to be inferred as well as the degree of hardness and bearing strength of these materials. The ASE which is planned to be deployed during Apollo Mission J-2 will monitor the seismic signals resulting from launch of the LM ascent stage from the lunar surface. ASE operating periods are restricted to minimum duration and frequency because the ALSEP telemetry capability does not allow the ASE to operate simultaneously with any other ALSEP experiment.

Table 5-3. Rationale for Lunar Surface Science Experiments (Continued)

EXPERIMENT		RATIONALE
TITLE	NO.	
• Lunar Surface Magnetometer (LSM)	S-034	This experiment will measure the vector magnetic field on the lunar surface and its temporal variations. Data from this experiment will also be used to derive information on the electrical properties and thermal state of the deep interior of the moon and on the interplanetary magnetic field that diffuses through the moon. The LSM was deployed on Apollo 12, 14, and 15 and is planned to be deployed on Apollo Mission J-2.
• Heat Flow Experiment (HFE)	S-037	This experiment will provide data on lunar soil thermal conductivity, contribute to the resolution of issues concerning lunar internal heating processes, and establish constraints on the interior temperature and composition of the moon. The HFE was deployed on Apollo 15 and is planned to be deployed on Apollo Mission J-2. The Apollo 15 HFE results indicate a net outward flow of heat from the lunar interior that is approximately one-half of the earth's net average heat flow.
Lunar Geology Investigation	S-059	The collection of geological samples and photography of geological features are planned to provide data for lunar geological studies that will increase the knowledge of the physical makeup of the moon, its history, the nature and history of the solar system, and the history of the earth. The activities that comprise this experiment are:

Table 5-3. Rationale for Lunar Surface Science Experiments (Continued)

EXPERIMENT		RATIONALE
TITLE	NO.	
• Documented sample with documented sample photography		The objective is to obtain samples representative of the landing area. The photography 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.
• Soil/rake sample including 1-kg soil sample		The soil/rake sample will increase the probability of returning deep or shocked Imbrium age rocks. Statistical significance of the sample may be increased by returning the maximum number of rocks. The 1-kg soil sample is to characterize the regolith in the vicinity where the rocks are collected.
• Radial sampling of a fresh crater, including photography		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).

Table 5-3. Rationale for Lunar Surface Science Experiments (Continued)

EXPERIMENT		RATIONALE
TITLE	NO.	
• Padded container samples		Protects crystalline rock samples from fracture and surface abrasion.
• Special surface (dust) samples		Taken with special surface sampler which collects very top layer of soil grains for studies of solar particles, their effects, and for accurate microcrater counting. Top surface layers in previously returned core tube samples have been disarranged to the extent that such studies could not be performed.
• Pristine core tube sample		Lunar core tube sample (single core tube) returned in CSVC which provides a regolith characterization, contamination-free sample for future scientific studies.
• Large boulder sampling		Can be used for crater dating if boulders are unambiguously related to crater of interest.
• Large, roughly equidimensional rock (15-20 cm on a side) showing clear evidence of erosion		Erosion features will allow the separation of the solar wind products from the rock/surface outgassing products.
• Geologic feature color and texture differences		Infers changes in age, origin, and composition of features.
• Bedrock (around blocky-rimmed craters)		Provides access to old surface material.
• Different rock types		Improve variety of return sample yield.
• Smooth areas free from surface activity		Provides statistically unbiased sample of the local regolith.
• Filleted rock on level ground		Indicative of surface dust transport and/or rock transport without benefit of slopes.

Table 5-3. Rationale for Lunar Surface Science Experiments (Continued)

EXPERIMENT		RATIONALE
TITLE	NO.	
• Filleted rock in fresh crater		Indicative of material slippage down crater slopes from impacts occurring after crater formation.
• Ray material from distant craters		Provide material for dating from deep within the crater from which the ray originates.
• Fresh secondary craters		Samples from crater soil and chips from rock(s) producing the crater will provide data on contemporary exposure histories.
• Large boulder chips		Provide data on age, surface conditions, micrometeoroid impact flux, etc.
• Chips from exposed surfaces and bottom of large, overturnable boulder		Chips and samples from soil underneath and adjacent to boulder provide data on surface radiation history.
• Dust on boulders		Dust and chip samples from under dust may concurrently establish erosional processes with dust representing erosional products.
• Boulder with overhang (permanent shadow)		SESC sample of soil under overhang will be used for analysis of volatile substances.
• Samples from natural split in boulder including East-West split		Chips from fracture surface and boulder top/bottom provide data on radiation history and long cosmic ray tracks; East-West split chips have been shielded from direct cosmic radiation.
• Rock/soil contacts, boundary zones (hills-level ground), disturbed/undisturbed surfaces		Photography and observations yield data to morphological changes which provide clues to past selenological history.
• Mound		Small rock and soil samples from mound interior provide data relative to mound origin and age with respect to nearby areas.

Table 5-3. Rationale for Lunar Surface Science Experiments (Continued)

EXPERIMENT		RATIONALE
TITLE	NO.	
• Rim sampling		The material from the rim of a crater will provide samples from the deepest part of the crater.
• Panoramic photography		These photographs, when joined as mosaics, provide accurate map control data.
• Polarimetric photography and samples		Comparison of polarimetric signatures with those of known materials will allow classification and correlation of lunar material even though textures are not resolvable.
• Double core tube sample and photographs (can be replaced by triple core tube approximately 1 meter long)		This objective provides 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). The photographs will record the surface characteristics and location of the sample area.
• Single core tube sample and photographs		This objective provides a sample for determining soil-type distribution to depths of approximately 38 centimeters in the lunar surface at selected locations (soil/rake sample area and targets of opportunity such as mounds and fillets). The photographs will record the surface characteristics and location of the sample area.
• Drill Core		This objective provides the only certain deep sample of regolith; a secondary objective is to determine stratigraphy in the sample area.
• Contingency Sample		Collect approximately 2-kg of lunar surface material to provide a "sure" lunar sample for earth return only if the lunar stay is terminated early in the EVA period. The first lunar sample obtained will suffice.

Table 5-3. Rationale for Lunar Surface Science Experiments (Continued)

EXPERIMENT		RATIONALE
TITLE	NO.	
• Small exploratory trench sample with photographs		The objective is to determine the character of regolith down to 6 to 24 centimeters 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.
• Large equidimensional rock (15 to 24 centimeters diameter) with photographs		The objective 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.
• Smaller equidimensional rock (6 to 15 centimeters diameter) with photographs		Similar to above. Several small rocks may be more valuable than one large rock because of higher statistical significance of more samples.
• Fillet sample		The volume of the fillet may be directly proportional to the time the rock has been in position and to the rock size.
• Lunar environmental soil/ rock sample		These samples will be the only truly virgin vacuum samples from the moon; provide biologically pure samples for gas analysis and for chemical and microphysical analyses.
Solar Wind Composition (SWC)	S-080	This experiment will determine the elemental and isotopic composition of the noble gases and other selected elements in the solar wind by measuring particle entrapment on an exposed aluminum and platinum foil sheet. The SWC was deployed on Apollo 11, 12, 14, and 15. It is planned to be deployed on Apollo Mission J-2.

Table 5-3. Rationale for Lunar Surface Science Experiments (Continued)

EXPERIMENT		RATIONALE
TITLE	NO.	
Cosmic Ray Detector (Sheets)	S-152	This experiment requires the return to earth of plastic detector sheets and other special glass, mineral, and tektite detectors exposed to the galactic cosmic ray and solar wind particle environment during TLC, and when on the lunar surface. These sheets will provide data for three scientific investigations which will lead to a better understanding of the contemporary flux of solar and galactic particles. One investigation will determine the abundances of individual nuclei above He in the energy range from 0.2 to 100 MeV/nucleon; and resolve isotopes of elements such as Be, Ne, Al, Si, S, Ar, Ca, and Fe. A second investigation will: (1) measure the energy spectra and elemental and isotopic abundances of solar and galactic cosmic ray nuclei of $Z \geq 3$ in the energy range from 1 to 200 MeV/nucleon; (2) calibrate glass detectors for use in future space missions by identifying the tracks of Fe nuclei; and (3) determine whether the space exposure and place of origin of tektites can be determined from the characteristics of the Fe. A third investigation will: (1) measure the composition and distribution of nuclear particles in the solar wind in the energy ranges from 0.5 to 10 keV/nucleon and from 1 to 100 MeV/nucleon; and (2) measure the flux of neutrons on the lunar surface. The related experiment, Cosmic Ray Detector (Helmets) (S-151), was performed on Apollo 8 and 12.

Table 5-3. Rationale for Lunar Surface Science Experiments (Continued)

EXPERIMENT		RATIONALE
TITLE	NO.	
Portable Magnetometer	S-198	This experiment will measure vector magnetic field components at several locations in the lunar landing area. The data will aid resolution of questions on the spatial variations of the lunar magnetic environment, and will aid in determining characteristics of lunar geological structures, especially magnetic characteristics associated with nearby large craters. This instrument will be used to measure the magnetic characteristics of an igneous sample in situ as a baseline for later magnetic measurements to be performed on the sample in the LRL. The Portable Magnetometer experiment was conducted on Apollo 14. The related ALSEP experiment, Lunar Surface Magnetometer (S-034), was deployed and successfully operated during Apollo 12 and 15, and is planned to be deployed on the Apollo Mission J-2. The related lunar orbital experiment, Subsatellite Magnetometer (S-174), was successfully deployed and operated during Apollo 15, and is planned to be deployed and operated on the Apollo Mission J-2.
Soil Mechanics: • Trench with trench photography	S-200	The objective is to photograph the soil layers that will be exposed on the side of a trench in accordance to a specified criteria. The achievable depth prior to wall failure indicates soil mechanical properties. The experiment will furnish qualitative information for design of future lunar shelters using lunar soil as a thermal radiation shield.

Table 5-3. Rationale for Lunar Surface Science Experiments (Continued)

EXPERIMENT		RATIONALE
TITLE	NO.	
Soil Mechanics (Continued): • Penetrometer and plate load tests with photographs		The objective is to obtain stress versus penetration data that may reflect nonhomogeneities in soil profile. Two penetrometer cones will be available (0.5 $in.^2$ and 0.2 $in.^2$) as well as a 1 in. by 5 in. load plate. The cones used will depend upon the soil bearing strength encountered. These data will be correlated with penetrometer and plate penetration data from simulated lunar soil tests to determine the lateral and vertical particle size distribution of lunar soil.
Far UV Camera/Spectroscope	S-201	This experiment will measure the amount and excitation of hydrogen in nearby and distant regions of the universe. The imagery obtained in this experiment will help identify characteristic Lyman-alpha emission of hydrogen from the lunar surface, geocorona, solar wind, interstellar wind, and clusters of galaxies. The spectra obtained will also detect other gases in these regions, and provide data on the temperature and density of these gases. Spectra obtained from low-elevation targets (approximately 20 degrees or less) may detect the presence of volcanic gases that may be emitted from the lunar surface near the line of sight.

SECTION VI

SCIENCE RECOVERY PLAN

6.1 GENERAL

This section was provided by the Science Requirements and Operations Branch/TD5, supported by the General Electric Company. It defines requirements of the Science and Applications Directorate (S&AD) for the return of time-critical scientific data and equipment from the splashdown recovery zone to the Lunar Receiving Laboratory (LRL) at the Manned Spacecraft Center (MSC), Houston, Texas. Guidelines for preparation and transportation of the data and equipment are presented in Paragraphs 6.2.1 and 6.2.2. Transportation priorities are specified in Table 6-1.

Data contained in this section are provided for experiment Principal Investigators, members of the scientific community, and personnel involved in planning for the recovery of equipment and lunar samples returned from the mission. These data are intended for use in implementing the science requirements presented in the MSC-controlled J-2 Mission Requirements Document (Reference 1) until such data are published in other MSC-controlled documents. These documents include the Apollo 16 Flight Mission Rules (Reference 17) and Recovery Requirements-Apollo 16 (Reference 22).

6.2 PREPARATION AND TRANSPORTATION REQUIREMENTS

6.2.1 PREPARATION OF DATA AND EQUIPMENT FOR RETURN TO MSC

6.2.1.1 Decontamination

Because of the MSC decision to discontinue quarantine precautions and procedures for the crew and other items returned from the moon, it is no longer necessary to specify decontamination requirements as has been the case on previous Apollo G- and H-Missions. The precautions and requirements associated with the processing of returned lunar samples, however, are still in effect.

6.2.1.2 Shipping Containers

Shipping containers to protect items from excessive shock and temperature during handling and flight will be provided by the Landing and Recovery Division.

6.2.2 TRANSPORTATION REQUIREMENTS

6.2.2.1 Flight Operations

Flight operations from the recovery zone to Ellington Air Force Base (EAFB), Houston, must be conducted with multiple or similar items divided between two aircraft to minimize the scientific impact involved if an aircraft should be lost.

6.2.2.2 Transfer of Items from EAFB to the LRL

Transporting of time-critical items from EAFB to the LRL will be accomplished by motor vehicle. Transfer of items from the couriers to LRL personnel will be accomplished at this time.

Table 6-1. J-2 Mission Scientific Data and Equipment Recovery Requirements Matrix

DATA/EQUIPMENT TO BE RETURNED TO LRL	QUANTITY	SHIPPING PRIORITY FROM RECOVERY AREA	REMARKS
• Sample Return Container (SRC) No. 1, S/N 1009 HRE*	1	Flight No. 2	The SRC's are not to be opened prior to delivery to the LRL.
• Sample Collection Bag No. 1	1		
• Small Documented Geological Samples (EVA No. 1)	60 (max.)		
• Core Tube Samples (EVA No. 1)	2		One upper core tube section and one lower core tube section.
• Organic Control Sample	1		The organic control sample installed in each SRC prior to flight will remain in the container throughout the mission.
• Deep Drill Core Sample (EVA No. 1)	2	Flight No. 1 or 2	Drill Core is returned in two sections; each section is composed of three joined core stem sections. Armalon cloth bag is used as return container.

*HRE - Hardware Reuse Evaluation (from the Apollo 12 Mission).

Table 6-1. J-2 Mission Scientific Data and Equipment Recovery Requirements Matrix (Continued)

DATA/EQUIPMENT TO BE RETURNED TO LRL	QUANTITY	SHIPPING PRIORITY FROM RECOVERY AREA	REMARKS
• Extra Sample Collection Bag No. 5 (EVA No. 1)	Large Geological Samples	Flight No. 1 or 2	
• SRC No. 2, S/N 1010	1	Flight No. 1	The SRC's are not to be opened prior to delivery to the LRL.
• Sample Collection Bag No. 2	1		
• Small Documented Geological Samples (EVA No. 2)	40 (max.)		
• Core Tube Samples (EVA No. 2)	4		Two ~~One~~ upper core tube sections and two lower core tube sections.
• Environmental Soil Sample (SESC No. 1020) (EVA No. 2)	1		Possible boulder overhang soil sample or trench bottom soil sample.
• Core Sample Vacuum Container (EVA No. 2)	1		Contains an upper core tube sample to be kept in a pristine state.

Table 6-1. J-2 Mission Scientific Data and Equipment Recovery Requirements Matrix (Continued)

DATA/EQUIPMENT TO BE RETURNED TO LRL	QUANTITY	SHIPPING PRIORITY FROM RECOVERY AREA	REMARKS
• Organic Control Sample	1	Flight No. 1	The organic control sample installed in each SRC prior to flight will remain in the container throughout the mission.
• Extra Sample Collection Bag No. 6 (EVA No. 2) Core Tube Samples	Large Geological Samples (2)	Flight No. 1 or No. 2	Flight assignment of collection bags and other data articles will be largely determined by the science value attached to the articles. Collection bags to be placed in special return containers similar to those used for the SRC's.
• Sample Collection Bag No. 3 (EVA No. 3)	1		
• Small Documented Geological Samples (EVA No. 3)	40 (max.)		
• Core Tube Samples (EVA No. 3)	~~3~~ 2		One upper core tube section and ~~two~~ one lower core tube sections.
• Extra Sample Collection Bag No. 7 (EVA No. 3)	Large Geological Samples		

Table 6-1. J-2 Mission Scientific Data and Equipment Recovery Requirements Matrix (Continued)

DATA/EQUIPMENT TO BE RETURNED TO LRL	QUANTITY	SHIPPING PRIORITY FROM RECOVERY AREA	REMARKS
• Extra Sample Collection Bags No. 4 and No. 8	Geological Samples	Flight No. 1 or No. 2	May be used as required on any of the three EVA's. Bags containing large rocks and sample overflow are to be divided equally between the two flights.
• Sample Return Bag (BSLSS Sample Bag or "Large Rock Bag")	Geological Samples		Contains sample overflow from each of the three EVA's especially extra large samples as "football-size" rocks.
• DSEA Tape From LM	1	Flight No. 2	The DSEA is hermatically sealed. The complete unit must be returned from the LM. At recovery, the unit must be placed in a magnetic-shielded container for shipment to the LRL.
• Padded Bag Rock Samples	2	Flight No. 1 or No. 2	
In SCB #6 EVA 2 • Special Soil Surface Grain Samples (in sampler protective housings)	2		

Table 6-1. J-2 Mission Scientific Data and Equipment Recovery Requirements Matrix (Continued)

DATA/EQUIPMENT TO BE RETURNED TO LRL	QUANTITY	SHIPPING PRIORITY FROM RECOVERY AREA	REMARKS
• Contingency Soil Sample	1	Flight No. 1 (if obtained)	Will be obtained only if lunar surface stay time and corresponding EVA period is foreshortened to the extent that a documented sample cannot be acquired. Sample to be scooped up with a DSB and then restowed in a suitable container.
• CM Data Recorder Reproducer Tape	1	Remove from CM upon receipt at LRL	The data recorder reproducer tape is the only record of telemetry transmissions during CM reentry.
• Solar Wind Composition Foil and Reel	1	Flight No. 1 or No. 2	Stowed in SWC stowage bag.
• Cosmic Ray Detector Panels	4		Stowed in special Cosmic Ray Detector stowage bag.
• Soil Mechanics Penetrometer Drum (in upper penetrometer assembly)	1		Stowed in lunar geology documented sample bag.

Table 6-1. J-2 Mission Scientific Data and Equipment Recovery Requirements Matrix (Continued)

DATA/EQUIPMENT TO BE RETURNED TO LRL	QUANTITY	SHIPPING PRIORITY FROM RECOVERY AREA	REMARKS
• Magazine/Cassettes from following camera systems:		Flight No. 1 or No. 2	The film magazines and cassettes will be placed in specially constructed containers at the recovery zone and then returned to EAFB. The total number of magazines and cassettes returned, except as noted, will be divided equally between the two flights and will remain in the custody of the Photographic Technology Division (PTD) couriers until arrival at MSC. All film data will be processed through bonded storage before being released to the PTD for development.
• 16-mm Data Acquisition Camera (Maurer)	21* Magazines		
• 70-mm Hasselblad Electric Data Camera (With Reseau)	13*,** Magazines		
• 70-mm Hasselblad Electric Camera	8*,*** Magazines 21* Magazines (Total)		
• 35-mm Nikon Camera	9* Cassettes		
• Far UV Camera/Spectroscope 35-mm Magazine	1 Magazine	Determined at time of CM recovery.	

*Indicated magazine/cassettes contain imagery data supporting other J-2 Mission operational tests and detailed objectives as well as those imagery data related to science objectives and science support activities.

**Includes 1 magazine of 500-mm photography

***Includes 1 magazine of CM UV Photography

Table 6-1. J-2 Mission Scientific Data and Equipment Recovery Requirements Matrix (Continued)

DATA/EQUIPMENT TO BE RETURNED TO LRL	QUANTITY	SHIPPING PRIORITY FROM RECOVERY AREA	REMARKS
• Magazines/Cassettes from following camera systems: (continued)			Remarks from the previous page apply except for shipping priority.
• 3-Inch Mapping Camera	1* Cassette	Determined at time of CM recovery.	
• 24-Inch Panoramic Camera	1 Cassette		
• Astronaut Flight Logs	-	Flight No. 1 with the astronauts.	Flight logs contain information vital to the interpretation and analysis of lunar surface activities as well as information related to mission operations and other mission objectives. Transcripts of the flight logs should be made available as quickly as possible after return to MSC.

*Cassette contains 1 roll of 5-inch metric camera film and 1 roll of 35-mm stellar camera film.

SECTION VII

LUNAR RECEIVING LABORATORY PLAN

7.1 GENERAL

This section was provided by the Lunar Receiving Laboratory (LRL)/TL. It defines requirements of the LRL as related to the preliminary examination, preparation, processing, and documentation of lunar samples returned from the Apollo J-2 Mission. Also included are requirements stipulating curator inventory control procedures, contamination avoidance safeguards and monitoring procedures, reporting of sample processing status, and security measures to be employed. Anticipated lunar samples from the Apollo J-2 Mission are listed in Table 7-1.

Requirements presented in this section are provided for experiment Principal Investigators (PI), members of the scientific community, and for personnel responsible for lunar sample operations in the LRL. Reference should be made to appropriate documents for detailed data. Such documents include the Lunar Receiving Laboratory Mission Plan (Reference 24) and an array of LRL procedural documents.

7.2 SCOPE

This section defines those requirements which the LRL must meet for a successful preliminary sample examination prior to sample distribution to sample PI's for the conduct of more detailed and exhaustive examinations and experiments. It addresses only those laboratory objectives pertaining to the physical characterization of the lunar sample, preparation of the sample and derivative subsamples, its long-term protection and storage, and the conduct of time-critical experiments.

These requirements are binding upon the LRL and the Lunar Samples Preliminary Examination Team (LSPET) unless defined in terms of target objectives. To illustrate, minimum levels of contamination, an example of a target objective, will be sought but cannot be guaranteed.

7.3 PRELIMINARY EXAMINATION

7.3.1 PURPOSE

The preliminary examination is intended to gain a general understanding of the materials returned from the moon. This should

a) Provide the basic information by which samples can be distributed for intensive scientific study according to a plan developed by the LSAPT.

b) Provide a basic catalog of lunar samples and a summary of analytical data that scientific investigators need to carry out and interpret their research.

c) Provide a summary description for the scientific public-at-large.

The preliminary examination period is also used to

a) Provide the basic inventory of lunar materials from each mission.

b) Perform certain time-critical experiments such as measurements of short-lived radioactivity.

c) Perform certain experiments that can only be conducted in the sequence of preliminary examination procedures, such as determining the composition of gases in an Apollo Lunar Sample Return Container (ALSRC).

d) Perform experiments that depend on examining whole rock surfaces, such as photometric measurements supporting the Lunar Geology Investigation Experiment and surface-impact pit counting.

e) Prepare certain samples for rapid distribution to Principal Investigators.

7.3.2 SURFACE TRAVERSE INFORMATION

7.3.2.1 Real Time Analysis

Members of the Preliminary Examination Team (PET) will watch and listen to the surface traverses as they proceed. They will be responsible for preparing

a) A preliminary traverse map.

b) A preliminary inventory of samples.

c) An annotated transcript of surface activities.

d) A list of the contents of each individual Sample Return Container (SRC).

e) A list of priorities for the order of processing of films depicting surface activity.

The PET will also identify useful still pictures to be produced from video tapes and provide early photographic data reductions.

7.3.2.2 Surface Photography

Surface photography will be returned immediately to the Photographic Laboratory and developed on a rush basis with three sets of 8 x 10 inch photographs to be transmitted immediately to the PET. The PET will be responsible for

a) Assembling panoramic photographs.

b) Associating photographic sites with the traverse map.

c) Identifying rocks that are "documented".

d) Making comparisons with TV and voice coverage.

e) Establishing a sequence of lunar surface activities that can be used as a basis for debriefing the crew.

7.3.2.3 Crew Debriefing

The crew will be debriefed by a small group of the PET as the sample collection bags are processed. The purpose of debriefing is to consolidate as much of the information as can be gained by association with the surface photography used in the debriefing. The debriefing may also include reruns of the video tapes.

7.3.3 PRELIMINARY DESCRIPTION PHASING

7.3.3.1 Container Opening

The two ALSRC's will be processed in the Sterile Nitrogen Atmosphere Processing (SNAP) line. If the ALSRC's have held a vacuum, they may be punctured for the gas analysis experiment. The core tubes will be removed and loaded into stretch cans and stored for later analysis.

Individual documented rocks and fines will be inventoried and processed according to operating procedures in the SNAP and Non-Sterile Nitrogen Processing Line (NNPL) processing lines.

Each sample collection bag (SCB) will be processed in the NNPL, unless a special circumstance exists that makes their processing in the SNAP line more desirable.

7.3.3.2 Inventory

An inventory photograph, weight, and brief description will be made as each rock or fines sample is unpacked.

7.3.3.3 Dusting

Rocks will be dusted by nitrogen jets prior to taking the documentary photograph.

7.3.3.4 Orthogonal Photography

A set of six orthogonal color photographs will be taken as soon as rocks are dusted off. These photographs will be used to assist in the early sample description phases. All photographs will be processed in the MSC Photographic Laboratory.

7.3.3.5 Models

Aluminum shells will be made of all suitable rocks at an early convenient time, probably concurrent with the photographic activity.

7.3.3.6 Macroscopic Descriptions

Macroscopic descriptions will be made in the processing line only when photographs have been received (expected to be two days after orthogonal photographs are taken). Procedures to be used are described in the SNAP line and NNPL documents.

7.3.3.7 Documentary Photography

A full set of 32 black and white and 6 color documentary photographs will be taken of each rock weighing greater than 50 grams. Reduced photographic coverage will be obtained on smaller rocks. All photographs will be processed in the MSC Photographic Laboratory.

7.3.3.8 Lunar Location and Orientation

Sample location should be determined primarily from surface documentation. Priority for early sample work will be given to those rocks for which surface locations are unknown, but which may be shown in some of the lunar surface photographs. The Lunar Geology Investigation Experiment Team will attempt to determine surface orientations by comparison of lunar surface photography with rocks viewed in the laboratory.

7.3.3.9 Additional Analyses

When sufficient rocks have been described to establish the general nature of the return, and the lunar location and orientation data are known, the PET will present a summary geologic map and rock description to the LSAPT. On the basis of this presentation, a number of samples may be selected for chipping, for thin section preparation, and for chemical or other analyses.

7.3.3.10 PI Experiments

The PI experiments listed below will be carried out as they can be conveniently worked into the sample processing schedule. They will be conducted according to their priorities for rapid access to sample.

a) Short-lived radioactive gases; R. Davis

b) Rock surface examination; D. Morrison, F. Horz, and J. Hartung

c) Rock location and orientation; geology investigation teams

7.3.3.11 LSAPT Interaction

Data will be submitted to the LSAPT in a coherent form as it is developed. These data will consist of:

a) Rock descriptions; a summary of the surface features, gross morphology, and the petrography (where available) of each rock.

b) Chemical and other analyses as they become available.

c) Photographs; a set of six color photographs of each rock. The complete stereo sets will be transmitted to the curator for use by the LSAPT.

d) Anomalies in the operation of the processing line.

e) Summary descriptions made, as required, by the PET and LSAPT.

After rock descriptions are completed, the LSAPT will prepare the sample allocation plan and submit it to NASA management for approval.

7.4 SAMPLE PROCESSING

Specific operating procedures for sample inventory processing and analyses are found in appropriate procedures documents.

Most specific decisions to perform analyses during the preliminary examination period are made in real time. Specific requirements suggested by the LSAPT, the LSPET, or the curator, are considered as sample allocations are made, and will be approved by the curator, with the advice and approval of the LSAPT.

7.4.1 INBOUND REQUIREMENTS FOR LUNAR SAMPLES

The ALSRC's and SCB's in the command module will be placed in Teflon bags and sealed by Landing and Recovery Division personnel aboard the recovery carrier. These seals are not to be broken until the containers have been entered into the appropriate nitrogen processing line.

7.4.2 PROCESSING STEPS

A generalized sample and data flow diagram for the preliminary examination is delineated in Figure 7-1.

All returned samples will be numbered, weighed, described, and photographed. Portions of selected samples will be taken for detailed analysis.

After a split of unsieved fines is removed from each fines sample and stored as an uncontaminated reserve, the remaining material will be sieved on a 1-centimeter sieve.

Fines samples will be further separated into fractions of less than 1 mm, 1 to 2 mm, 2 to 4 mm, and 4 to 10 mm. These fractions will be given individual sample numbers.

Each fragment retained on a 1-centimeter sieve will constitute a unique sample.

Each unique sample will be assigned a separate number and canned separately with a numbered tag placed inside the can; the number tag will be identical to the last three digits of the sample number.

Complete photographic records will be obtained on each rock sample greater than 50 grams. An abbreviated sequence will be taken on each smaller rock and on all groups of coarse fines.

Samples of fines having a volume greater than approximately 250 cubic centimeters will be split as soon as possible into fractions of less than 250 cubic centimeters and stored separately.

Rocks will be chipped in accordance with a chipping plan to be prepared after initial descriptions are available. Chipping will be carried out in such a way that fragments will not be scattered and lose their genealogy. Rock chipping will be documented to clearly show the orientation and location of the chip with respect to the main rock.

Models will be made of all rocks with a mass greater than 50 grams, unless the rocks are fragile or have unique or damageable features.

Each core tube will be considered a separate sample. X-rays will be obtained of each core prior to opening.

Each Special Environment Sample Container (SESC) will be separately numbered, canned, and stored until it can be transferred to an appropriate sampling facility.

7.5 OPERATING CONDITIONS

7.5.1 GENERAL

The SNAP line and NNPL cabinets, tools, and containers in which lunar samples are processed are constructed primarily of stainless steel, aluminum, and Teflon. Samples shall not be contacted by any other material.

Every possible effort will be made to assure that sample processing areas are clean. Tools, containers, and outbound sample return containers will be given special attention. Known sources of contaminants will be removed where possible and characterized where removal is not possible. All cabinets will be precleaned to level CP-2 and all tools to level CP-7, as described in MSC 03243.

Introduction into the processing cabinetry of materials cleaned to lower levels can be done only by waiver. A complete record will be developed of materials which come in contact with the lunar sample and which could be sources of contamination.

Sample handling should minimize the diffusion of material to mixed states and avoid cross contamination of samples. Rocks will be handled with extreme care to minimize surface abrasion. Dust will be removed by blowing or vacuuming, not by brushing. If several fines fractions are to be split from the same source sample, coarse fractions will be split before fine fractions.

7.5.2 SAMPLE INVENTORY, TRACKING, AND CONTROL

The disposition of material according to size will be

a) Samples greater than 50 grams in weight will be designated as rocks, given unique numbers, and subjected to full inventory, photographic, and descriptive treatment.

b) Samples retained on a 1-centimeter screen by less than 50 grams in weight will be individually numbered, tracked, canned, and inventoried but not given full photographic and descriptive treatment.

c) Material between 1 mm and 1 centimeter in size will be designated as coarse fines and further separated according to sizes of 1 to 2 mm, 2 to 4 mm, and 4 to 10 mm. Each size range (from each bag or box) will be numbered, inventoried, and canned separately.

d) Material less than 1 mm in size will be designated as fine fines and that fraction from each bag or box will be numbered, inventoried, and canned separately.

Numbering will be in accordance with a predesignated block scheme established by the curator.

Inventory activity will include the assignment of a number and the acquisition of a photograph simultaneously showing the sample, its number, and weight.

All items such as core tubes, bits, SESC's, etc., will be numbered and weighed.

A data package will be prepared for each separate sample (each unique generic number). This data package will accompany the sample and include the full treatment accorded to that sample.

Trackings of samples will be recorded in three ways. Every transaction will be recorded in the Preliminary Analysis Computation Retrieval and Transmission (PACRAT) computer system (MSC 03287), in hardcopy of the PACRAT operator's log, and on the sample status board. Transfers from one processing area to another will require prior approval of the curator and Chairman of the PET and also be subject to normal transfer procedures with sign-off by delivering and receiving Area Test Directors on the Lunar Sample Custody Transfer Form. The curator must approve all sample transfer forms.

A printout of the contents of each cabinet, according to PACRAT, will be made each day. A daily inventory check against the PACRAT listing will be performed to verify the location of samples in the cabinet lines.

At the end of the preliminary examination, a full inventory will be made and all samples and data packages turned over to the curator. Any remaining sample from biological characterization will be returned to the curator.

7.6 CONTAMINATION MONITORING

7.6.1 ORGANIC CONTROL SAMPLES

Two pieces of Yorkmesh (organic control samples) will be provided with each SRC and both will be subjected to F-250 processing. One will be retained and the other taken to the moon and back in the SRC.

Analysis of portions will be performed. Additional Yorkmesh monitors cleaned along with SRC components will be available for distribution as needed.

7.6.2 ORGANIC CONTAMINATION

The level of organic contamination will be determined by measuring the amount of organic material remaining in the final flush solution resulting from cabinet cleaning. No monitors will be exposed during sample processing. Known sources of organic contamination will be analyzed. During the mission, samples of N_2 will be bubbled through an organic solvent, which will subsequently be analyzed by gas chromatography.

7.6.3 GAS MONITORING

Periodic monitoring of inlet N_2 (from supply truck) will be performed by the Gas Analysis Laboratory.

The N_2 environment of the cabinets in which samples are handled (SNAP line and NNPL) will be monitored for

a) Moisture (alumina sensor)

b) Oxygen (paramagnetic meter)

c) CO, CO_2, Ar, O_2, H_2, and methane (CH_4) (gas chromatography).

The target level of contamination by each of these gases during sample operations is given in Reference 24. A permanent record will be obtained on the level of contaminants in each processing area.

7.6.4 PARTICULATE MONITORING

The nature and size distribution of particulate matter in the sample processing areas will be monitored and samples will be taken for a permanent reference. After cabinet cleaning, and prior to and following operations, particle size distribution will be measured using a Royco or πCM particle counter. Prior to introduction of lunar samples, fallout coupons will be exposed in the cabinets. One set of these coupons will be preserved for a permanent record. The other set will be analyzed by microscopy and microbe techniques in the LRL or at the White Sands Test Facilities (WSTF).

7.7 DATA ACQUISITION, FLOW, AND DISTRIBUTION

All data and photographs will be acquired according to the procedures specified for the various laboratories. All film, hardcopy, photographs,

copies of data packages, operational records, etc., will be transferred regularly to the Data Control Room. Copies and distribution will be made only from the Data Control Room and in strict accordance with MSC 03288, Operating Procedures for Data and Photo Control.

7.7.1 REPORTING

7.7.1.1 PET Results

Results of the preliminary examination will be reported as follows:

a) Weekly summary reports.

b) Periodic summary reports for management levels at MSC and NASA Headquarters.

c) A summary report on the entire examination for publication in a scientific journal.

d) Briefings to the LSAPT as required for proper understanding of the results and as an aid to sample allocation.

e) Scientific results briefing by the PET when significant amounts of data are available to warrant it. This would be at the discretion of the PET Vice-Chairman.

7.7.1.2 Contamination Control Report

A comprehensive report on the results of contamination monitoring will be prepared following the mission.

7.7.1.3 Sample Catalog

A complete catalog of the samples including descriptions, photographs, and attendant analyses will be published following the mission.

7.7.1.4 LRL Mission Reports

A daily LRL status and progress report will be prepared and distributed to MSC management and other interested parties, during the first 15 days of peak mission operations.

7.8 MISSION SECURITY OPERATIONS

A security guard station will be established in the Airlock, Room 174, to control access, by access list, to the Sample Operations Area. All other

accesses to the area will be secured and only opened under emergency conditions. The station will be manned 24 hours/7 days per week until all lunar samples have been transferred to the Sample Packaging Facility for secure storage.

7.9 LUNAR GEOLOGY INVESTIGATION EXPERIMENT INTERFACE

The PET members of the Lunar Geology Investigation Experiment will examine models and actual lunar rocks to determine surface orientation and location. Models will be handled solely in the Building 250 trailer complex. Actual rocks may be examined either in the SNAP line or in the NNPL.

Table 7-1. Anticipated J-2 Mission Lunar Samples

SAMPLE	IMMEDIATE CONTAINER	RETURN CONTAINER
Contingency Sample*	Documented Sample Bag	Contingency Sample Return Container
Selected Documented Geological Samples, Including Rocks and Fines	Prenumbered Teflon Documented Sample Bags (140 max.)/Sample Collection Bags No. 1, No. 2, and No. 3	SRC No. 1 - S/N 1009 HRE SRC No. 2 - S/N 1010 Sample Collection Bag No. 3 (See Note 1)
Other Documented Geological Samples, Including Large Rocks and Sample Overflow from the SRC's and SCB's	Extra Sample Collection Bags No. 4, No. 5, No. 6, No. 7, and No. 8 Sample Return Bag (BLSS Sample Bag) (Big Rock Bag)	Same (See Note 1) Same (See Note 1)
Special Crystalline Rock Samples (2)	Padded Sample Bag (2)	Same
Surface Top Layer Grain Samples (2)	Special Surface Sampler (2)	Sample Collection Bag
Deep Core Sample taken with ALSD	Core Drill String (2 sections)/Beta Cloth Bag	Same
Core Tube Samples (May be Single, Double, or Triple Core Tube Samples) (See Note 2)	SRC No. 1 (2 Core Tubes from EVA No. 1) SRC No. 2 (3 Core Tubes from EVA No. 2) Sample Collection Bag No. 3 (3 Core Tubes from EVA No. 3)	SRC No. 1 - S/N 1009 HRE SRC No. 2 - S/N 1010 Same

*Sample to be obtained only in the event that the lunar surface stay time and subsequent EVA is foreshortened to the extent that a documented sample cannot be acquired.

Table 7-1. Anticipated J-2 Mission Lunar Samples (Continued)

SAMPLE	IMMEDIATE CONTAINER	RETURN CONTAINER
Special Environmental Samples	Special Sample Containers:	
• Pristine Core Tube Sample	Core Sample Vacuum Container (Taken on EVA No. 2)	SRC No. 2 - S/N 1010
• Environmental Soil Sample (Taken from Bottom of Trench or Boulder Overhang Area)	SESC No. 1020 (Taken on EVA No. 2)	SRC No. 2 - S/N 1010
Soil Mechanics Penetrometer Drum (Contains record of penetrometer test results)	Upper Penetrometer Assembly	Lunar Geology Documented Sample Bag
Solar Wind Composition Foil and Reel	SWC Stowage Bag	Same
Cosmic Ray Detector Panels (4)	Cosmic Ray Detector Stowage Bag	Same (See Note 3)
Organic Control Samples	SRC No. 1 - S/N 1009 HRE	SRC No. 1 - S/N 1009 HRE
	SRC No. 2 - S/N 1010	SRC No. 2 - S/N 1010

NOTES:

(1) SRC No. 1, SRC No. 2, and Sample Collection Bag No. 3 to contain documented geological samples obtained on EVA No. 1, EVA No. 2, and EVA No. 3, respectively. Extra sample collection bags are provided for each EVA to take care of sample overflow and large rock samples. An additional sample collection bag and sample return bag are also available to accomodate other miscellaneous geological samples.

(2) The exact type of core tube sample obtained (single, double, or triple) is dependent upon the type of geological conditions encountered and exact activity performed on each EVA.

(3) Temperature indicators (4) on the cosmic ray detector stowage bag are to be read by LRL personnel and recorded for PI use.

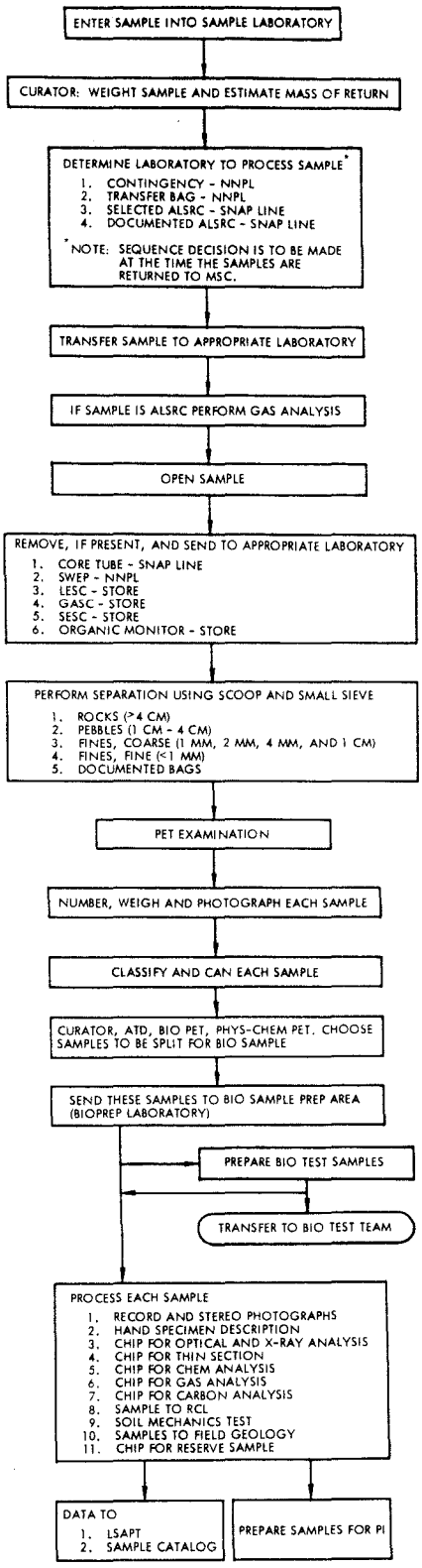

Figure 7-1. General Sample Flow Diagram

SECTION VIII

SCIENCE CONTINGENCY DATA

8.1 GENERAL

This section was provided by the Science Requirements and Operations Branch/TD5. General information is contained in this section for use in real-time replanning and rescheduling of Apollo Mission J-2 science-related activities if a contingency or off-nominal condition should occur during the mission.

Data contained in this section are provided for experiment Principal Investigators, members of the scientific community, and personnel responsible for science contingency planning. These data are intended for use in implementing the lunar orbital and surface science requirements presented in the MSC-controlled J-2 Mission Requirements Document (Reference 1) until such data are published in other MSC-controlled documents. These documents include the Apollo 16 Flight Plan (Reference 2), Apollo 16 Lunar Surface Procedures (Reference 3), Apollo 16 Flight Mission Rules (Reference 17), and Scientific Experiments Contingency and Planning Procedures, Mission J-2/Apollo 16 (Reference 25). Reference 25 contains detailed contingency data and procedures for all lunar orbit and lunar surface science experiments and science-related detailed objectives.

8.2 CONTINGENCY PLANNING DATA

Table 8-1 lists the lunar orbit science experiments and science-related detailed objectives assigned to the J-2 Mission. Indicated in this table are the effects of a scrubbed mission in terms of recycling requirements and the identification of useful science data that can be obtained from various contingency missions induced by an anomalous condition such as a spacecraft subsystem failure. The contingency missions considered are

a) Earth orbit (EO)

b) Lunar flyby (LF)

c) Lunar orbit/no lunar landing (LO/NLL)

d) No transearth coast EVA (NTE)

It should be noted that on any alternate or contingency mission, the SIM bay door should be jettisoned and the SIM science sensors and cameras should be activated to verify hardware operation and to evaluate operational procedures.

Table 8-2 lists contingency lunar surface science activities which can be conducted in the event of the following anomalous situations:

a) Crew unable to locate touchdown point in the landing ellipse

b) Not enough time for an EVA

c) Time available for a brief EVA 1 only (1 or 2 men)

d) Time available for an EVA 1 only (2 men)

e) Time available for a one-man EVA 1 only (No EVA 2 or EVA 3 possible)

f) One-man EVA 1 (EVA 2 planned, no EVA 3 possible)

g) Two-man EVA 1 (EVA 2 planned, no EVA 3 possible)

h) One-man EVA 2 or EVA 3

Table 8-2 is not addressed to the major surface contingency situation whereby the LRV becomes inoperable or cannot be deployed and three EVA's with the use of both crewmen are still possible. In this case, three walking traverses are to be planned with the requirements and activities as identified in this section and Section IV.

Table 8-1. Lunar Orbit Science Experiments/Objectives - Science Data Return Matrix for Contingency Missions

EXPERIMENT/OBJECTIVE	SL	CONTINGENCY MISSION			
		EO	LF	LO/NLL	NTE
SM Orbital Photographic Tasks (DO):					
• 24-Inch Panoramic Camera	G[3]	G[1]	N	G	N[6]
• 3-Inch Mapping Camera/Stellar Camera	G[3]	G[1]	N	G	N[6]
• Laser Altimeter	G	N	N	G	N/A
Visual Observations From Lunar Orbit (DO)	G	G[1]	N	G	N/A
CM Photographic Tasks (DO)	G	G[1]	G[4]	G	N/A
UV Photography - Earth and Moon(S-177)	G	N	G[4]	G	N/A
Gegenschein From Lunar Orbit (S-178)	G	N	N	G	N/A
Gamma-Ray Spectrometer (S-160)	G[5]	N	G[4*]	G[**]	N/A
Alpha Particle Spectrometer (S-162)	G[5]	N	G[4]	G	N/A
X-Ray Fluorescence (S-161)	G[5]	G[1]	G[4]	G	N/A
Mass Spectrometer (S-165)	G[5]	G[4]	G[4]	G	N/A
S-Band Transponder (CSM/LM) (S-164)	G	N	N	G	N/A
Bistatic Radar (S-170)	G	N	N	G	N/A
Subsatellite:	N[2]	G[1]	G[4]	G	N/A
• Magnetometer (S-174)	N/A	N	G[4]	G	N/A
• Particle Shadows/Boundary Layer (S-173)	N/A	G[1]	G[4]	G	N/A
• S-Band Transponder (S-164)	N/A	N	N	G	N/A

LEGEND:

SL - Scrubbed Launch: can be recycled without experiment effect
EO - Earth Orbit
LF - Lunar Flyby
LO/NLL - Lunar Orbit/No Lunar Landing
NTE - No TEC EVA Period
G - Go (Useful science data can be acquired)
N - No/Go (No useful science date can be acquired)
N/A - Not Applicable
DO - Detailed Objective

SUPERSCRIPTS:

1 - Objectives may be changed if operated during this contingency mission
2 - Batteries may have to be charged
3 - Film may require reloading
4 - Possibly partial or degraded data
5 - Dependent on time period (calibration sources may require renewal)
6 - No returned imagery data

*Additional degraded data results if the LM (RTG radiation source) is docked to the CSM.

**Degraded data results only if the LM is docked to the CSM.

Table 8-2. Surface Science Experiments - EVA Decisions

SITUATION	CONTINGENCY	AGENT	ACTION
a)	Crew unable to locate touchdown point in the landing ellipse.	Crew	1. Make visual observations through Lunar Module (LM) window and describe features around the LM.
		MCC	2. Compare television images and the astronauts' description of features to overall features in the map package.
		MCC/Crew	3. Revise the ALSEP deployment and traverse plans as required.
b)	Not enough time for an EVA.	Crew	1. Make careful observations and descriptions of surface through LM windows or by a SEVA. Numerous still camera photos should be taken with both black and white and color film. Photos with polarizing filter in three different positions should be made.
		MCC	2. Study landing area on maps and submit pertinent questions relating to surface smoothness or roughness, the contours of surface, size of rocks, and craters in the area.

Table 8-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
c)	Time for brief EVA 1 only (1 or 2 men)	Crew	1. Make careful observations and descriptions of surface through LM windows. Numerous still camera photos should be taken with both black and white and color film. Photos with polarizing filter in three different positions should be made.
		MCC	2. Study landing area on maps and submit pertinent questions relating to surface smoothness or roughness, the contours of surface, size of rocks, and craters in the area.
		Crew	3. Collect the soil (contingency) sample.
		Crew	4. If possible, take a photographic panorama of the landing area and photos of nearby surface features. Take photos of surface under LM descent engine and around footpads.
		Crew	5. Retrieve the CRD (S-152) panels.

Table 8-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
d)	Time for EVA 1 only (2 men)	Crew	1. Pull "red" lanyard of CRD (S-152) experiment.
		Crew	2. Deploy ALSEP according to priorities. • HFE • LSM • PSE • ASE
		Crew	3. Perform lunar geology investigations during the return traverse from the ALSEP site. NOTE • Photograph and describe geological features as well as collect documented samples (including the core samples). • Reduce the number of stations and distance attempted.
		Crew	4. Retrieve the CRD (S-152) panels.

Table 8-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
e)	Time for a one-man EVA 1 only. (No EVA 2 or 3 possible)	Crewman	1. Pull "red" lanyard of CRD (S-152) experiment.
		Crewman	2. Deploy ALSEP according to priorities. • HFE • LSM • PSE • ASE
		Crewman	3. Perform lunar geology investigations during the traverse from the ALSEP site. NOTE • Photograph and describe geological features as well as collect documented samples (including the core samples). • Reduce the number of stations and distance attempted.
		Crewman	4. Retrieve the CRD (S-152) panels.

Table 8-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
f)	One-man EVA 1 (EVA 2 planned, no EVA 3 possible)	Crewman	1. Pull "red" lanyard on CRD (S-152) experiment.
		Crewman	2. Deploy the Solar Wind Composition (S-080) experiment.
		Crewman	3. Deploy ALSEP according to priorities. • HFE • LSM • PSE • ASE
		Crewman	4. Perform lunar geology investigations during the return traverse from the ALSEP site. NOTE • Photograph and describe geological features as well as collect documented samples (including the core samples). • Reduce the number of stations and distance attempted.
		Crewman	5. Deploy the Far UV Camera/Spectroscope (S-201) experiment.

Table 8-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
g)	Two-man EVA 1 (EVA 2 planned, no EVA 3 possible)	Crew	1. Pull "red" lanyard of CRD (S-152) experiment.
		Crew	2. Deploy the Solar Wind Composition (S-080) experiment.
		Crew	3. Deploy the Far UV Camera/Spectroscope (S-201) experiment. NOTE Decisions for settings to obtain new targets will be made in real time.
		Crew	4. Deploy ALSEP according to priorities. • HFE • LSM • ASE • PSE
		Crew	5. Perform lunar geology investigations during the return traverse from the ALSEP site. NOTE • Photograph and describe geological features as well as collect documented samples (including the core samples).

Table 8-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
g)	Two-man EVA 1 (EVA 2 planned, no EVA 3 possible)(Cont'd)	Crew	NOTE • Reduce the number of stations and distance attempted.
h)	One-man EVA 2 or EVA 3	Crewman	1. If LRV is operable: a. Perform geology sample collection and documentation, and take portable magnetometer measurements during the LRV traverse. b. Take panorama photographs at stations along the traverse. c. Retrieve the CRD (S-152) panels. NOTE Decision for retrieving the CRD (S-152) panels during EVA 2 or EVA 3 will be made in real time. d. Retrieve the film transport device from the Far UV Camera/Spectroscope (S-201) experiment.

Table 8-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
h)	One-man EVA 2 or EVA 3 (Continued)	Crewman	NOTE Decision for retrieving the film transport device during EVA 2 or EVA 3 will be made in real time. e. Retrieve the foil from the Solar Wind Composition (S-080) experiment. NOTE Decision for retrieving the SWC foil during EVA 2 or EVA 3 will be made in real time.
		Crewman	2. If LRV is inoperable: a. Perform geology sample collection and documentation during the walking traverse. NOTE Crewman may abbreviate documentation requirements for samples if MCC concurs.

Table 8-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
h)	One-man EVA 2 or EVA 3 (Continued)	Crewman	b. Take panorama photographs at stations along the traverse. c. Take a portable magnetometer measurement as far as possible from LM. NOTE Decisions to take additional measurements at other locations will be made in real time. d. Retrieve the CRD (S-152) panels. NOTE Decision for retrieving the CRD (S-152) panels during EVA 2 or EVA 3 will be made in real time. e. Retrieve the film transport device from the Far UV Camera/Spectroscope (S-201) experiment. NOTE Decision for retrieving the film transport device during EVA 2 or EVA 3 will be made in real time.

Table 8-2. Surface Science Experiments - EVA Decisions (Continued)

SITUATION	CONTINGENCY	AGENT	ACTION
h)	One-man EVA 2 or EVA 3 (Continued)	Crewman	f. Retrieve the foil from the Solar Wind Composition (S-080) experiment. NOTE Decision for retrieving the SWC foil during EVA 2 or EVA 3 will be made in real time.

APPENDIX A

ACRONYMS AND ABBREVIATIONS

Å	Angstron Unit (1×10^{-10}m)
ac	Alternating Current
ACTR	Actuator
AEC	Automatic Exposure Control
AFMA	Apollo Flight Mission Assignments
Al	Aluminum
ALSD	Apollo Lunar Surface Drill
ALSEP	Apollo Lunar Surface Experiments Package
ALHT	Apollo Lunar Hand Tools
ALHTC	Apollo Lunar Hand Tool Carrier
ALSRC	Apollo Lunar Sample Return Container (also called SRC)
AM	Amplitude Modulated
AMU	Atomic Mass Unit
APO	Apollo Program Office
Ar	Argon
Ar^{36}	Isotope of Argon
Ar^{38}	Isotope of Argon
Ar^{40}	Isotope of Argon
ASA	American Standards Association
ASE	Active Seismic Experiment
AS&E	American Science and Engineering, Incorporated
ASI	Apollo Standard Initiator
ASPO	Apollo Spacecraft Program Office
ASSY	Assembly
ATD	Area Test Director

AZ	Azimuth
Be	Beryllium
BSLSS	Buddy Secondary Life Support System
BW	Black and White
C	Centigrade
Ca	Calcium
CaF_2	Calcium Fluoride
CCB	Configuration Control Board
CDR	Commander
CEX	Color Exterior
CH_4	Methane
℄	Center Line
CM	Command Module
cm	Centimeter
CO	Carbon Monoxide
CO_2	Carbon Dioxide
CRD	Cosmic Ray Detector
C/S	ALSEP Central Station
CsI	Cesium Iodide
CSM	Command and Service Module
CSVC	Core Sample Vacuum Container
DAC	Data Acquisition Camera
Decl.	Declination (measured in celestial coordinates)
DIA	Diameter
DO	Detailed Objective

DOI	Descent Orbit Insertion
DPS	Descent Propulsion System
DSEA	Data Storage Electronics Assembly
E	East
EAFB	Ellington Air Force Base
EMI	Electromagnetic Interference
EPO	Earth Parking Orbit
EVA	Extravehicular Activity
Ex	Example
f	Camera Aperture Opening Reference (also T)
Fe	Iron
FMC	Forward Motion Compensation
FOV	Field of View
FWD	Forward
GASC	Gas Analysis Sample Container
GCTA	Ground-Commanded Television Assembly
GET	Ground Elapsed Time
GLA	Grenade Launch Tube Assembly
gm	Gram
GN_2	Gaseous Nitrogen
H_2	Hydrogen
H_2O	Water

HBW	High-Speed Black and White
HCEX	High-Speed Color Exterior
HD	Highly Desirable
He	Helium
HEC	Hasselblad Electric Camera
HEDC	Hasselblad Electric Data Camera
HFE	Heat Flow Experiment
HFE	Heat Flow Electronics
hr	Hour
HRE	Hardware Reuse Evaluation
ID	Identification
IMC	Image Motion Compensation
IU	Instrument Unit
JPL	Jet Propulsion Laboratory
K	Kelvin
K	Potassium
K^{40}	Isotope of Potassium
keV	One Thousand Electron Volts
kg	Kilogram
km	Kilometer
KSC	Kennedy Space Center
LBW	Low-Speed Black and White
LCRU	Lunar Communications Relay Unit

LDAC	Lunar Surface 16-mm Data Acquisition Camera
LESC	Lunar Environment Sample Container
LFLC	Long Focal Length Camera
LiF	Lithium Fluoride
LM	Lunar Module
LMP	Lunar Module Pilot
LOI	Lunar Orbit Insertion
LP	Long-Period
LPX	Long-Period Seismic Sensor (horizontal X-direction)
LPY	Long-Period Seismic Sensor (horizontal Y-direction)
LPZ	Long-Period Seismic Sensor (vertical Z-direction)
LRL	Lunar Receiving Laboratory
LRV	Lunar Roving Vehicle
LSAPT	Lunar Samples Analysis and Planning Team
LSM	Lunar Surface Magnetometer
LSPET	Lunar Sample Preliminary Examination Team
LSUV	Lunar Surface UV Camera
m	Meter, Milli
M	Mandatory
MAX	Maximum
MC	Mapping Camera
MCC	Mission Control Center
MESA	Modularized Equipment Stowage Assembly
MeV	One Million Electron Volts
Mg	Magnesium

MIN	Minimum
min	Minute
MIP	Mission Implementation Plan
mm	Millimeter
MPA	Mortar Package Assembly
MRD	Mission Requirements Document
MRO	Memory Read-Out
MSC	Manned Spacecraft Center
MSFEB	Manned Space Flight Experiments Board
MSFN	Manned Space Flight Network
MSPD	Mission Science Planning Document
N	North
Na	Sodium
N/A	Not Applicable
NaI	Sodium Iodide
Ne	Neon
nm	Nanometer
NM	Nautical Mile
NNPL	Non-Sterile Nitrogen Processing Line
No.	Number
NRL	Naval Research Laboratory
NW	Northwest
O_2	Oxygen
OMSF	Office of Manned Space Flight
OSSA	Office of Space Sciences and Application

PACRAT	Preliminary Analysis Computation Retrieval and Transmission
PC	Panoramic Camera
PDU	Power Distribution Unit
PET	Preliminary Examination Team
PI	Principal Investigator
PKG	Package
PLSS	Portable Life Support System
PM	Portable Magnetometer
PM	Pulse Modulated
ppm	Parts Per Million
PSCB	Padded Sample Collection Bag
PSE	Passive Seismic Experiment
PTD	Photographic Technology Division
R. Asc.	Right Ascension (measured in celestial coordinates)
RCA	Radio Corporation of America
RCL	Radiation Counting Laboratory
RCS	Reaction Control System
REV	Revolution
RH	Right Hand
Rn	Radon
RTG	Radioisotope Thermoelectric Generator
S	South
S	Sulphur
SA	Saturn Apollo
S&AD	Science and Applications Directorate

SC	Stellar Camera
S/C	Spacecraft
SCB	Sample Collection Bag
SE	Southeast
sec	Second
SESC	Special Environmental Sample Container
SEQ	Scientific Equipment Bay
SEVA	Standup Extravehicular Activity
Si	Silicon
SIM	Scientific Instrument Module
SM	Service Module
SNAP	Sterile Nitrogen Atmosphere Processing (Line)
SNAP	System for Nuclear Auxiliary Power
SO	Special Order
SP	Short-Period
SPS	Service Propulsion System
SPZ	Short-Period Seismic Sensor (vertical Z-direction)
SRC	Sample Return Container (also known as ALSRC)
SRP	Self-Recording Penetrometer
SSD	Surface Sampler Device
SSW	South, Southwest
SW	Southwest
SW	Switch
SWC	Solar Wind Composition
SWEP	Solar Wind Experiment Package

T	Camera Aperture Opening Reference (also f)
TBD	To Be Determined
TEC	Transearth Coast
TEI	Transearth Injection
Th	Thorium
Tl	Thallium
TRW	TRW, Incorporated
TV	Television
U	Uranium
UHT	Universal Hand Tool
USGS	United States Geological Survey
UTD	University of Texas at Dallas
UV	Ultraviolet
V/h	Velocity-to-Height
VHBW	Very High-Speed Black and White
W	West
WSTF	White Sands Test Facility
X_S	SM Station Designation
Z	Atomic Number
h	Hour (superscript)
m	Minute (superscript)
°	Degrees
35	35-mm Nikon Camera
$\geq$	Greater Than or Equal To

$<$	Less Than
∞	"Infinite" focus distance
γ	Gamma
μ	Micron
σ	Sigma

APPENDIX B

GLOSSARY

ALBEDO	The amount of electromagnetic radiation reflected by a body expressed as a percentage of the radiation incident on the body, commonly used with reference to the relative brightness of a body or geologic structure.
ALPHA PARTICLE	A nuclear particle of atomic mass 4 made up of 2 protons and 2 neutrons.
ANGSTROM UNIT	A unit of length equal to 10^{-10} meters or 10^{-4} microns commonly used in specifying wavelengths of electromagnetic radiation.
APERTURE	A small opening such as a camera shutter through which light rays pass to expose film when the shutter is open.
ATTENUATION	Decrease in intensity usually of wave phenomena such as light or sound.
BISTATIC RADAR	A radar system whereby the transmitter and receiving units are not at the same location. In this experiment, the transmitter sources are from the CSM S-band and VHF antennas in lunar orbit. The reflected radar signals from the lunar surface received by earth-based tracking stations.
BOUNDARY LAYER	The interaction layer between the solar wind bow shock and the magnetopause. Also, the interaction layer between the moon and the undisturbed portion of the solar wind (see Figure 2-11).
BOW SHOCK	The shock wave produced by the interaction of the solar wind with the earth's magnetosphere.
BRECCIA	A coarse-grained clastic rock (rocks formed of fragments of pre-existing rocks).
BREWSTER ANGLE	An angle used in characterizing incident and reflected waves of electromagnetic radiation. The tangent of this angle is equal to the index of refraction of the medium through which the incident waves travel with respect to the medium from which the reflected waves emerge.

CARTOGRAPHIC	Related to the production of accurately scaled maps as of the moon's surface.
CASSETTE	Container of photographic film as from the 24-Inch Panoramic Camera or 3-Inch Mapping Camera.
CISLUNAR	Pertaining to the space between the earth and moon or the moon's orbit.
COLLIMATOR	A device for producing beams of parallel rays of light or other electromagnetic radiation.
COLORIMETRIC	Pertaining to the measurement of the intensities of different colors as of lunar surface materials.
CONVERGENCE ANGLE	Angle between the lines of sight from two separate stations from which a subject is photographed to the subject. The merging of these separate photographs results in stereoscopic imagery of the subject.
COSMIC RAYS	Streams of very high energy nuclear particles, commonly protons, that bombard the earth and moon from all directions.
COSMOLOGY	Related to the investigation of the character and origin of the universe.
CROSS-SUN	A direction approximately 90 degrees to the solar vector, used in specifying lunar surface photography requirements.
CROSS-TRACK	In a plane perpendicular to the instantaneous direction of a spacecraft's ground track.
DIFFUSE DENSITY	The degree of darkening of a photographic film approximately proportional to the mass of metallic silver per unit area.
DOPPLER TRACKING	A continuous-wave, trajectory-measuring system using the doppler effect caused by a target moving relative to a ground transmitter and receiving stations.
DOWN-SUN	In the same direction as the solar vector and used in specifying lunar surface photography requirements.
EARTHSHINE	Illumination of the moon's surface by sunlight reflected from the earth.

ECLIPTIC PLANE	The plane defined by the earth's orbit about the sun.
EFFLUENT	Any liquid or gaseous substance discharged from the spacecraft such as waste water, urine, fuel cell purge products, etc.
EJECTA	Lunar material thrown out (as resulting from meteoroid impact or volcanic action).
ELECTRON	The extranuclear constituent of all atoms carrying a negative charge and a mass of 1/1836 that of a proton.
EXOSPHERE	The outermost portion of the earth's or moon's atmosphere from which gases can escape into outer space.
EXPOSURE	The product of illumination (luminous flux per unit area) and the time interval during which a photographic film is subjected to the illumination.
FAR UV	The region of the UV radiation spectrum lying between 2000 Å and 400 Å (border of X-ray region).
FIELD	A region or space in which a given effect (e.g., force) exists such as a magnetic or gravity field. Such an effect is usually expressed in scalar form although the vector form is required for analyses performed with respect to a coordinate system.
FIELD OF VIEW	The capture area locus of electromagnetic radiation referenced to the opening of a sensor element within which the sensor can efficiently detect and register such radiation on a recording device. Usually expressed in degrees and most commonly used with reference to the imagery area in space "seen" by the lens of an optical instrument such as a camera.
FILLET	Debris (soil) piled up against rock is called a fillet.
FLUORESCENCE	Emission of radiant energy in response to the absorption of radiant energy at a different wavelength.

FLUX	The time rate of flow (per unit area, as well, for some applications) of some quantity such as the flux of cosmic rays or the flux of plasma particles in the solar wind that strike the lunar surface.
GALACTIC	Pertaining to a galaxy in the universe such as the Milky Way.
GAMMA	The average slope of the diffuse density versus the relative $\log_{10}$ exposure curve (see Appendix E) used in specifying photographic film processing requirements.
GAMMA	A measure of magnetic field strength equal to 1×10^{-5} gauss.
GAMMA-RAY	Electromagnetic radiation emitted by an atomic nucleus as a result of a quantum transition from a higher to a lower energy level of the nucleus. Other nuclear constituents are also emitted as a result of this transition. Gamma-rays are in the energy range from 10 kiloelectron volts to 10 million electron volts.
GARDENING	Reference to the overturning, reworking, and changing of the lunar surface due to such overall processes as meteoroid impact, possible volcanic action, aging, and the like.
GEGENSCHEIN	A faint light covering a 20-degree field-of-view projected on the celestial sphere.
GENEALOGY	The history of the origin, formation, and subsequent changes incurred in a particular lunar sample.
GEOCHEMICAL GROUP	A group of three experiments especially designed to study the chemical differentiation and constituents of the lunar surface remotely from lunar orbit, viz, S-160, S-161, and S-162.
GEODESY	The science which deals mathematically with the exact size and shape of the earth and other planets, the planet's external gravity field, and with surveys of such precision that overall size and shape of the earth or planet must be taken into consideration.

GEOPHONE	A small detection device implanted in the lunar surface during the deployment of the ASE to record subsurface transmissions of seismic energy from artificial and natural sources.
GEOPHYSICAL	Pertaining to the physics of the earth, moon, and other planetary bodies, as well as their surrounding environment.
GNOMON	A rod pivoted about a free bearing that is used on the lunar surface to indicate the local vertical, to give sun position, and to serve as a distance scale when photographing lunar samples "in situ". Color and reflectance scales are provided on the rod and on one leg of the gnomon for a colorimetric reference.
GRADIENT	The spatial rate of change of a function. For example, the change in local lunar surface magnetic field strength with distance (as from the LM).
GRANITIC	Having the characteristics of granite rock.
IGNEOUS ROCK	Rock formed from molten material as from volcanic processes.
IMBRIAN AGE	The oldest of the four major lunar time-stratigraphic units is called the Imbrian System. The Imbrian Age represents the period during which the Imbrian System developed, that is, a very short interval of time during the formation of the Imbrium Basin.
IN SITU	In place or natural locale.
INTERSTELLAR WIND	Apparent motion of interstellar hydrogen past the sun in the plane of the Milky Way, from an apparent source in the central region of the Milky Way.
ION	An atom or group of atoms that carries a positive or negative electric charge as a result of having lost or gained one or more electrons, respectively.
IONOSPHERE	The part of the earth's atmosphere beginning at an altitude of about 40 km and extending outward 400 km or more, containing free electrically-charged particles, and consisting of several regions within which occur one or more layers that very in height and ionization with time of day, season, and the solar cycle.

ISOSTATIC EQUILIBRIUM	General equilibrium in the earth or lunar crust maintained by a yielding flow of rock material beneath the surface that is under gravitative stress.
J-2 MISSION	The second mission of a class of Apollo missions (J-series) in the Apollo Program providing the capability for extended lunar surface staytimes, longer mission duration, improved surface mobility and communications, more extensive surface science experiments and exploration, and an orbital science payload package (SIM).
KINESCOPE	A motion picture made from a television camera sequence.
LIBRATION POINT	One of five theoretical locations in space of the rotating earth-moon system where the gravitational attraction forces of the moon and earth are equal. It is believed that interplanetary dust and other forms of particulate matter collect at these points and that reflected sunlight from these particles can indicate their presence either by direct observation or by photographic imagery.
LIMB	The outer edge of the apparent disc of a celestial body, as the moon or earth, or a portion of the edge.
LITHOLOGY	The character of a rock formation.
LUNATION	The interval between two successive passages of the moon through conjunction or opposition respectively; therefore, the period of the moon phases.
LYMAN-ALPHA RADIATION	The characteristic radiation emitted by hydrogen at a wavelength of 1216 Å, first observed in the solar spectrum by rocket-borne spectrographs.
MAGMATIC	Pertaining to molten material or mass from which igneous rock results by cooling and crystallization.
MAGNETOPAUSE	The boundary between the solar wind bow shock/ earth magnetosphere interaction boundary layer and the magnetosphere (see Figure 2-11).

MAGNETOSHEATH	The region between the solar wind bow shock and the magnetotail region of the earth's magnetosphere, also called the boundary layer of the magnetosphere (see Figure 2-11).
MAGNETSOPHERE	The region of the earth's atmosphere where ionized gases contribute to the determination of the dynamics of the atmosphere and where the forces of the earth's magnetic field are predominant (see Figure 2-11).
MAGNETOTAIL	The tube-like elongated region of the earth's magnetosphere of undetermined length in the antisolar direction, also called the geomagnetic tail (see Figure 2-11).
MARE	A large dark flat area on the lunar surface (Lunar Sea).
MARIA	Plural form of mare.
MASCONS	Large mass concentrations beneath the surface of the moon. They are believed to contain large bodies or masses that have impacted the lunar surface from outer space.
MASS SPECTROMETER	An instrument which differentiates chemical species in terms of their different isotopic masses.
METEORITIC	Pertaining to material apparently originating from meteoroids.
METRIC PHOTOGRAPHY	Recording of surface topography by means of photography, together with an appropriate network of coordinates, to form the basis of accurate measurements and reference points for precise photographic mapping.
MICROSCOPIC	Of such a size as to be observed, if at all, only under optical magnification.
MONOENERGETIC SOURCE	A source of electromagnetic radiation confined to a very narrow frequency range used, for example, as a calibration source for spectrometers.
MORPHOLOGY	The external structure of rocks in relation to the development of erosional forms or topographic features.

MOULTON POINT	A theoretical point along the sun-earth line located 940,000 statute miles behind the earth at which the sum of all gravitational forces is zero (in a rotating coordinate system).
NADIR	That point on the earth (or moon) vertically below the observer.
NEUTRON	An uncharged elementary particle that has a mass nearly equal to that of a proton and is present in all known atomic nuclei except the hydrogen nucleus.
NON-FRIABLE ROCK	Rock that is not easily crumbled or pulverized.
NUCLEON	A constituent particle of an atomic nucleus. For example, a proton or a neutron which falls in terms of mass between a meson and a hyperon.
OCCULTATION	The shutting off of the light of one celestial body by the intervention of another as the eclipse of a star or planet by the moon.
P-10	A gas mixture consisting of 90 percent argon, 9.5 percent carbon dioxide, and 0.5 percent helium used to fill the X-ray detectors of the X-Ray Fluorescence Experiment.
PANORAMA	Lunar surface photographs taken from a point to portray lunar surface features 360 degrees around that point.
PARALLAX	The apparent displacement of an object as seen from two different points not on a straight line with the object.
PETROGRAPHY	Systematic description of rocks based on observations in the field (e.g., on the moon), on returned specimens, and on thin microscopic sections.
PHOTOMULTIPLIER TUBE	An electron tube that uses a photocathode to produce photoelectric emission in response to a light flash stimulus (such as provided from the X-Ray Experiment scintillator). This photoelectric emission is amplified to produce a measureable output current through a process utilizing multiple states of secondary electron emission.

PLASMA	An electrically-conductive gas comprised of neutral particles, ionized particles, and free electrons but which, when taken as a whole, is electrically neutral.
POLARIMETRIC	Referring to the measurement of the intensity of polarized light in a partially polarized light beam or the measurement of the extent of polarization.
POSIGRADE	Lunar orbital motion in the direction of lunar rotation.
PROTON	The positively charged constituent of atomic nuclei. For example, the entire nucleus of a hydrogen atom having a mass of 1.67252×10^{-27} kilograms.
PYROCLASTIC DETRITUS	Material formed by fragmentation as a result of volcanic or igneous action.
RADON	Isotopes of a radioactive gaseous element with atomic number 86 and atomic masses of 220 and 222 formed by the radioactive decay of radium.
RAY	Bright material extending radially outward from fresh lunar craters that is composed of ejecta from the formation of the crater.
REGOLITH	The unconsolidated residual material that resides on the solid surface of the moon (or earth).
RESEAU	A system of lines (small "crosses") forming small squares of standard size that is photographed by a separate exposure on the same film with the particular image photographed so as to facilitate the measurement of distances.
RETROGRADE	Lunar orbital motion opposite the direction of lunar rotation.
S-BAND	A frequency band used in radar and communications extending from 1.55 to 5.2 kilomegahertz.
SCARP	A line of cliffs produced by faulting or erosion.
SCINTILLATOR	A device for detecting and registering individual scintillations (a flash of light produced in a phosphor by an ionizing event) as produced by radioactive emissions.

SEISMIC	Related to mechanical vibration within the surface of the earth or moon resulting from, for example, impact of meteoroids on the surface.
SENSITOMETRIC	Pertaining to the measurement of the light response characteristics of photographic film under controlled conditions of exposure and development.
SHOCKED ROCKS	Rocks which have been formed by or subjected to the extremes of temperature and pressure present during major lunar evolutionary events.
SIDELAP	Overlap of two aerial photographic strips in a direction perpendicular to the length of the strips.
SOLAR CORONA	A halo, pearly white in color, surrounding the sun; its full extent can be seen during a total solar eclipse.
SOLAR WIND	Streams of plasma particles (mostly hydrogen and helium) emanating from and flowing approximately radially outward from the sun.
SPALLATION	A nuclear reaction in which low mass subatomic particles are ejected as the result of bombardment (as by high energy protons).
SPATIAL	Pertaining to the location of points referenced to three-dimensional space as contrasted with temporal (pertaining to time) locations.
SPECTROGRAPH	A spectroscope with a photographic recording device.
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.
SPECTROSCOPIC	Referring to measurements made with a spectrometer.
SPECTRUM	The totality of wavelengths (or frequencies) of electromagnetic radiation.

STELLAR	Of or pertaining to stars. The stellar camera composing a part of the 3-Inch Mapping Camera is used to photograph star fields for use in establishing a precision spacecraft attitude reference to provide postmission camera pointing data.
STEREO	A type of photography in which photographs taken of the same subject area from different angles are combined to produce visible features in three-dimensional relief.
SUBSATELLITE	A small unmanned satellite, deployed from the CSM SIM bay while in lunar orbit, that is designed to obtain various types of solar wind particle, lunar magnetic field, and S-band tracking data over an extended period of time.
TALKBACK DISPLAY	A CM crew cue display associated typically with an event or operation activity which exhibits a striped or "barber pole" color scheme format during the execution of the event or activity and a grey color when the event or activity has been properly completed.
TEKTITE	Glassy bodies of probable meteoritic origin and of rounded but indefinite shape that are found in various places on the earth.
TEMPORAL	Referring to the passage or measurement of time.
TERMINATOR	The line separating the illuminated and the darkened areas of a body such as the earth or moon which is not self-luminous.
TERRA	Those portions of the lunar surface other than the maria; the lighter areas of the moon.
THORIUM	A heavy metallic element with an atomic number of 90 and an atomic mass of 232.
TIDAL	Referring to the seismic movement of layers forming the outer portion of the lunar surface or within the lunar mantle as a result of the gravitational attraction of the earth and other planetary bodies. Similar in nature to the tidal movements of the earth's oceans.

TIMELINE	A detailed schedule of astronaut or mission activities indicating the activity and time at which it is to occur within the mission.
TOPOGRAPHIC	Pertaining to the accurate graphical description, usually on maps or charts, of the physical features of an area on the earth or moon.
TOPOLOGY OF THE MAGNETOTAIL	Pertaining to the study of the composition, structure, and time-tracing of solar wind particles appearing in the earth's magnetotail.
TRANSEARTH	During transit from the moon to the earth.
TRANSIENT	An initial, short-lived effect preceding the obtainment of operating equilibrium of a system. For example, the initial current surge that occurs when as electrical system is energized.
TRANSLUNAR	During transit from the earth to the moon.
TRANSPONDER	A combined receiver and transmitter whose function is to transmit signals automatically when triggered by an interrogator.
UMBRA	The dark central portion of the shadow of a large body such as the earth or moon.
UP-SUN	Into the direction of the solar vector, used in specifying lunar surface photography requirements.
URANIUM	A heavy metallic element of atomic number 92 and principal atomic weight of 238.
UV RADIATION	Electromagnetic radiation of shorter wavelength than visible radiation; roughly radiation in the wavelength interval from 100 to 4000 Å.
VECTOR	A physical quantity requiring both magnitude and direction for its specification, as magnetic force field and spacecraft velocity vectors.
WAVELENGTH	The distance between maxima (or minima) of a periodic phenomenon such as an electromagnetic wave.

X-RAY	Electromagnetic radiation of non-nuclear origin within the wavelength interval of 0.1 to 100 angstroms (between gamma-ray and ultraviolet radiation).
ZERO PHASE	A photographic orientation in which the camera, subject, and sun are coplanar with the camera between the sun and the subject.
ZODIACAL LIGHT	A faint glow extending around the entire zodiac but showing most prominently in the neighborhood of the sun. (It may be seen in the west after twilight and in the east before dawn as a diffuse glow. The glow may be sunlight reflected from a great number of particles of meteoritic size in or near the ecliptic in the planetoid belt.)

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NOTES TO APPENDIX E

1. The density-log exposure (D-log E) curves presented in this appendix describe the results of a specific set of processing conditions for a specific emulsion batch. Because of changes in characteristics between different batches of emulsion, and because of changes in available film-development chemistries and hardware, it is not possible to provide on a current basis curves which specify detailed capabilities of the PTD. The D-log E curves in this appendix reflect general sensitometric data from the film supplier or data derived in establishing development controls for previous Apollo flight films. These curves are not intended to specify particular development processes for flight films, but are included for the purpose of facilitating communication between scientific investigators and the PTD in order to determine optimum film types and processing.

   Further background information regarding photographic films and development processes can be obtained from the document referenced below.*

2. Films to be exposed by the SIM bay cameras will be developed in a spray-type Fultron processor acquired for this purpose.

3. Appendix E, Film Characteristics and Processing Test Data, was provided by the Photographic Technology Division/JL.

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*K. R. Erb and D. J. Kelch, "An Introduction to Photography in the Earth Sciences," Data Corporation, DTN-69-11, Technical Note, November 1969.

ACRONYMS AND ABBREVIATIONS FOR APPENDIX E

ASA	American Standards Association
C	Centigrade
cm	Centimeter
CRT	Cathode Ray Tube
F	Fahrenheit
fpm	Feet per minute
K	Kelvin
m	Milli
min	Minute
mm	Millimeter
MS	Medium-speed
No.	Number
PTD	Photographic Technology Division
R.L.E.	Relative Log_{10} Exposure
RMS	Root Mean Square
sec	Second
SO	Special Order
°	Degree
'	Minute (superscript)
"	Second (superscript)
γ	Gamma
μ	Micron

APPENDIX E

FILM CHARACTERISTICS AND PROCESSING TEST DATA

CONTENTS

	Page
KODAK HIGH SPEED RECORDING FILM TYPE 2485	E-1
KODAK PANATOMIC-X AERIAL FILM TYPE 3400*	E-2
KODAK PLUS-X AERIAL FILM TYPE 3401	E-3
KODAK HIGH DEFINITION AERIAL FILM TYPE 3414 (Formerly SO-349 and 3404)	E-4
KODAK EKTACHROME EF FILM TYPE SO-168	E-5
KODAK DOUBLE-X AEROGRAPHIC FILM TYPE SO-174 (Formerly SO-267)	E-6
KODAK EKTACHROME MS FILM TYPE SO-368	E-7
KODAK SPECTROSCOPIC FILM TYPE IIa-0	E-8
KODAK NUCLEAR TRACK EMULSION TYPE NTB-3	E-9

*Kodak Panatomic-X Aerial Film Type SO-164 is identical to Kodak Panatomic-X Aerial Film Type 3400 except for the backing material. It has been selected because it is readily available in 16-mm format.

KODAK HIGH SPEED RECORDING FILM TYPE 2485

(Estar-AH Base)

(This material was obtained from manufacturer's published information unless a specific test source is referenced.)

FILM CHARACTERISTICS*

An extremely high-speed, panchromatic film with extended red sensitivity. It is especially recommended for a wide variety of photorecording applications where weak signals of extremely short duration must be recorded, or where very high writing speeds are required. Speed and contrast can be varied over a very wide range for such a high-speed film by selecting the most suitable combination of developer time and temperature.

The varied uses of this film include: a wide range of photo instrumentation with all types of light sources; CRT recording with all phosphors, especially blue-emitting phosphors; high-speed photography at low light levels; streamer-chamber photography; medical-science applications, such as pupillography; photography of re-entry phenomena;and other applications which require fleeting signals be recorded on a "go-or-no-go" basis.

BASE

This film has a 4.0-mil Estar-AH polyester base with fast-drying PX backing. The 0.10 density of this base reduces light piping and provides halation protection.

EXPOSURE

Suggested aerial exposure indexes for mechanized processing will be found in the tables which follow.

Aerial exposure indexes are designed for use with the Kodak Aerial Exposure Computer, Kodak Publication No. R-10. Aerial exposure indexes are not equivalent to, and should not be confused with, the conventional film speeds used in pictorial photography.

IMAGE STRUCTURE CHARACTERISTICS; MX-641 chemicals, 2 developer racks, 3 fpm

Characteristic	Value**	Classification
Resolving Power		
Test-object contrast 1000:1	58 lines/mm	Moderately low
Test-object contrast 1.6:1	21 lines/mm	
RMS Granularity (at net density of 1.0)	18	Coarse

* This material describes the general characteristics of this film type. Sensitometric curves describe the results of a specific set of processing conditions on a specific emulsion batch. Experimenters are reminded that results may change somewhat from one emulsion to the next. Specific characteristics are determined for mission films as far as possible in advance of actual mission.

** Interpolated from Kodak published data for results obtained at PTD for MX-641 chemistry.

MECHANIZED PROCESSING

The Kodak Versamat Film Processor, Model 11 C-M, can be used to process this film using Kodak Versamat 641 chemicals.

PROCESSING CHEMICALS:

Kodak Versamat 641 Developer Starter
Kodak Versamat 641 Developer and Replenisher
Kodak Versamat 641 Fixer and Replenisher

PROCESSING SEQUENCES WITH KODAK VERSAMAT CHEMICALS:

Processing Step	Number of Racks	Path Length (feet)	Temperature
Develop	2	4 or 8	85°F ± ½°F
Fix*	3	12	85°F, nominal
Wash	2	8	80° to 82°F
Dry			120° to 145°F**

* Fixer replenisher should be introduced into tank No. 3 of the processor.

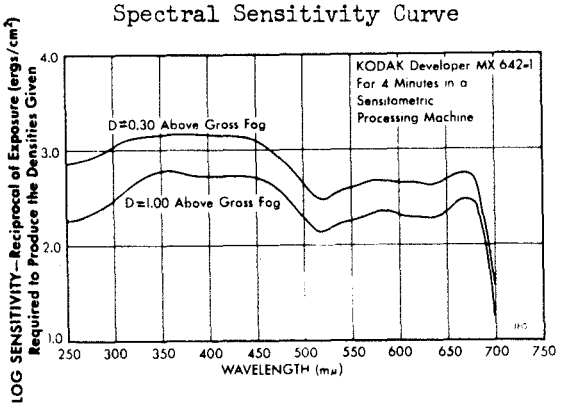
** The temperature of the dryer may require adjustment, depending upon the ambient temperature conditions in the processing area. Set temperature approximately 5 degrees above temperature required to dry clear film.

SUGGESTED AERIAL EXPOSURE INDEXES, GAMMAS, AND MACHINE SPEEDS WITH KODAK VERSAMAT 641 CHEMICALS AT 85°F PROCESSING:

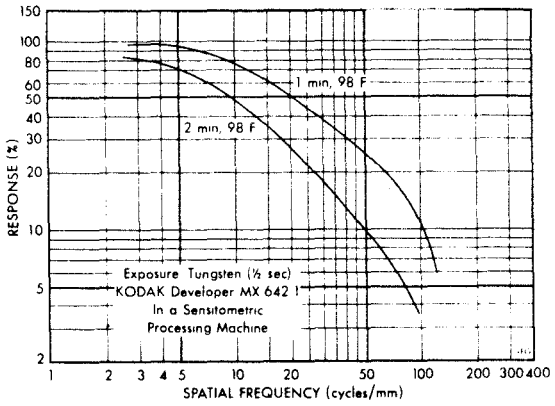
Machine Speed (feet per minute)	Number of Developer Racks	Average Gamma	Average Exposure Index
3	2	1.45	2350 (ASA)
4.5	2	1.05	—
6	2	0.66	—

KODAK HIGH SPEED RECORDING FILM TYPE 2485
(Estar-AH Base)

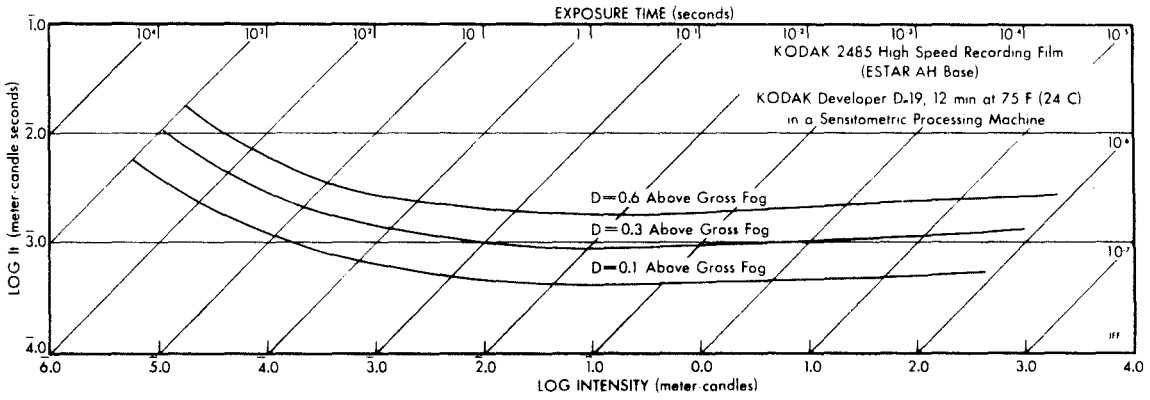
Spectral Sensitivity Curve



Modulation Transfer Function Curve



Reciprocity Curve

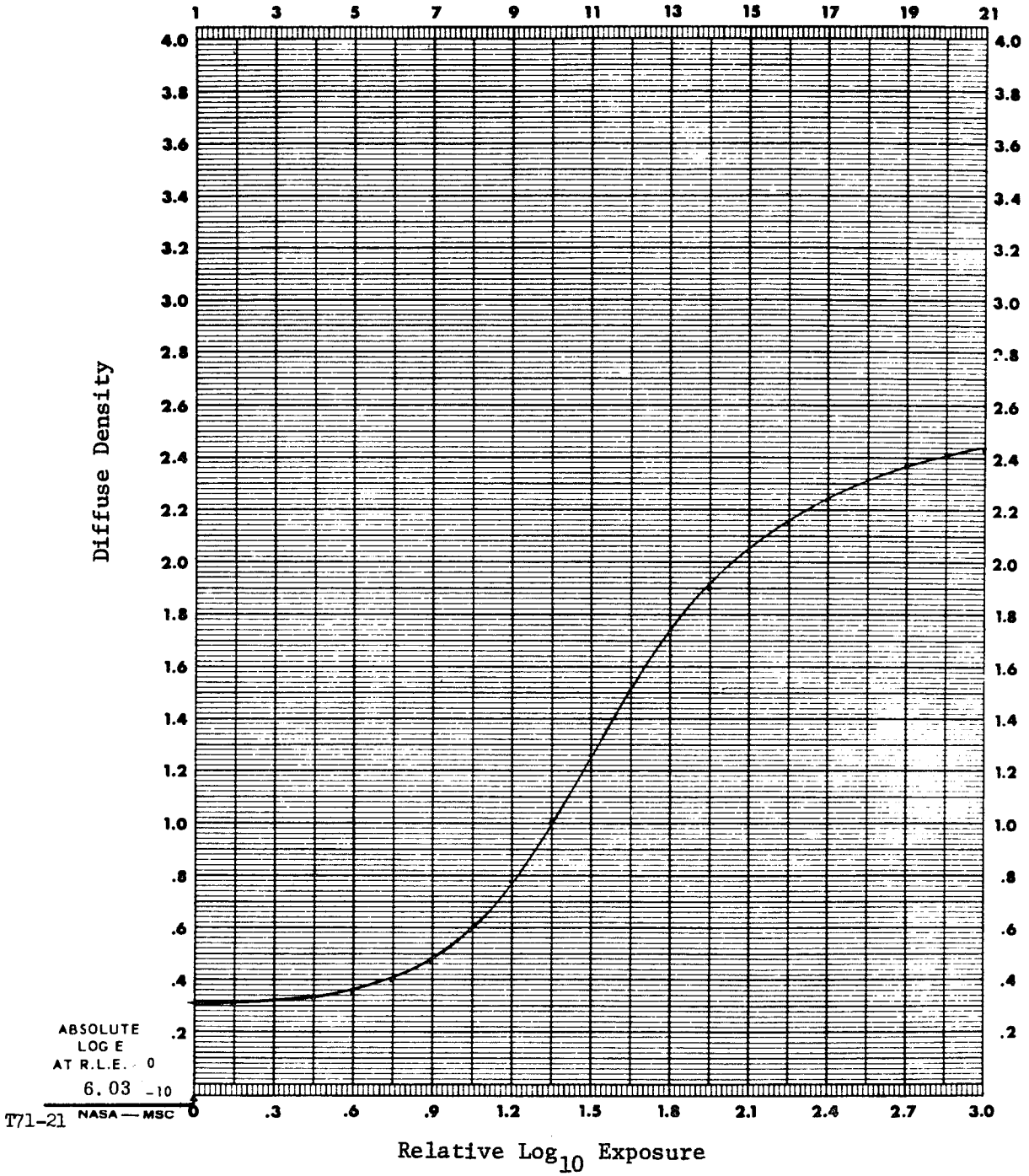


DATE June 1971 CONTROL # G TASK _____ PREPARED BY _____

FILM 2485 EMULSION # 33-1 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY
SENSITOMETER I-B	PROCESSOR Vmt 11C-M #1	INSTRUMENT MacBeth
ILLUMINANT 2850 °K	CHEMISTRY MX-641	TYPE TD 403
TIME 1/100 SEC.	SPEED 2 TANKS 4 FPM	APERTURE SIZE 4 MM
FILTER 4750 K + SCW+1.0ND	TEMP °F 85 TIME _____	FILTER Visual

SPEED ( ) _____
D-MAX _____
GAMMA 1.68
BASE + FOG .32

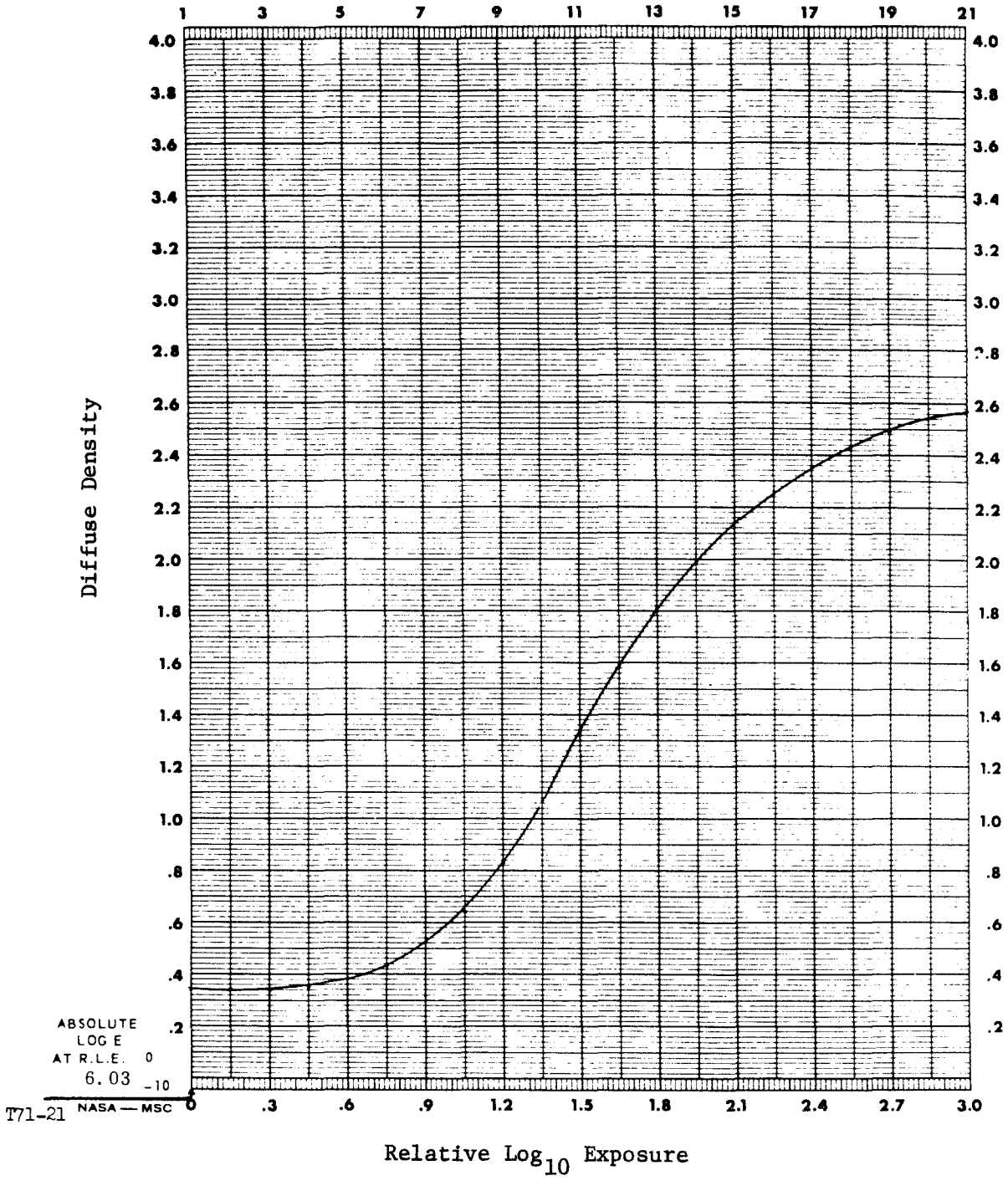


DATE June 1971 CONTROL # G TASK _____ PREPARED BY _____

FILM 2485 EMULSION # 33-1 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY	
SENSITOMETER	I-B	PROCESSOR	Vmt. 11C-M	INSTRUMENT	TD 403
ILLUMINANT	2850 K	CHEMISTRY	MX-641	TYPE	DD
TIME	1/100 SEC.	SPEED	2 TANKS 4 FPM	APERTURE SIZE	4 MM
FILTER	4750 + SCW + 1.0N	TEMP °F	85 TIME	FILTER	Visual

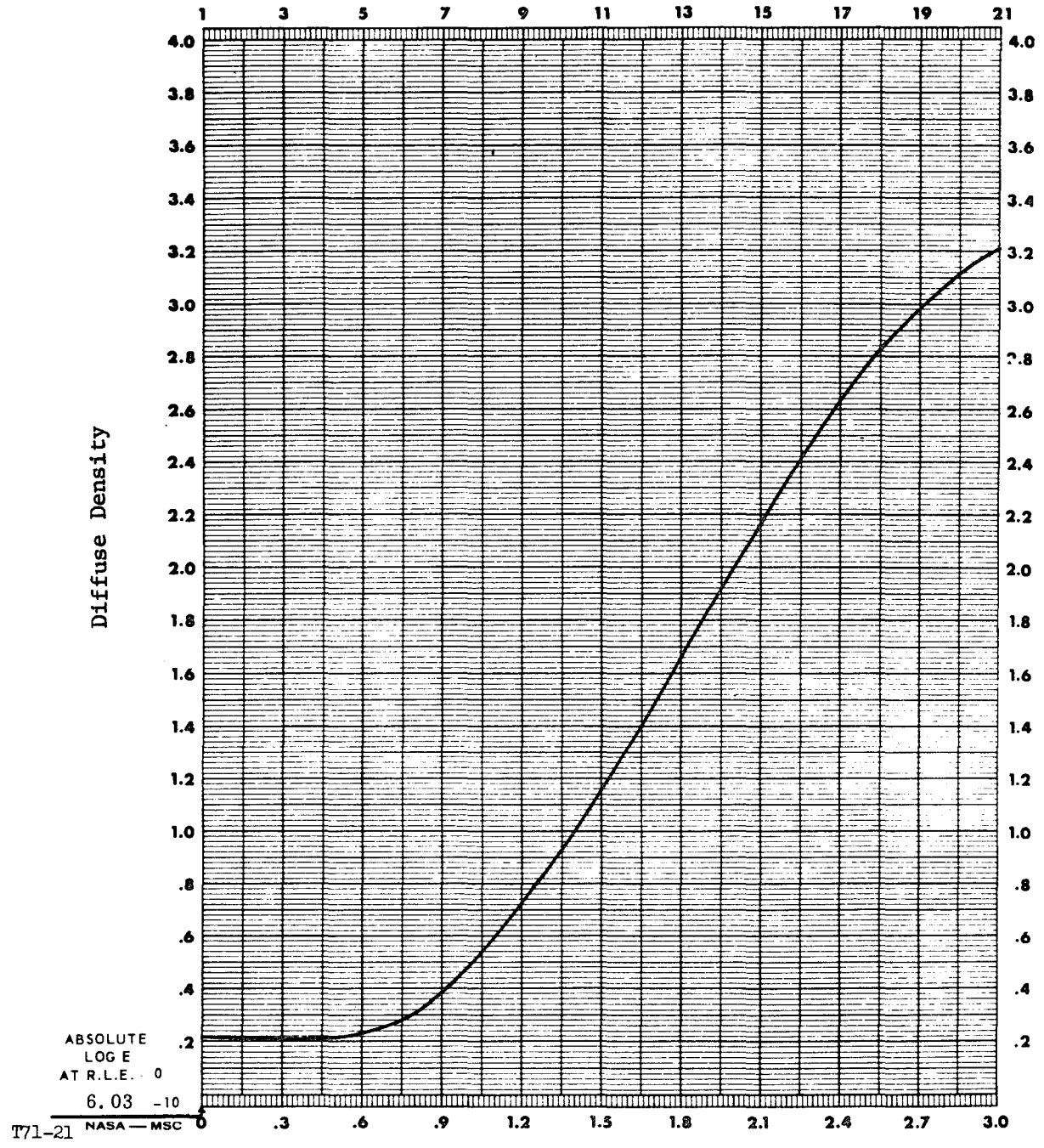
SPEED ( ) _____
D-MAX _____
GAMMA _____
BASE + FOG .32



DATE June 1971 CONTROL # H TASK _____ PREPARED BY _____

FILM 2485 EMULSION # 26-1 (16mm) MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Houston	INSTRUMENT	MacBeth	SPEED ( )	
ILLUMINANT	2850 °K	CHEMISTRY	D-19	TYPE	TD 203	D-MAX	
TIME	1/100 SEC.	SPEED	TANKS	APERTURE SIZE	4 MM	GAMMA	1.7
FILTER	4750°K+SCW+1.0ND	TEMP °F	85 TIME 6 min	FILTER	Visual	BASE + FOG	.23



KODAK PANATOMIC-X AERIAL FILM TYPE 3400
(Estar Thin Base)

(This material was obtained from manufacturer's published information unless a specific test source is referenced.)

FILM CHARACTERISTICS*

A panchromatic, negative camera film that has intermediate speed, high contrast, and extended red sensitivity. The high acutance and very high resolution of this film favor a small-negative format. The emulsion, coated on a 2.5-mil Estar base (for dimensional stability and tear resistance), is hardened for high-temperature, rapid processing in a continuous processing machine, such as the Kodak Versamat Film Processor, Model 11.

Note: This film is not normally used in commercial aerial cameras available in today's market. It is designed for use in certain military cameras that have been specially constructed or modified to handle thin-base films.

BASE

This film has a 2.5-mil Estar polyester base with a dyed gel backing. The total nominal thickness of this film is 2.89 mils.

EXPOSURE

Suggested aerial exposure indexes for mechanized processing will be found in the tables which follow.

Aerial exposure indexes are designed for use with the Kodak Aerial Exposure Computer, Kodak Publication No. R-10. Aerial exposure indexes are not equivalent to, and should not be confused with, the conventional film speeds used in pictorial photography.

IMAGE-STRUCTURE CHARACTERISTICS; MX-641 chemicals with 2 developer racks at 10 fpm

Characteristic	Value	Classification
Resolving Power		
Test-object contrast 1000:1	200 lines/mm	Very high
Test-object contrast 1.6:1	80 lines/mm	
RMS Granularity (at net density of 1.0)	18	Very fine

* This material describes the general characteristics of this film type. Sensitometric curves describe the results of a specific set of processing conditions on a specific emulsion batch. Experimenters are reminded that results may change somewhat from one emulsion to the next. Specific characteristics are determined for mission films as far as possible in advance of actual mission.

MECHANIZED PROCESSING

This film should be processed in equipment made especially for this purpose. Conventional rewind equipment is not recommended, because of the physical characteristics of the Estar thin base. Continuous-type processing machines--such as spray, deep tank, or roller transport--are best for processing this film.

The Kodak Versamat Film Processor, Model 11, can be used to process this film using Kodak Versamat 641 chemicals.

PROCESSING CHEMICALS:

Kodak Versamat 641 Developer Starter
Kodak Versamat 641 Developer Replenisher
Kodak Versamat 641 Fixer and Replenisher

PROCESSING SEQUENCES WITH KODAK VERSAMAT CHEMICALS:

Processing Step	Number of Racks	Path Length (feet)	Temperature
Develop	1 or 2	4 or 8	85°F ± ½°F
Fix*	3	12	85°F, nominal
Wash	2	8	80° to 82°F
Dry			120° to 145°F**

* Fixer replenisher should be introduced into tank No. 3 of the processor.

** The temperature of the dryer may require adjustment, depending upon the ambient temperature conditions in the processing area. Set temperature approximately 5 degrees above temperature required to dry clear film.

SUGGESTED AERIAL EXPOSURE INDEXES, GAMMAS, AND MACHINE SPEEDS WITH KODAK VERSAMAT 641 CHEMICALS AT 85°F PROCESSING TEMPERATURE:

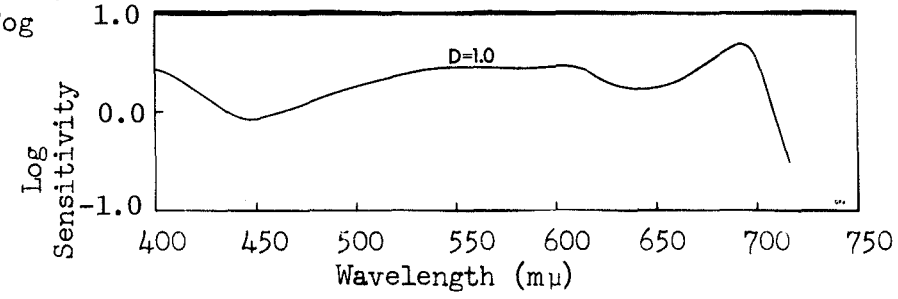
Machine Speed (feet per minute)	Number of Developer Racks	Average Gamma	Average Aerial Exposure Index
5	1	2.80	16
	2	2.90	20
10	1	2.30	10
	2	2.60	12
15*	1	1.90	6.4
	2	2.30	10
20*	1	1.60	6.4
	2	2.20	8

* Represents condition where fixing, washing, or drying problems exist

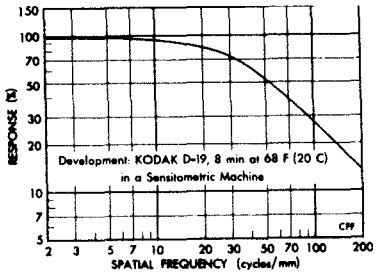
KODAK PANATOMIC-X AERIAL FILM 3400
(Estar Thin Base)

Spectral Sensitivity Curve

D-19
D = 1.0 above
gross fog



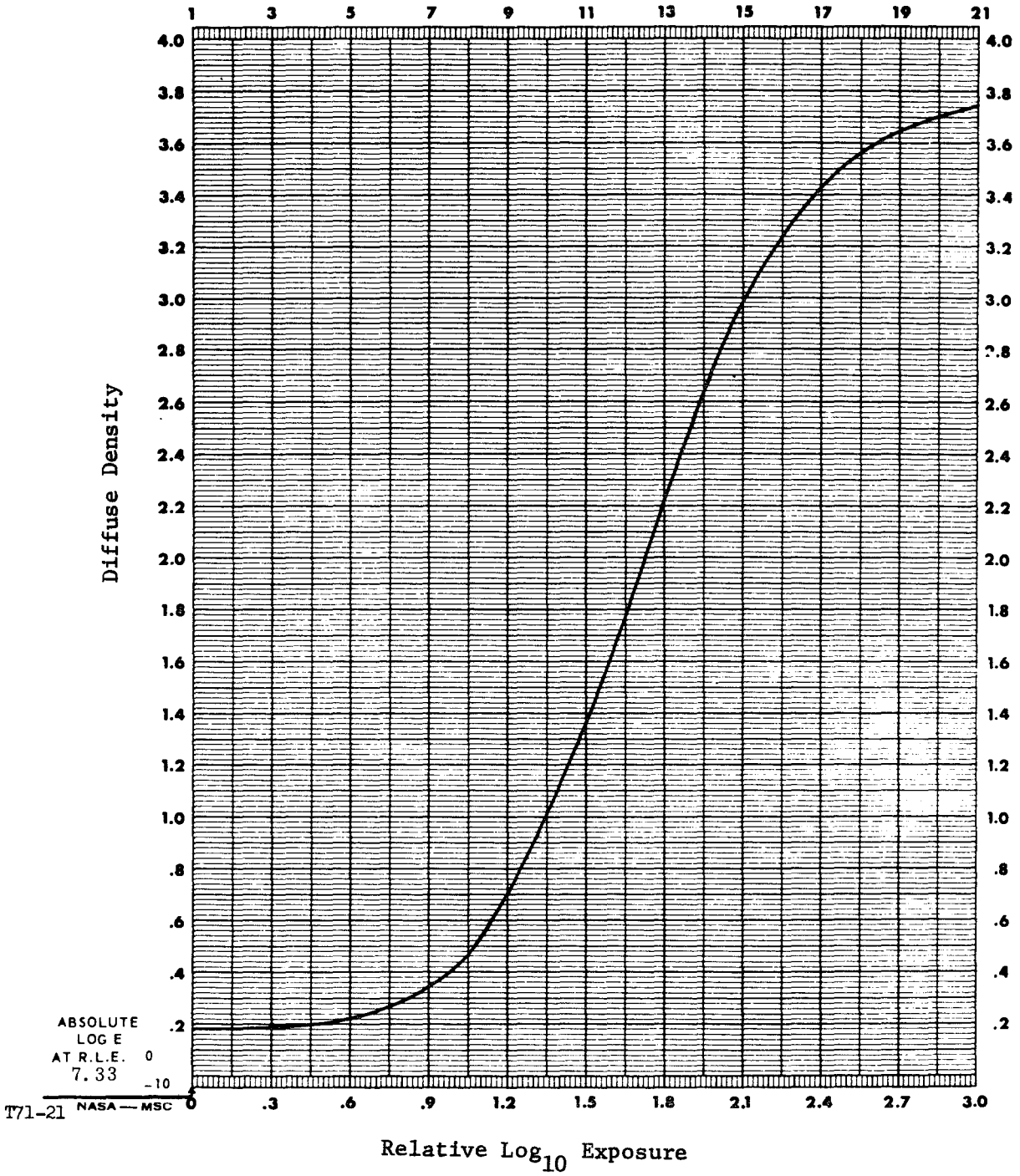
Modulation Transfer Function Curve



DATE June 1971 CONTROL # A TASK _____ PREPARED BY _____

FILM 3400 EMULSION # 235-7 MFG _____ EXPIRATION DATE _____

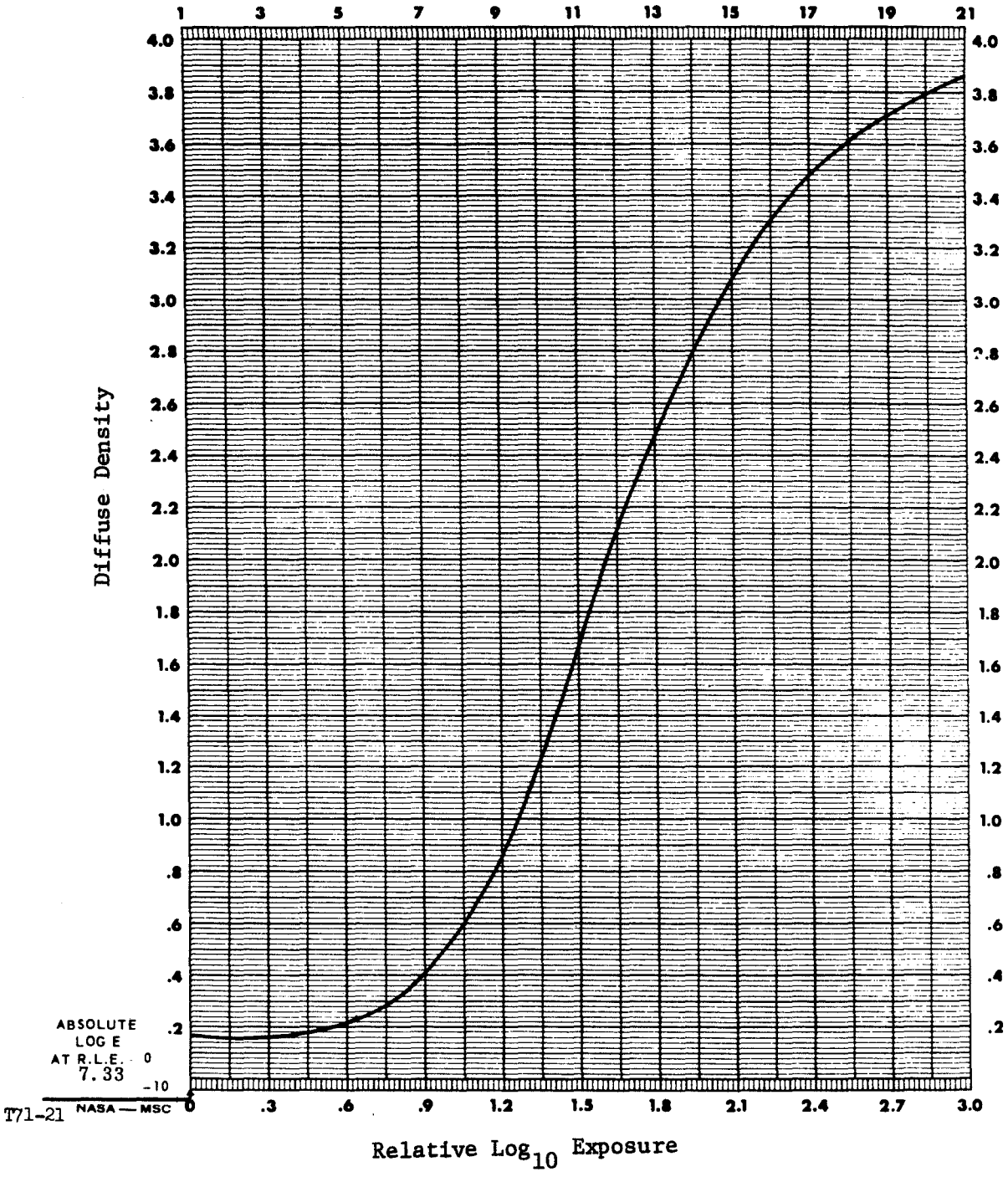
EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY	
SENSITOMETER I-B		PROCESSOR Vmt 11C-MI #1		INSTRUMENT TD 403	SPEED ( )
ILLUMINANT 2850	°K	CHEMISTRY MX-641		TYPE DD	D-MAX
TIME 1/50	SEC.	SPEED 2	TANKS 5.75 FPM	APERTURE SIZE 4	MM GAMMA
FILTER 4750°K + SCW		TEMP °F 85	TIME	FILTER Visual	BASE + FOG .19



DATE ~~June 1971~~ CONTROL # A TASK _____ PREPARED BY _____

FILM 3400 EMULSION # 224-7 (70mm) MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Vmt 11C-M #2	INSTRUMENT	MacBeth	SPEED ( )	
ILLUMINANT	2850 °K	CHEMISTRY	MX-641	TYPE	TD 403	D-MAX	
TIME	1/50 SEC.	SPEED	2 TANKS 6 FPM	APERTURE SIZE	4 MM	GAMMA	
FILTER	LC5900 + SCW	TEMP °F	85 TIME	FILTER	Visual	BASE + FOG	



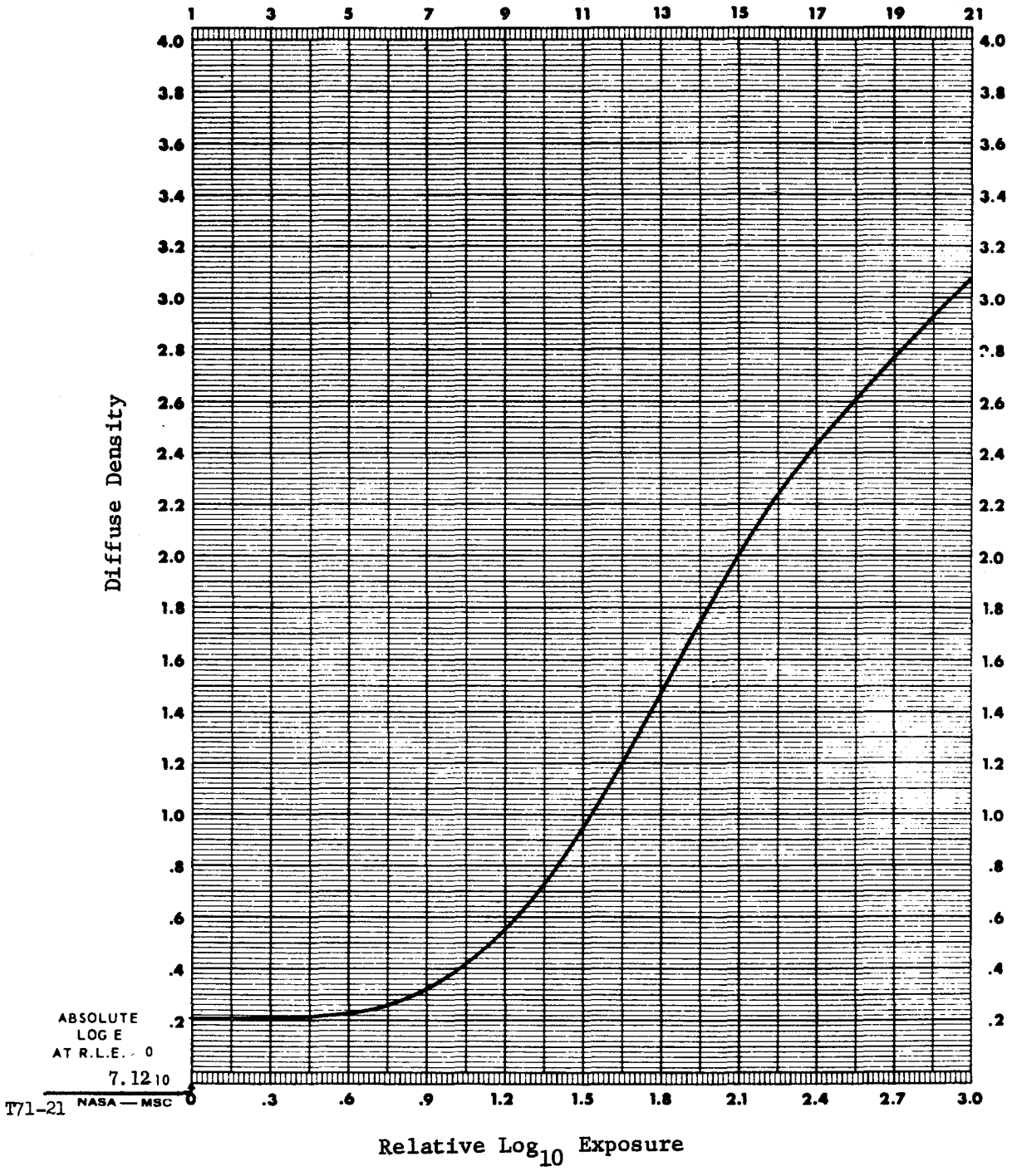
T71-21 NASA — MSC

DATE June 1971 CONTROL # B TASK _____ PREPARED BY _____

FILM 3400 EMULSION # 205 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA	PROCESSING DATA	DENSITOMETRY
SENSITOMETER I-B	PROCESSOR Fultron	INSTRUMENT MacBeth
ILLUMINANT 2850 °K	CHEMISTRY MX-819	TYPE TD 403
TIME 1/100 SEC.	SPEED _____ TANKS 20 FPM	APERTURE SIZE 4 MM
FILTER 4750 K+ Wr 12	TEMP °F _____ TIME _____	FILTER Visual

SPEED ( ) _____
D-MAX _____
GAMMA _____
BASE + FOG _____

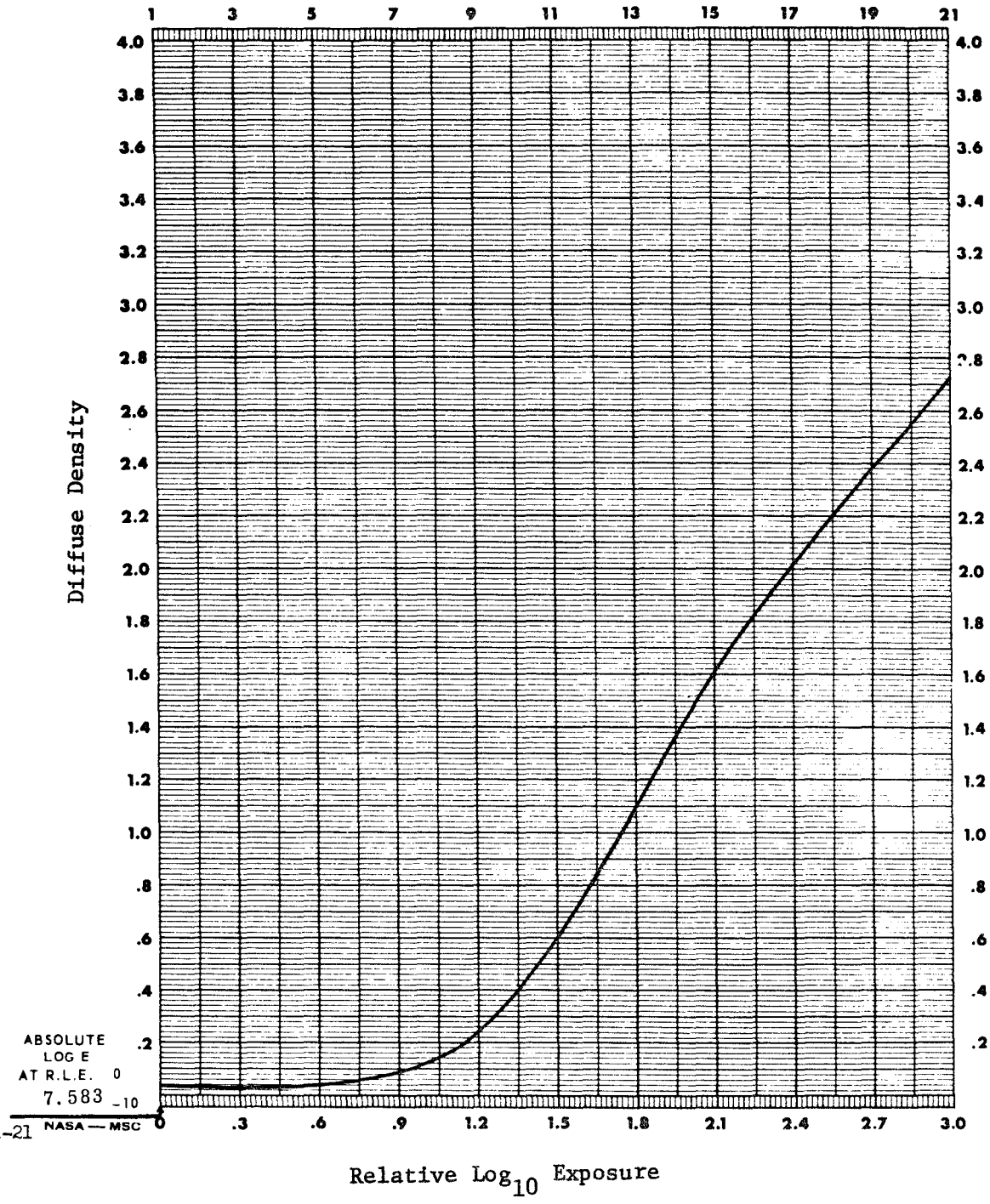


T71-21 NASA — MSC

DATE June 1971 CONTROL # K TASK _____ PREPARED BY _____

FILM SO-164 EMULSION # 01=01 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Houston	INSTRUMENT	MacBeth	SPEED ( )	
ILLUMINANT	2850 °K	CHEMISTRY	D=19	TYPE	TD 203	D-MAX	
TIME	1/25 SEC.	SPEED	TANKS FPM	APERTURE SIZE	4 MM	GAMMA	1.70
FILTER	5500 °K	TEMP °F	75 TIME 54"	FILTER	Status A visual	BASE + FOG	.05



KODAK PLUS-X AERIAL FILM TYPE 3401
(Estar Thin Base)

(This material was obtained from manufacturer's published information unless a specific test source is referenced.)

FILM CHARACTERISTICS*
A panchromatic, negative camera film that has high contrast, medium speed, high acutance, fine grain, and extended red sensitivity. The emulsion is coated on a 2.5-mil Estar base which provides tear resistance and dimensional stability. This film is suitable for high-temperature processing in continuous-processing machines, such as the Kodak Versamat Processor, Model 11.

Note: This film is not normally used in the aerial cameras available in today's market. It is designed for use in certain military cameras that have been specially constructed or modified to handle thin-base films.

BASE
This film has a 2.5-mil Estar polyester base with a dyed gel backing. The total nominal thickness is 3.06 mils.

EXPOSURE
Suggested aerial exposure indexes for mechanized processing will be found in the tables which follow.
Aerial exposure indexes are designed for use with the Kodak Aerial Exposure Computer, Kodak Publication No. R-10. Aerial exposure indexes are not equivalent to, and should not be confused with, the conventional film speeds used in pictorial photography.

IMAGE-STRUCTURE CHARACTERISTICS; MX-641 chemicals with 2 developer racks at 10 fpm

Characteristic	Value**	Classification
Resolving Power		
Test-object contrast 1000:1	100 lines/mm	High
Test-object contrast 1.6:1	40 lines/mm	
RMS Granularity (at net density of 1.0)	32	Medium

*This material describes the general characteristics of this film type. Sensitometric curves describe the results of a specific set of processing conditions on a specific emulsion batch. Experimenters are reminded that results may change somewhat from one emulsion to the next. Specific characteristics are determined for mission films as far as possible in advance of actual mission.

** Interpolated from Kodak published data for results obtained at PTD for MX-641 chemistry.

MECHANIZED PROCESSING

This film should be processed in equipment made especially for this purpose. Conventional rewind equipment is not recommended, because of the physical characteristics of the Estar thin base. Continuous-type processing machines--such as spray, deep tank, or roller transport--are best for processing this film.

The Kodak Versamat Film Processor, Model 11, can be used to process this film using Kodak Versamat 641 chemicals.

PROCESSING CHEMICALS:

Kodak Versamat 641 Developer and Starter
Kodak Versamat 641 Developer and Replenisher
Kodak Versamat 641 Fixer and Replenisher

PROCESSING SEQUENCES WITH KODAK VERSAMAT CHEMICALS:

Processing Step	Number of Racks	Path Length (feet)	Temperature
Develop	2	4 or 8	85°F ± ½°F
Fix*	3	12	85°F, nominal
Wash	2	8	80°F to 82°F
Dry			120°F to 145°F**

* Fixer replenisher should be introduced into tank No. 3 of the processor.

** The temperature of the dryer may require adjustment, depending upon the ambient temperature conditions in the processing area. Set temperature approximately 5 degrees above temperature required to dry clear film.

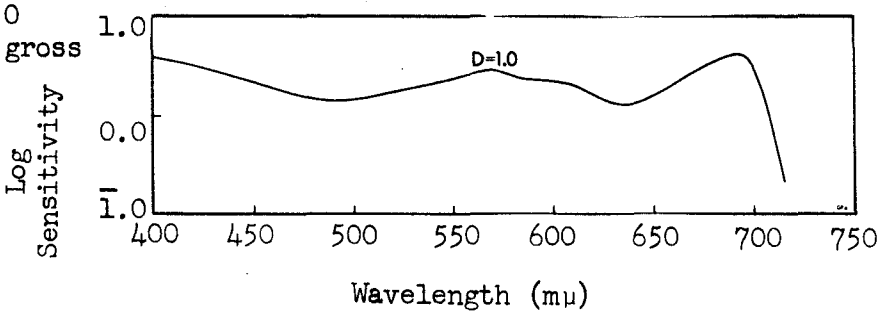
SUGGESTED AERIAL EXPOSURE INDEXES, GAMMAS, AND MACHINE SPEEDS WITH KODAK VERSAMAT 641 CHEMICALS AT 85°F PROCESSING TEMPERATURE

Machine Speed (feet per minute)	Number of Developer Racks	Average Gamma	Average Aerial Exposure Index
5	2	2.61	64
10	2	2.27	50
15	2	1.87	40
20	2	1.52	32

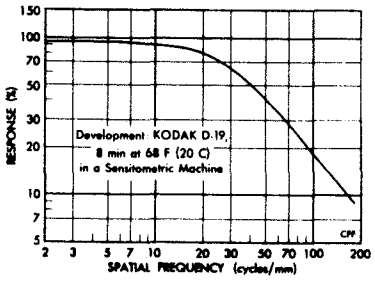
KODAK PLUS-X AERIAL FILM 3401
(Estar Thin Base)

D-19
D = 1.0
above gross
fog

Spectral Sensitivity Curve



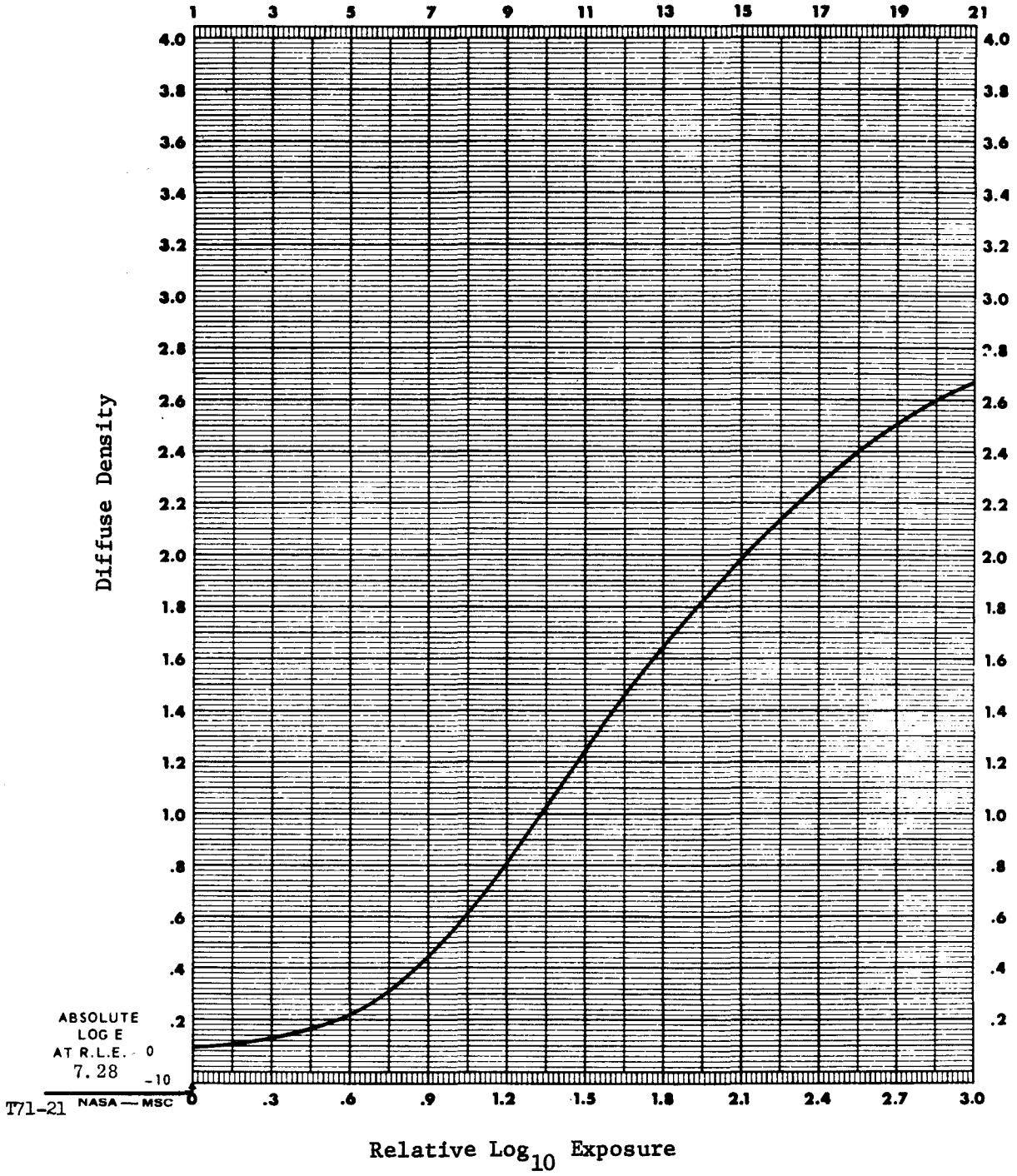
Modulation Transfer Function Curve



DATE June 1971 CONTROL # C TASK _____ PREPARED BY _____

FILM 3401 EMULSION # 331-2 MFG _____ EXPIRATION DATE _____

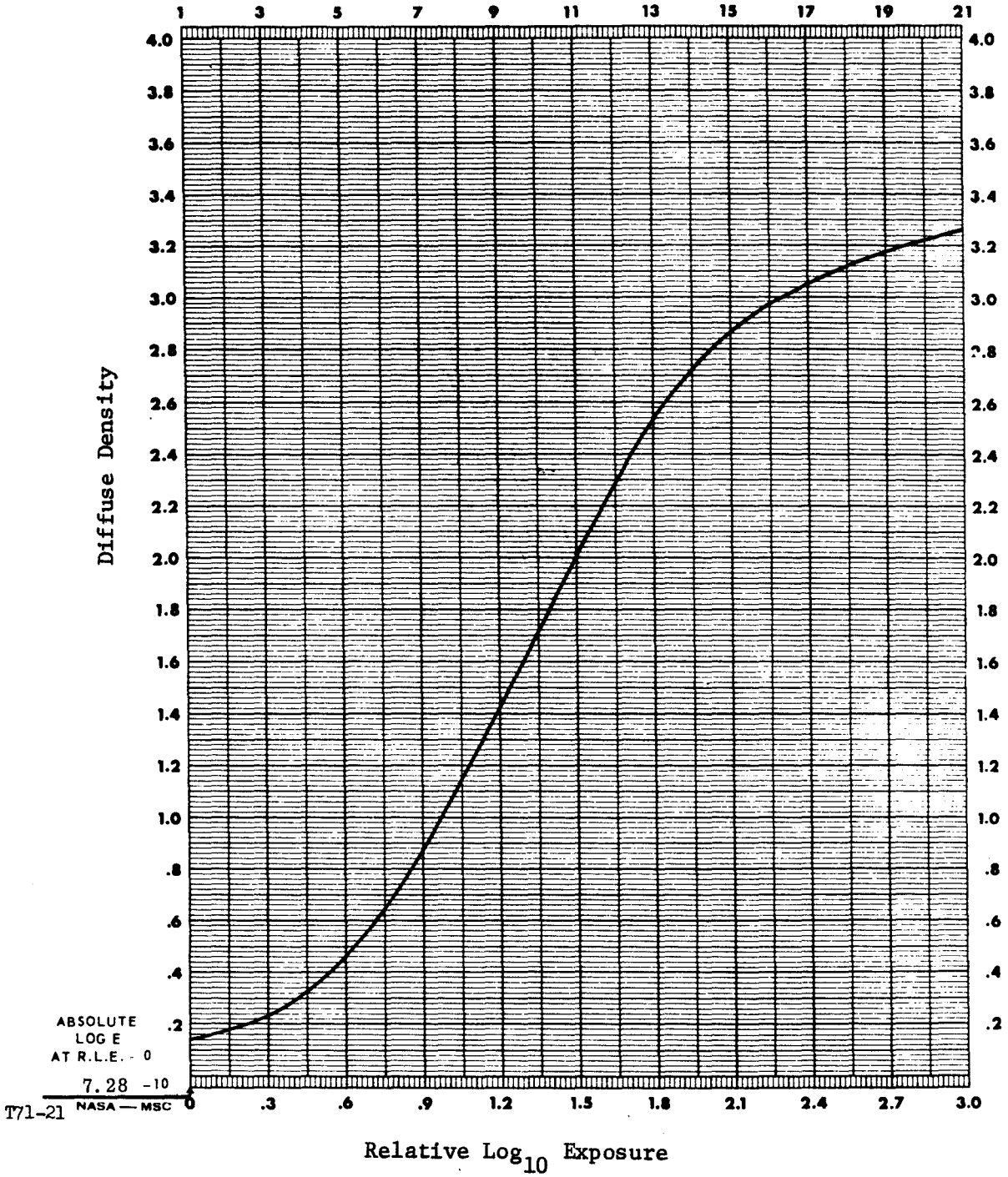
EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY	
SENSITOMETER I-B		PROCESSOR Vmt 11C-M		INSTRUMENT TD 403	SPEED ( )
ILLUMINANT 2850 °K		CHEMISTRY MX-641		TYPE DD	D-MAX
TIME 1/50 SEC.		SPEED 1 TANKS 10.25 FPM		APERTURE SIZE 8 MM	GAMMA 1.39
FILTER 5500°K		TEMP °F 85 TIME		FILTER Visual	BASE + FOG .10



DATE June 1971 CONTROL # D TASK _____ PREPARED BY _____

FILM 3401 EMULSION # 294-6 (35mm) MFG _____ EXPIRATION DATE _____

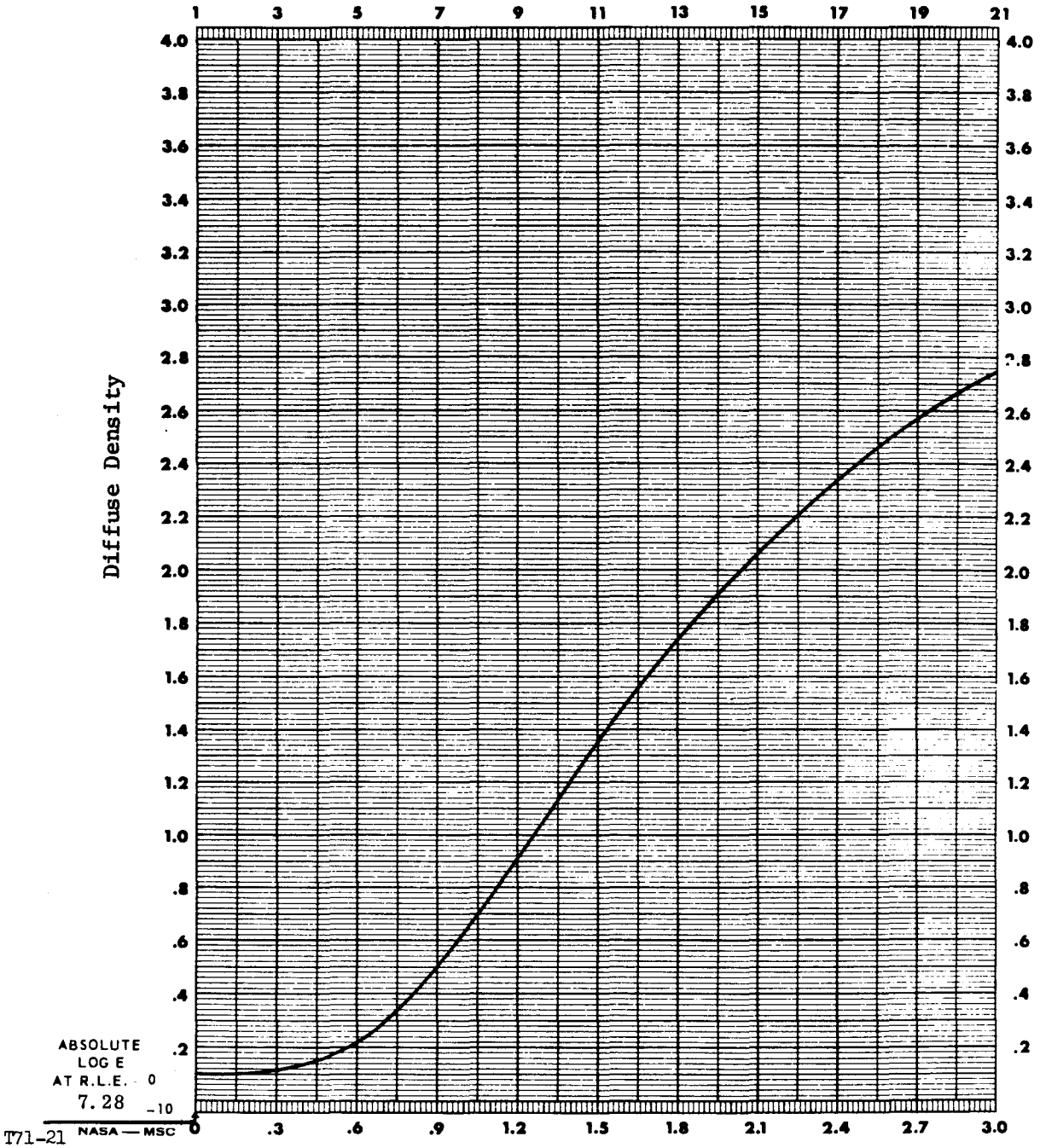
EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Hi-Speed	INSTRUMENT	MacBeth	SPEED ( )	
ILLUMINANT	2850 °K	CHEMISTRY	D-19	TYPE	TD 217 DR	D-MAX	
TIME	1/50 SEC.	SPEED	TANKS FPM	APERTURE SIZE	4 MM	GAMMA	
FILTER	5500°K	TEMP °F	76 TIME 8'50"	FILTER	Visual	BASE + FOG	



DATE June 1971 CONTROL # C TASK _____ PREPARED BY _____

FILM 3401 EMULSION # 294-6 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Vmt 11C-M	INSTRUMENT	TD 403	SPEED ( )	
ILLUMINANT	2850 °K	CHEMISTRY	MX-641	TYPE	DD	D-MAX	
TIME	1/50 SEC.	SPEED	1 TANKS 10 FPM	APERTURE SIZE	4 MM	GAMMA	1.41
FILTER	5500 °K	TEMP °F	85 TIME	FILTER	M-58 Visual	BASE + FOG	.10



KODAK HIGH DEFINITION AERIAL FILM TYPE 3414 (Formerly SO-349 and 3404) (Estar Thin Base)

(This material was obtained from manufacturer's published information unless a specific test source is referenced.)

FILM CHARACTERISTICS*

A panchromatic, negative camera film that has slow speed, high contrast, extended red sensitivity, maximum definition, and extremely fine grain. This film is designed for extremely high-altitude, stable-platform aerial photography. The emulsion is hardened for high-temperature, rapid processing and is coated on a 2.5-mil Estar base for dimensional stability and tear resistance.

Note: This film is not recommended for use in aerial cameras commonly available on today's market. It is designed for use in cameras that have been specially constructed or modified to handle the thinner-based films.

BASE

This film has a 2.5-mil Estar polyester base with a dyed gel backing. The total nominal thickness of this film is 3.0 mils.

EXPOSURE

Suggested aerial exposure indexes for mechanized processing will be found in the tables which follow.

Aerial exposure indexes are designed for use with the Kodak Aerial Exposure Computer, Kodak Publication No. R-10. Aerial exposure indexes are not equivalent to, and should not be confused with, the conventional film speeds used in pictorial photography.

IMAGE-STRUCTURE CHARACTERISTICS; D-19 chemicals with 8-minute development at 68°F

Characteristic	Value	Classification
Resolving Power		
Test-object contrast 1000:1	630 lines/mm	Extremely High
Test-object contrast 1.6:1	250 lines/mm	Extremely High
RMS Granularity (at net density of 1.0)	9	

* This material describes the general characteristics of this film type. Sensitometric curves describe the results of a specific set of processing conditions on a specific emulsion batch. Experimenters are reminded that results may change somewhat from one emulsion to the next. Specific characteristics are determined for mission films as far as possible in advance of actual mission.

MECHANIZED PROCESSING

This film should be processed in equipment made especially for this purpose. Conventional rewind equipment is not recommended, because of the physical characteristics of the Estar thin base. Continuous-type processing machines--such as spray, deep tank, or roller transport--are best for processing this film.

The Kodak Versamat Film Processor, Model 11, equipped with a Kodak Versamat Stop Bath Kit, Model 11, can be used to process this film using Kodak Versamat 641 chemicals.

PROCESSING CHEMICALS:

Kodak Versamat 641 Developer Starter
Kodak Versamat 641 Developer Replenisher
Kodak Stop Bath SB-5a or Kodak Indicator Stop Bath
Kodak Versamat 641 Fixer and Replenisher

PROCESSING SEQUENCES WITH KODAK VERSAMAT CHEMICALS:

Processing Step	Number of Racks	Path Length (feet)	Temperature
Develop	2	8	95° ± ½°F
Stop Bath	1	4	95°F
Fixer*	2	8	95°F
Wash	2	8	90° to 92°F
Dry		8	120° to 145°F**

* The fixer replenisher is introduced into machine tank No. 5 (second fixer tank).

** For optimum physical quality, dryer temperature should be the minimum required. The temperature of the dryer may require adjustment, depending upon the ambient temperature conditions in the processing area. Set temperature 5 degrees above temperature required to dry clear film.

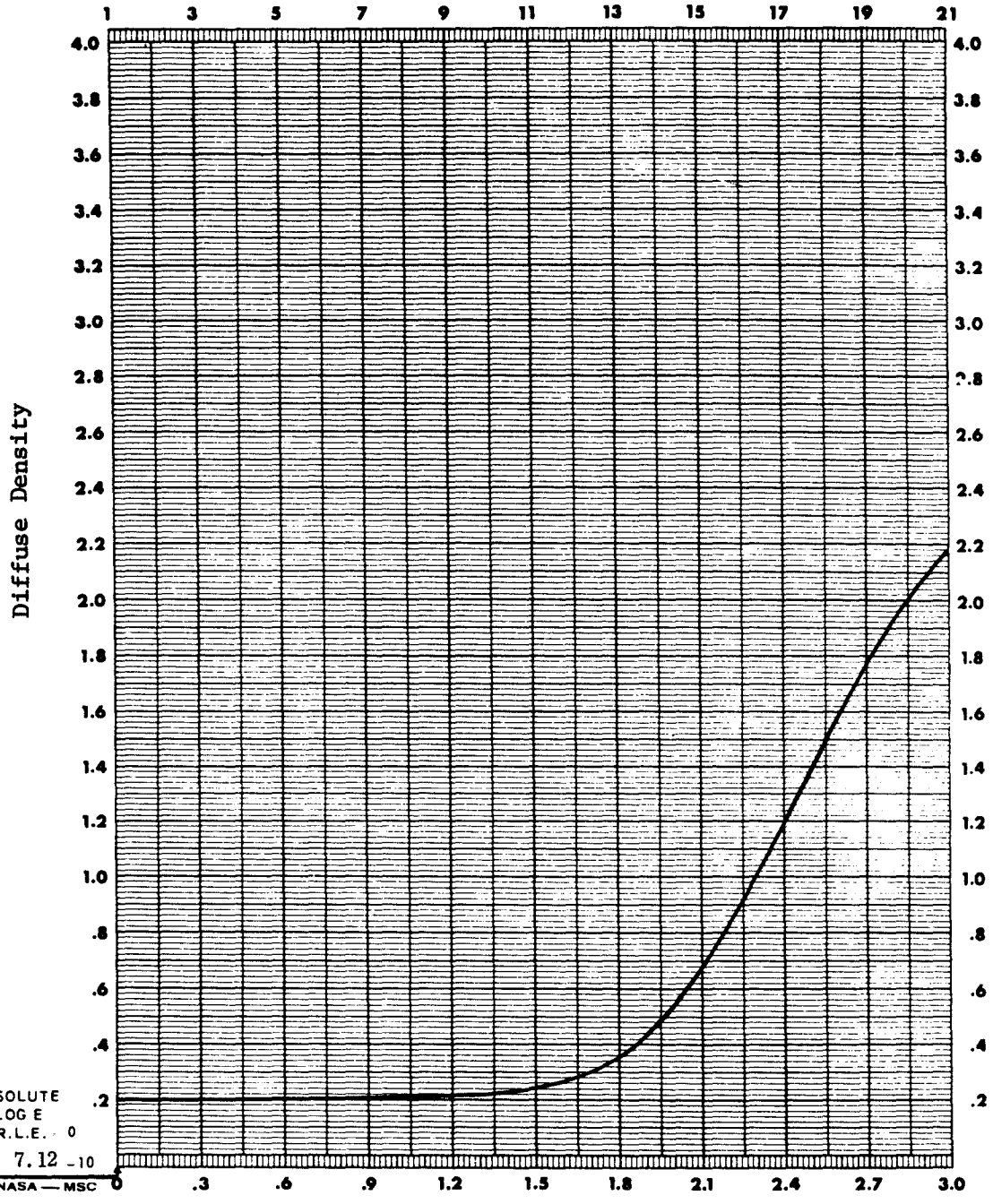
SUGGESTED AERIAL EXPOSURE INDEXES, GAMMAS, AND MACHINE SPEEDS WITH KODAK VERSAMAT 641 CHEMICALS AT 95°F PROCESSING TEMPERATURE:

Machine Speed (feet per minute)	Number of Developer Racks	Average Gamma	Average Aerial Exposure Index
5	1	2.38	6.61
	2	2.00	10.23
10	1	2.50	4.68
	2	2.31	7.08
15	1	2.48	3.55
	2	2.30	5.62
20	1	2.15	2.69
	2	2.44	5.12

DATE June 1971 CONTROL # E TASK _____ PREPARED BY _____

FILM 3414 EMULSION # _____ MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Fultron	INSTRUMENT	MacBeth	SPEED ( )	
ILLUMINANT	2850 °K	CHEMISTRY	MX-819	TYPE	TD 403	D-MAX	
TIME	1/100 SEC.	SPEED	TANKS 20 FPM	APERTURE SIZE	4 MM	GAMMA	
FILTER	4750 °K	TEMP °F	TIME	FILTER	Visual	BASE + FOG	

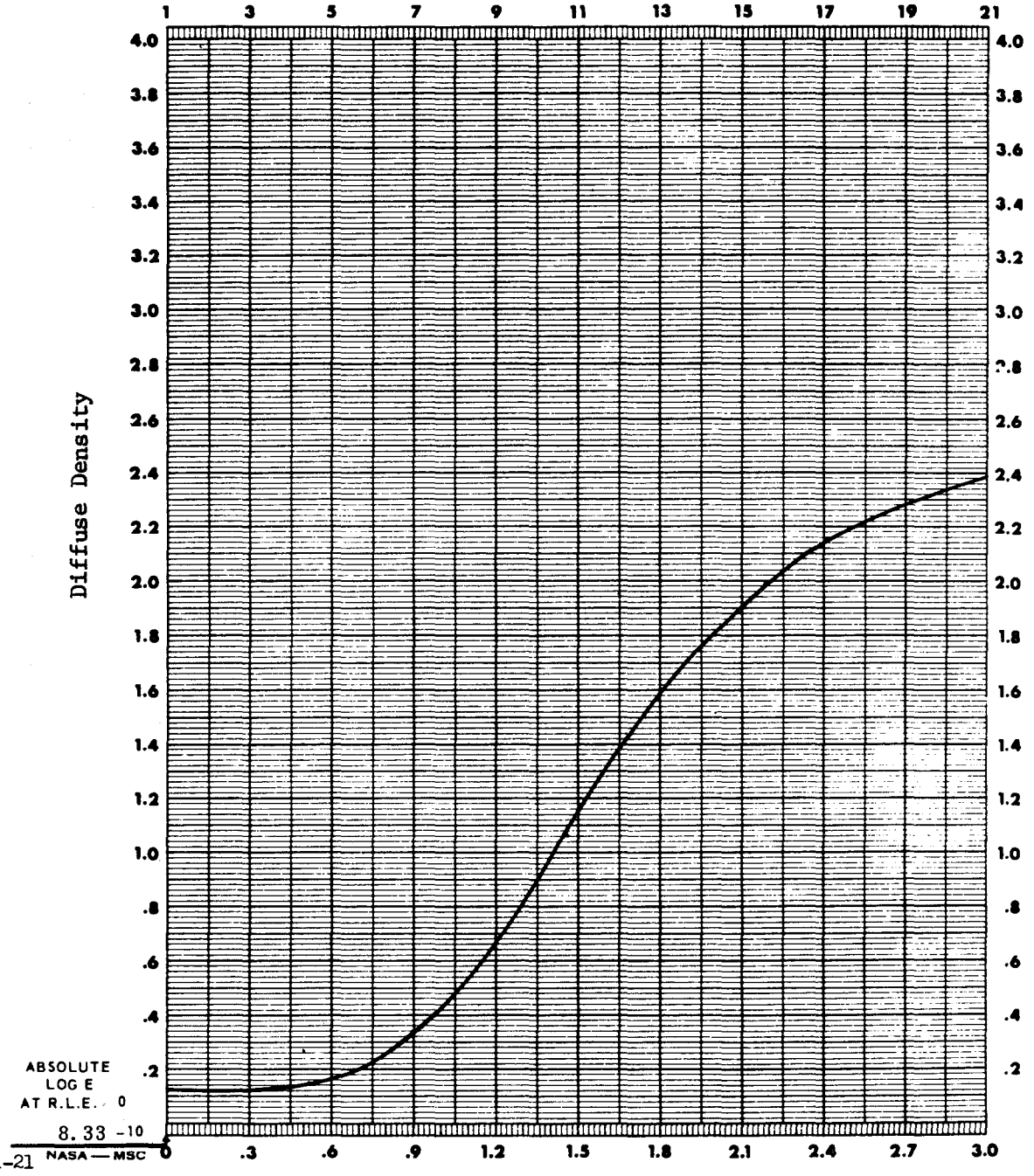


T71-21 NASA — MSC

DATE June 1971 CONTROL # F TASK _____ PREPARED BY _____

FILM SO-349 EMULSION # 9-1 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY	
SENSITOMETER	I-B	PROCESSOR	Vmt 11C-M#1	INSTRUMENT	MacBeth
ILLUMINANT	2850 °K	CHEMISTRY	G4-L	TYPE	TD 403
TIME	1/5 SEC.	SPEED 2 TANKS	8.25 FPM	APERTURE SIZE	4 MM
FILTER	4750°K + SCW	TEMP °F	80 TIME	FILTER	Visual
				SPEED ( )	
				D-MAX	
				GAMMA	1.7
				BASE + FOG	



T71-21 NASA — MSC

KODAK EKTACHROME EF FILM TYPE SO-168
(Estar Thin Base)

(This material was obtained from manufacturer's published information unless a specific test source is referenced.)

FILM CHARACTERISTICS*

A high-speed, color-reversal film for low level reconnaissance and mapping. This film has a 2.5-mil Estar base and high dimensional stability.

Note: This film is not available for use in commercial aerial cameras. It is a Special Order item designed for use in certain military cameras that have been constructed or modified to handle thin-base films.

BASE

This film has a 2.5-mil Estar polyester base with clear gel backing.

EXPOSURE

Suggested aerial exposure indexes for mechanized processing will be found in the tables which follow.

Aerial exposure indexes are designed for use with the Kodak Aerial Exposure Computer, Kodak Publication No. R-10. Aerial exposure indexes are not equivalent to, and should not be confused with, the conventional film speeds used in pictorial photography.

IMAGE-STRUCTURE CHARACTERISTICS; EA-4 chemicals at 3.2 fpm

Characteristic	Value	Classification
Resolving Power		
Test-object contrast 1000:1	80 lines/mm	Medium
Test-object contrast 1.6:1	40 lines/mm	Low
RMS Granularity (at net density of 1.0)	15	

MECHANIZED PROCESSING

The Kodak Ektachrome RT Processor, Model 1411, can be used to process this film using Kodak EA-4 chemicals.

* This material describes the general characteristics of this film type. Sensitometric curves describe the results of a specific set of processing conditions on a specific emulsion batch. Experimenters are reminded that results may change somewhat from one emulsion to the next. Specific characteristics are determined for mission films as far as possible in advance of actual mission.

PROCESSING SEQUENCES WITH KODAK PROCESS EA-4 CHEMICALS:

Processing Step	Number of Racks	Time	Temperature
Prehardener	1 & 2	2'30"	95° ± 1°F
Neutralizer	3	1'15"	97° ± 3°F
First Developer	4 & 5	2'30"	100° ± ½°F
First Stop	6	1'15"	100° ± 1°F
Wash	7	1'15"	88° to 95°F
Color Developer	8 & 9	2'30"	110° ± 1°F
Second Stop	10	1'15"	110° ± 1°F
Wash	11	1'15"	88° to 95°F
Bleach	12	1'15"	110° ± 1°F
Fix	13	1'15"	110° ± 1°F
Wash	14	1'15"	88° to 95°F
Dryer		2'30"	125° ± 5°F

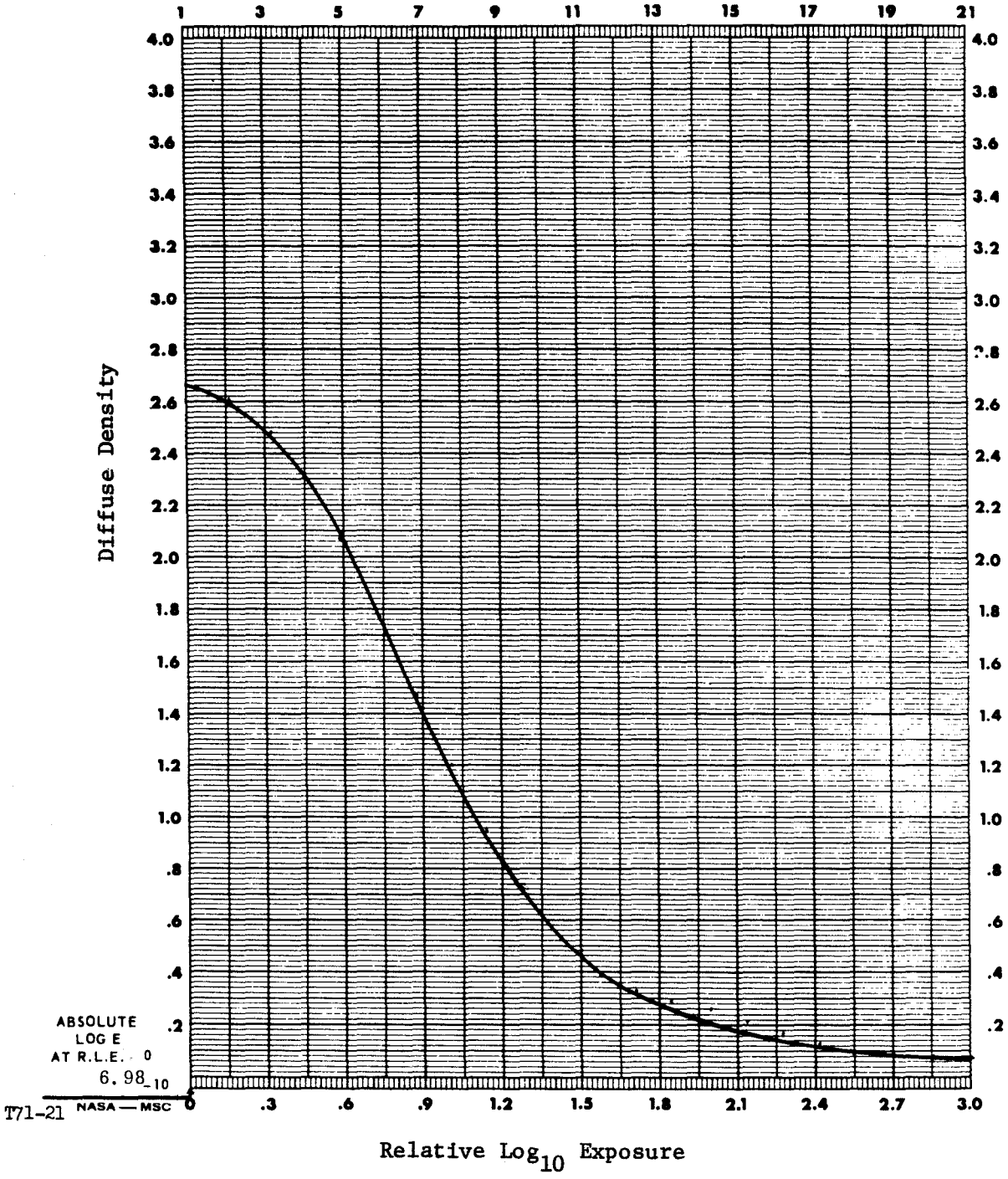
SUGGESTED AERIAL EXPOSURE INDEXES, GAMMAS, AND MACHINE SPEEDS WITH KODAK PROCESS EA-4 CHEMICALS AT 93.8°F:

Machine Speed (feet per minute)	Number of Developer Racks	Average Gamma	Average Exposure Index
3.2	2	1.51	148 (ASA)

DATE June 1970 CONTROL # P TASK _____ PREPARED BY _____

FILM SO-168 EMULSION # 6-1 (16mm) MFG _____ EXPIRATION DATE _____

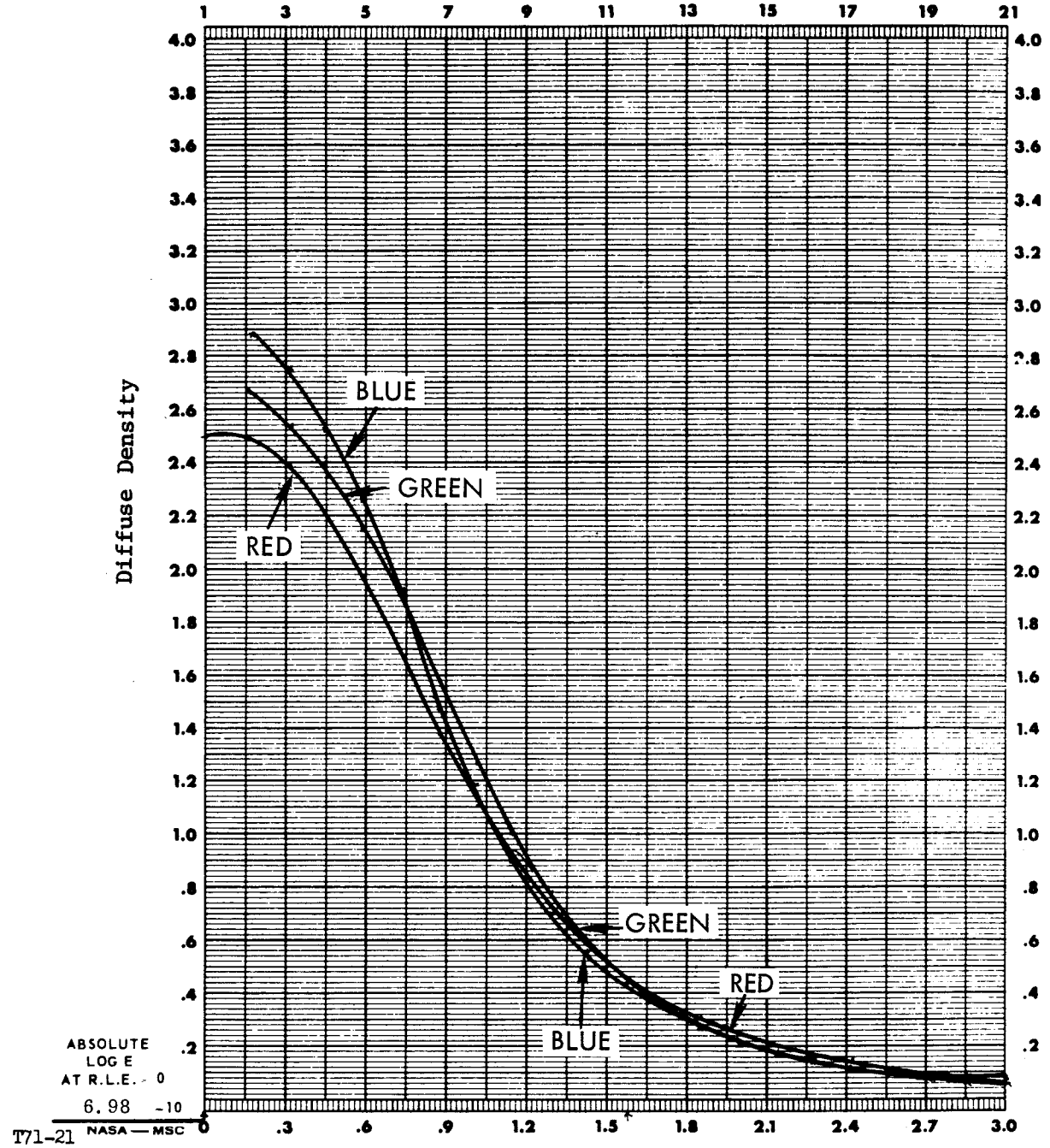
EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	RAM	INSTRUMENT	MacBeth	SPEED ( )	
ILLUMINANT	2850 °K	CHEMISTRY	ME-4	TYPE	TD 203	D-MAX	
TIME	1/100 SEC.	SPEED	TANKS FPM	APERTURE SIZE	4 MM	GAMMA	
FILTER	C5900	TEMP °F	TIME	FILTER	Visual	BASE + FOG	



DATE June 1970 CONTROL # P TASK _____ PREPARED BY _____

FILM SO-168 EMULSION # 6-1 (16mm) MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	RAM	INSTRUMENT	MacBeth	SPEED ( )	
ILLUMINANT	2850 °K	CHEMISTRY	ME-4	TYPE	TD 203	D-MAX	
TIME	1/100 SEC.	SPEED	TANKS FPM	APERTURE SIZE	4 MM	GAMMA	
FILTER	C5900	TEMP °F	TIME	FILTER	Status A	BASE + FOG	



KODAK DOUBLE-X AEROGRAPHIC FILM TYPE SO-174 (Formerly SO-267)
(Estar Base)

(This material was obtained from manufacturer's published information unless a specific test source is referenced.)

FILM CHARACTERISTICS*

A panchromatic, negative camera film that has high sensitivity, high acutance, good contrast, and wide exposing latitude. Its extended red sensitivity permits greater speed through haze-cutting filters. This film is on a 4.0-mil Estar base which provides very high resistance to tearing and extremely good dimensional stability, and its exposure, image-structure characteristics, and machine processing are the same as Type 2405 film. This film is suitable for high-temperature, rapid processing in the Kodak Versamat Film Processor.

BASE

This film has a 4.0-mil Estar polyester base with fast drying (PX) backing.

EXPOSURE

Suggested aerial exposure indexes are designed for use with Kodak Aerial Exposure Computer, Kodak Publication No. R-10. Aerial exposure indexes are not equivalent to, and should not be confused with, the conventional film speeds used in pictorial photography.

IMAGE-STRUCTURE CHARACTERISTICS; MX-641 chemicals with 2 developer racks at 8 fpm

Characteristic	Value	Classification
Resolving Power		
Test-object contrast 1000:1	85 lines/mm	Medium
Test-object contrast 1.6:1	38 lines/mm	Low
RMS Granularity (at net density of 1.0)	36	

MECHANIZED PROCESSING

This film should be processed in equipment made especially for this purpose, such as the Kodak Versamat Film Processor, Model 11, using Kodak Versamat 641 chemicals.

* This material describes the general characteristics of this film type. Sensitometric curves describe the results of a specific set of processing conditions on a specific emulsion batch. Experimenters are reminded that results may change somewhat from one emulsion to the next. Specific characteristics are determined for mission films as far as possible in advance of actual mission.

PROCESSING CHEMICALS:

Kodak Versamat 641 Developer and Starter
Kodak Versamat 641 Developer Replenisher
Kodak Versamat 641 Fixer and Replenisher

PROCESSING SEQUENCES WITH KODAK VERSAMAT CHEMICALS:

Processing Step	Number of Racks	Path Length (feet)	Temperature
Develop	1 or 2	4 or 8	85°F ± ½°F
Fix*	3	12	85°F, nominal
Wash	2	8	80° to 82°F
Dry			120° to 145°F**

* Fixer replenisher should be introduced into tank No. 3 of the processor.

** The temperature of the dryer may require adjustment, depending upon the ambient temperature conditions in the processing area. Set temperature approximately 5 degrees above temperature required to dry clear film.

SUGGESTED AERIAL EXPOSURE INDEXES, GAMMAS, AND MACHINE SPEEDS WITH KODAK VERSAMAT CHEMICALS AT 80°F PROCESSING TEMPERATURE:

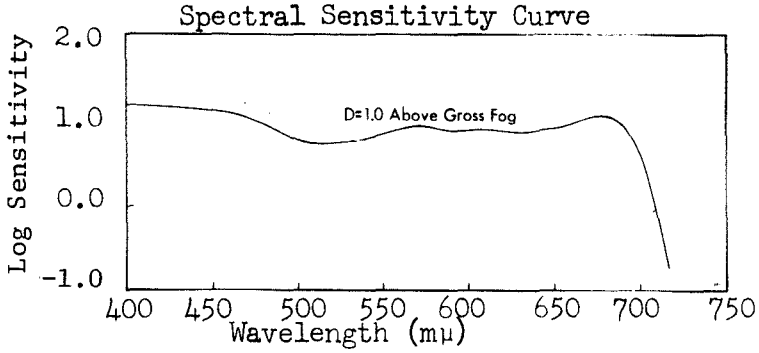
Machine Speed (feet per minute)	Number of Developer Racks	Average Gamma	Average Exposure Index
8	2	1.12	690 (ASA)

KODAK DOUBLE-X AEROGRAPHIC FILM SO-174

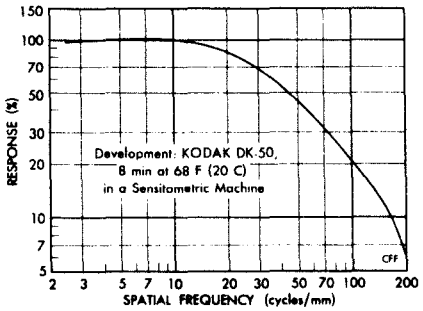
(Estar Base)

DK-50
D = 1.0 above
gross fog

Spectral Sensitivity Curve



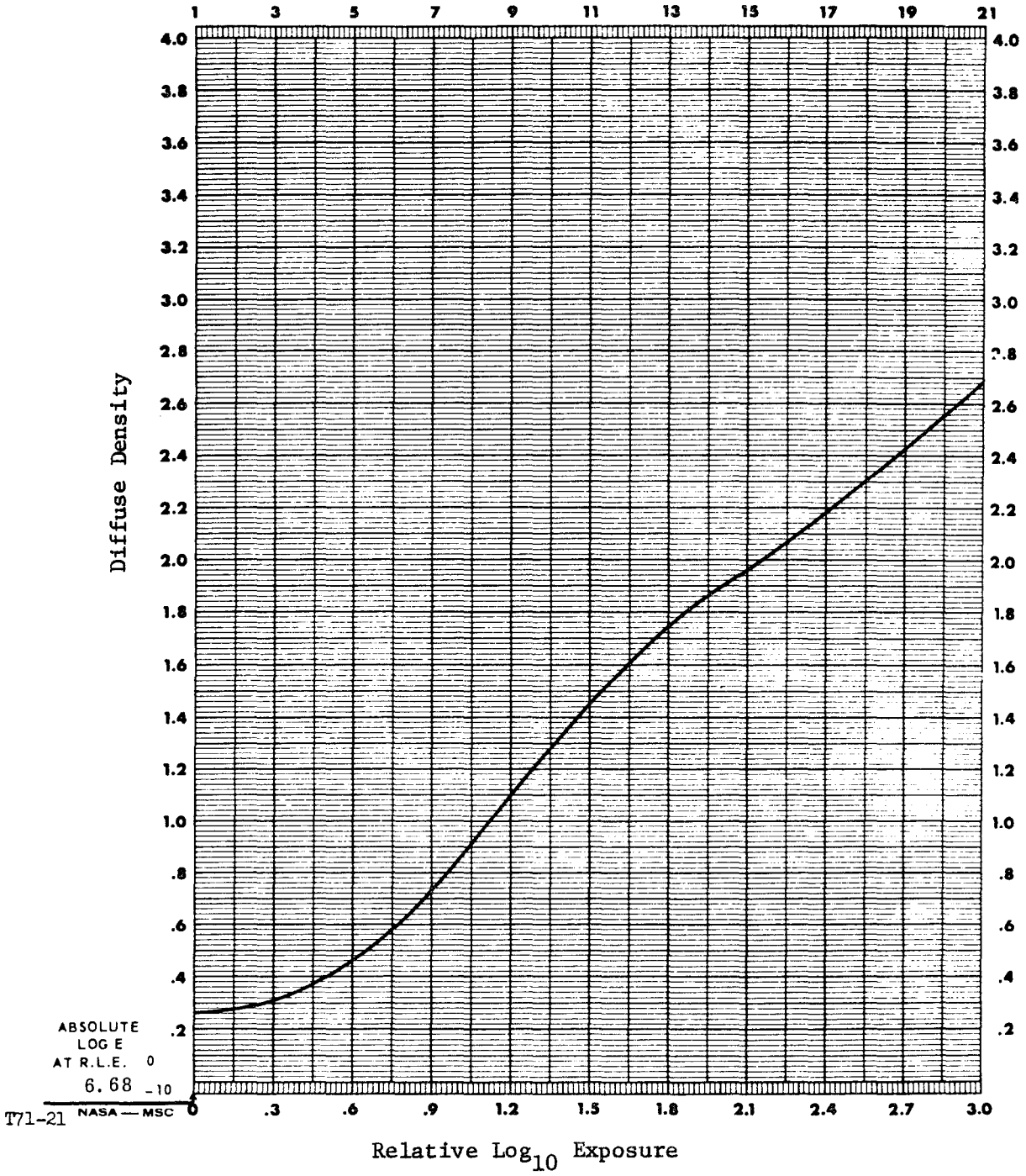
Modulation Transfer Function Curve



DATE June 1971 CONTROL # L TASK _____ PREPARED BY _____

FILM SO-174 EMULSION # 1-1 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Vmt 11C-M #2	INSTRUMENT	MacBeth	SPEED ( )	
ILLUMINANT	2850 °K	CHEMISTRY	MX-641	TYPE	TD 403	D-MAX	
TIME	1/50 SEC.	SPEED	2 TANKS 6 FPM	APERTURE SIZE	4 MM	GAMMA	1.25
FILTER	5500°K+.6ND	TEMP °F	80 TIME	FILTER	Visual	BASE + FOG	.22



KODAK EKTACHROME MS FILM TYPE SO-368
(Estar Thin Base)

(This material was obtained from manufacturer's published information unless a specific test source is referenced.)

FILM CHARACTERISTICS*

A medium-speed, color-reversal film for low-altitude mapping and reconnaissance. This film has an antihalation undercoating. The physical characteristics, exposure, image-structure characteristics, and mechanized processing of this film are the same as those given for Kodak Aerial Color Film Type 2448.

Note: This film is not available for use in commercial aerial cameras. It is a Special Order item designed for use in certain military cameras that have been constructed or modified to handle thin-base films.

BASE

This film has a 2.5-mil Estar polyester base with fast-drying (PX) backing.

EXPOSURE

Suggested aerial exposure indexes for mechanized processing will be found in the tables which follow.

Aerial exposure indexes are designed for use with the Kodak Aerial Exposure Computer, Kodak Publication No. R-10. Aerial exposure indexes are not equivalent to, and should not be confused with, the conventional film speeds used in pictorial photography.

IMAGE-STRUCTURE CHARACTERISTICS; Kodak EA-4 chemicals with 2 developer racks at 3.2 fpm

Characteristic	Value	Classification
Resolving Power		
Test-object contrast 1000:1	80 lines/mm	Medium
Test-object contrast 1.6:1	36 lines/mm	Low
RMS Granularity (at net density of 1.0)	12	

* This material describes the general characteristics of this film type. Sensitometric curves describe the results of a specific set of processing conditions on a specific emulsion batch. Experimenters are reminded that results may change somewhat from one emulsion to the next. Specific characteristics are determined for mission films as far as possible in advance of actual mission.

MECHANIZED PROCESSING

The Kodak Versamat Film Processor, Model 1411, can be used to process this film using Kodak Versamat EA-4 chemicals.

PROCESSING SEQUENCES WITH KODAK EA-4 CHEMICALS:

Processing Step	Number of Racks	Time	Temperature
Prehardener	1 & 2	2'30"	95° ± 1°F
Neutralizer	3	1'15"	97° ± 3°F
First Developer	4 & 5	2'30"	100° ± ½°F
First Stop	6	1'15"	100° ± 1°F
Wash	7	1'15"	88° to 95°F
Color Developer	8 & 9	2'30"	110° ± 1°F
Second Stop	10	1'15"	110° ± 1°F
Wash	11	1'15"	88° to 95°F
Bleach	12	1'15"	110° ± 1°F
Fix	13	1'15"	110° ± 1°F
Wash	14	1'15"	88° to 95°F
Dryer		2'30"	125° ± 5°F

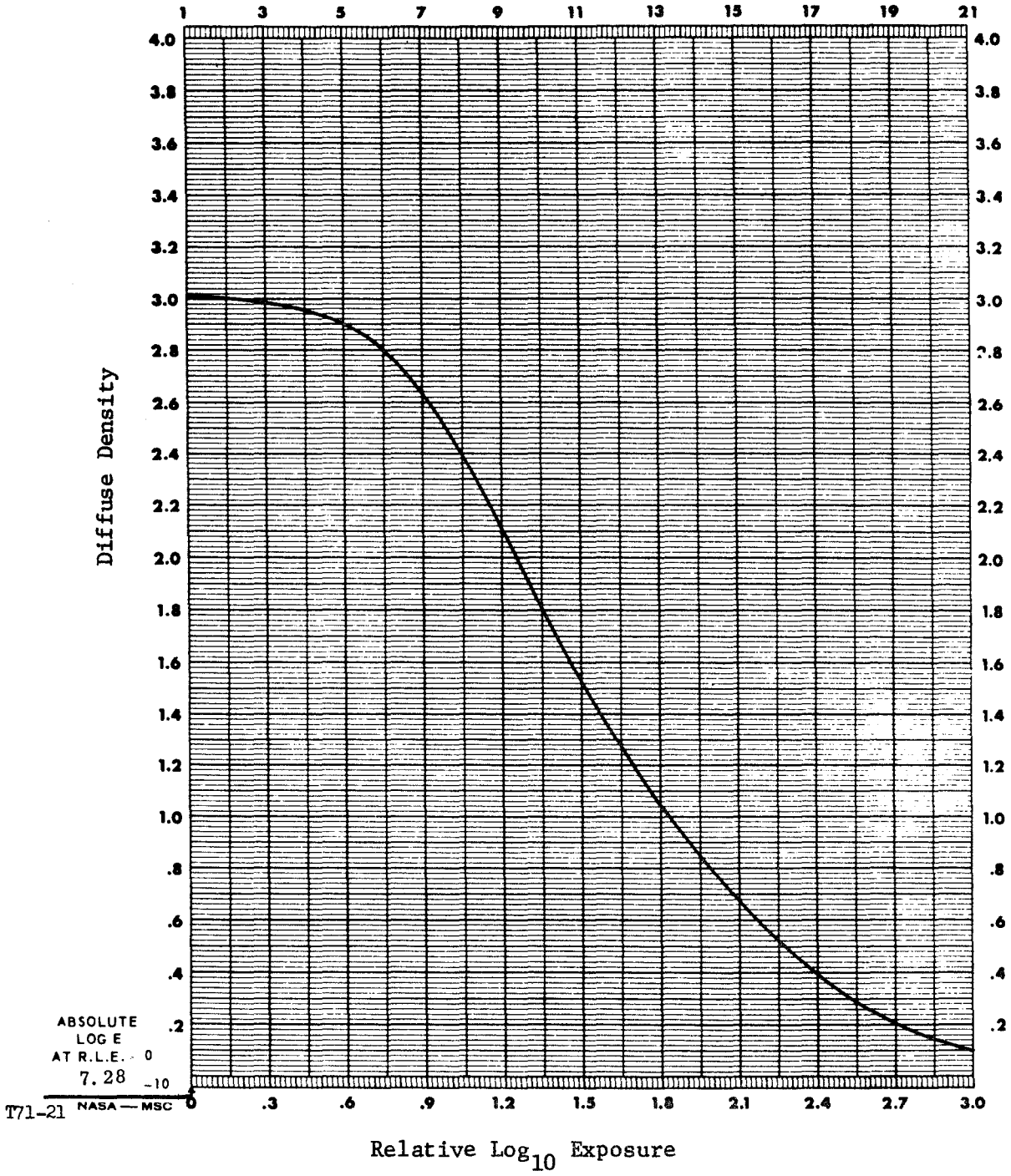
SUGGESTED AERIAL EXPOSURE INDEXES, GAMMAS, AND MACHINE SPEEDS WITH KODAK EA-4 CHEMICALS AT 109°F PROCESSING TEMPERATURE:

Machine Speed (feet per minute)	Number of Developer Racks	Average Gamma	Average Aerial Exposure Index
3.2	2	1.93	6

DATE June 1971 CONTROL # M TASK _____ PREPARED BY _____

FILM SO-368 EMULSION # 16-31(16mm) MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY			
SENSITOMETER	I-B	PROCESSOR	Hi-Speed	INSTRUMENT	MacBeth	SPEED ( )	
ILLUMINANT	2850 °K	CHEMISTRY	ME-2A	TYPE	TD 203	D-MAX	
TIME	1/50 SEC.	SPEED	TANKS 34 FPM	APERTURE SIZE	4 MM	GAMMA	1.8
FILTER	5500°K	TEMP °F	74.5 TIME	FILTER	Visual	BASE + FOG	

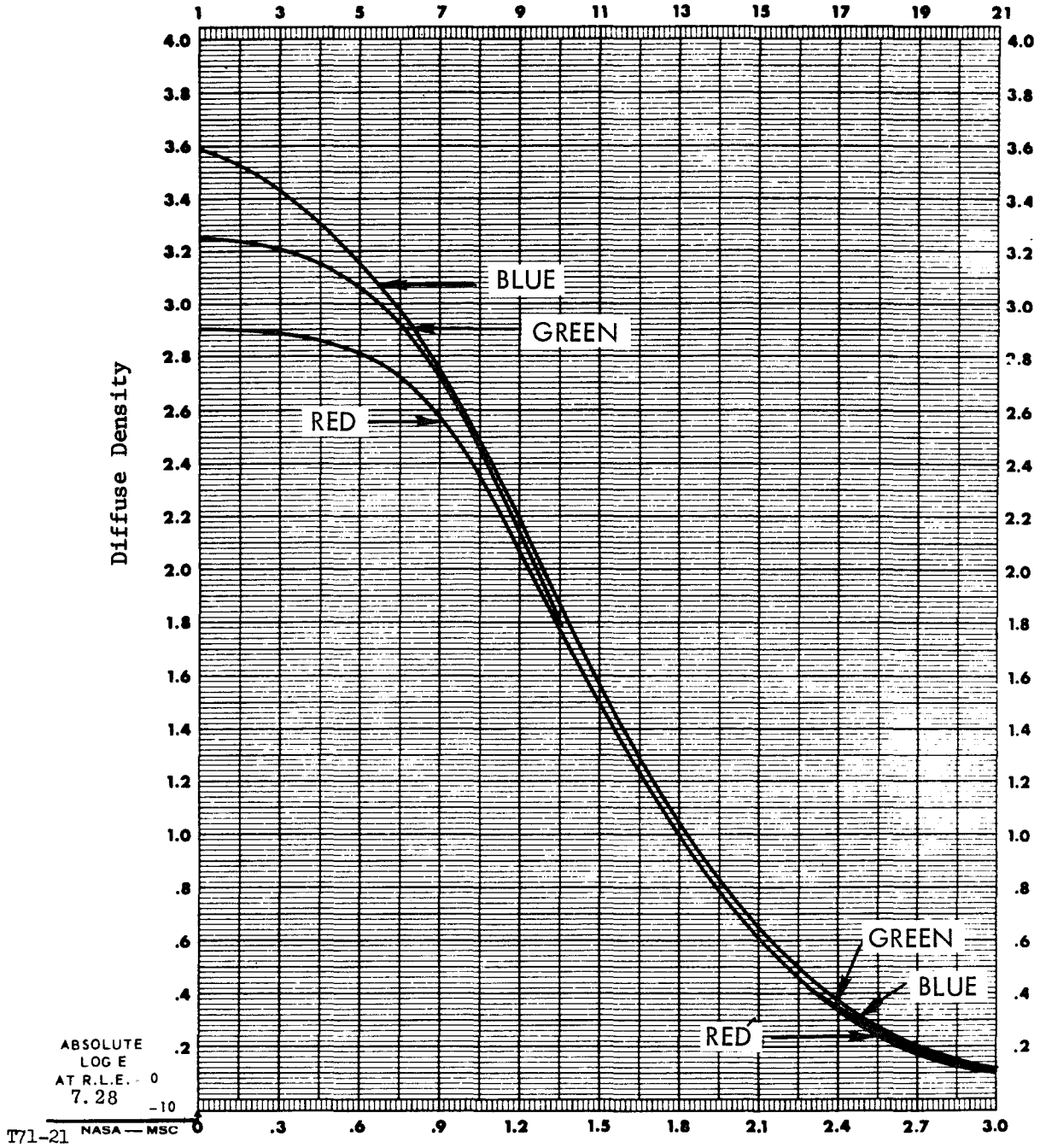


DATE June 1971 CONTROL # M TASK _____ PREPARED BY _____

FILM SO-368 EMULSION # 16-31 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY	
SENSITOMETER	I-B	PROCESSOR	Hi-Speed	INSTRUMENT	MacBeth
ILLUMINANT	2850 °K	CHEMISTRY	ME-2A	TYPE	TD 203
TIME	1/50 SEC.	SPEED ____ TANKS	34 FPM	APERTURE SIZE	4 MM
FILTER	5500°K	TEMP °F	74.5 TIME	FILTER	Status A

SPEED ( ) _____
D-MAX _____
GAMMA _____
BASE + FOG _____

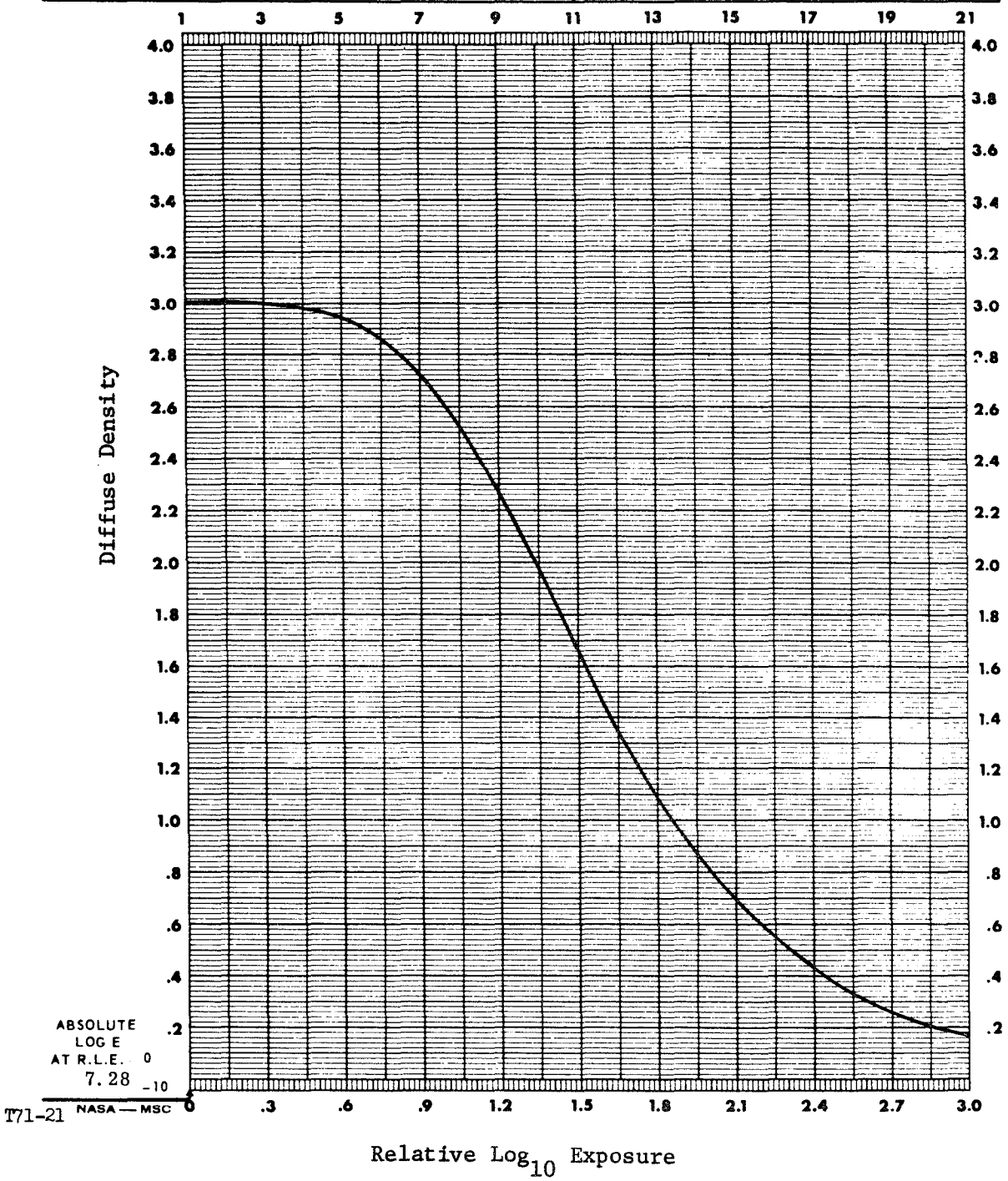


Relative Log_{10} Exposure

DATE June 1971 CONTROL # N TASK _____ PREPARED BY _____

FILM SO-368 EMULSION # 17-31 (70mm) MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY	
SENSITOMETER	I-B	PROCESSOR	Hi-Speed	INSTRUMENT	Quantascan
ILLUMINANT	2850 °K	CHEMISTRY	ME-2A	TYPE	
TIME	1/50 SEC.	SPEED	TANKS 3 1/2 FPM	APERTURE SIZE	MM
FILTER	5500 °K	TEMP °F	74.5 TIME	FILTER	Visual
				SPEED (ASA)	58
				D-MAX	
				GAMMA	
				BASE + FOG	



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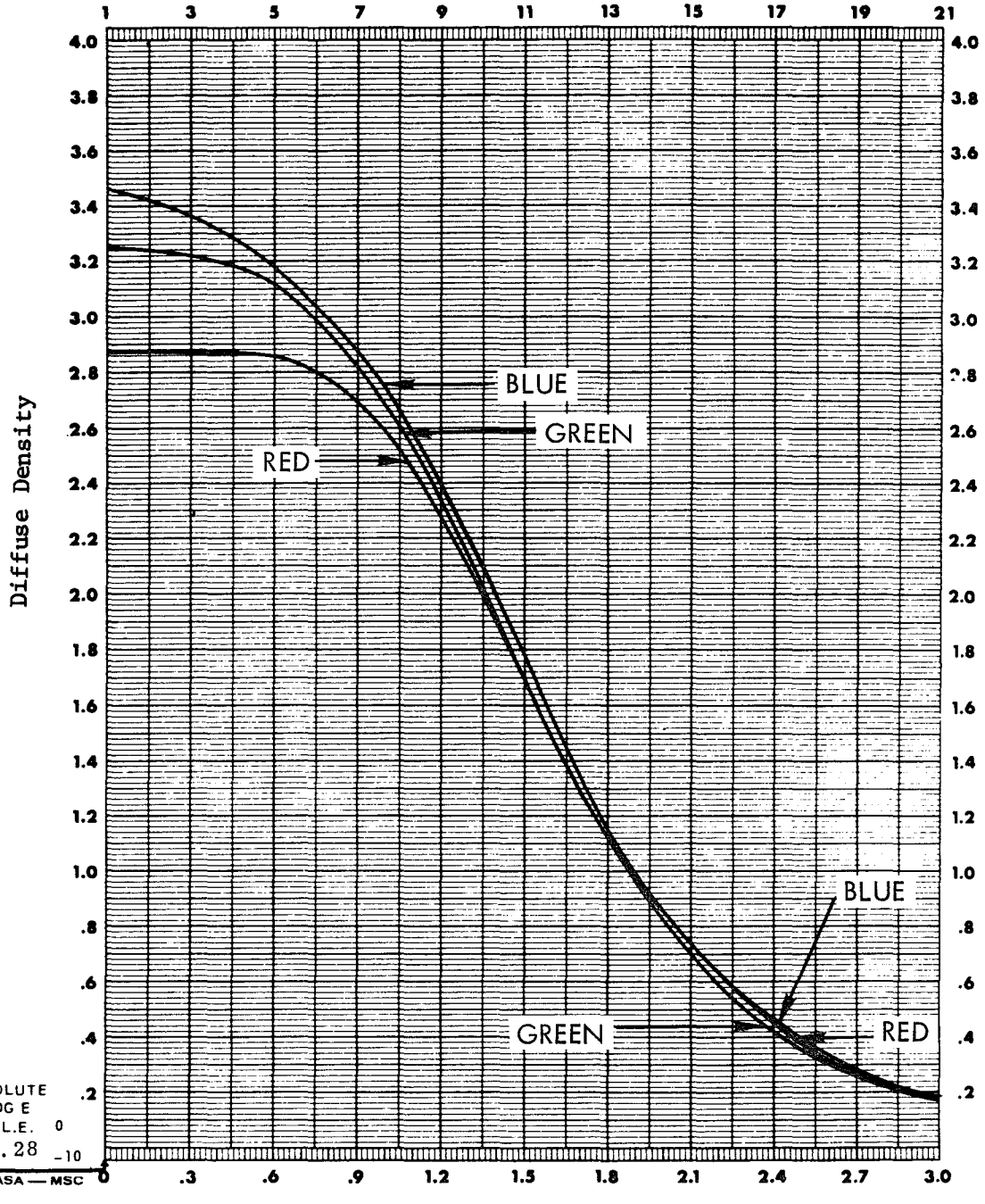
DATE June 1971 CONTROL # N TASK _____ PREPARED BY _____

FILM SO-368 EMULSION # 17-31 (70mm) MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY	
SENSITOMETER	I-B	PROCESSOR	Hi-Speed	INSTRUMENT Quantascan	SPEED (ASA) 58
ILLUMINANT	2850 °K	CHEMISTRY	ME-2A	TYPE _____	D-MAX _____
TIME	1/50 SEC.	SPEED _____ TANKS	3 1/2 FPM	APERTURE SIZE _____ MM	GAMMA _____
FILTER	5500 °K	TEMP °F 74.5	TIME _____	FILTER Status A	BASE + FOG _____



T71-21 NASA — MSC

KODAK SPECTROSCOPIC FILM TYPE IIa-O

(This material was obtained from manufacturer's published information unless a specific test source is referenced.)

FILM CHARACTERISTICS*
A medium-speed spectroscopic film for recording low-intensity illumination with long exposure times.

USE
Photographic applications of this film include astronomy in the ultraviolet region of the spectrum, and Raman spectra.

BASE
This film has a 4.0-mil Estar base.

IMAGE-STRUCTURE CHARACTERISTICS

Characteristic	Value	Classification
Resolving Power		
Test-object contrast 1000:1	95 lines/mm	Medium
Test-object contrast 1.6:1	69 lines/mm	--
RMS Granularity		
(at net density of 1.0)	32	Medium

MECHANIZED PROCESSING
This film can be processed in the Hi-Speed film processor, using Kodak D-76 chemicals.

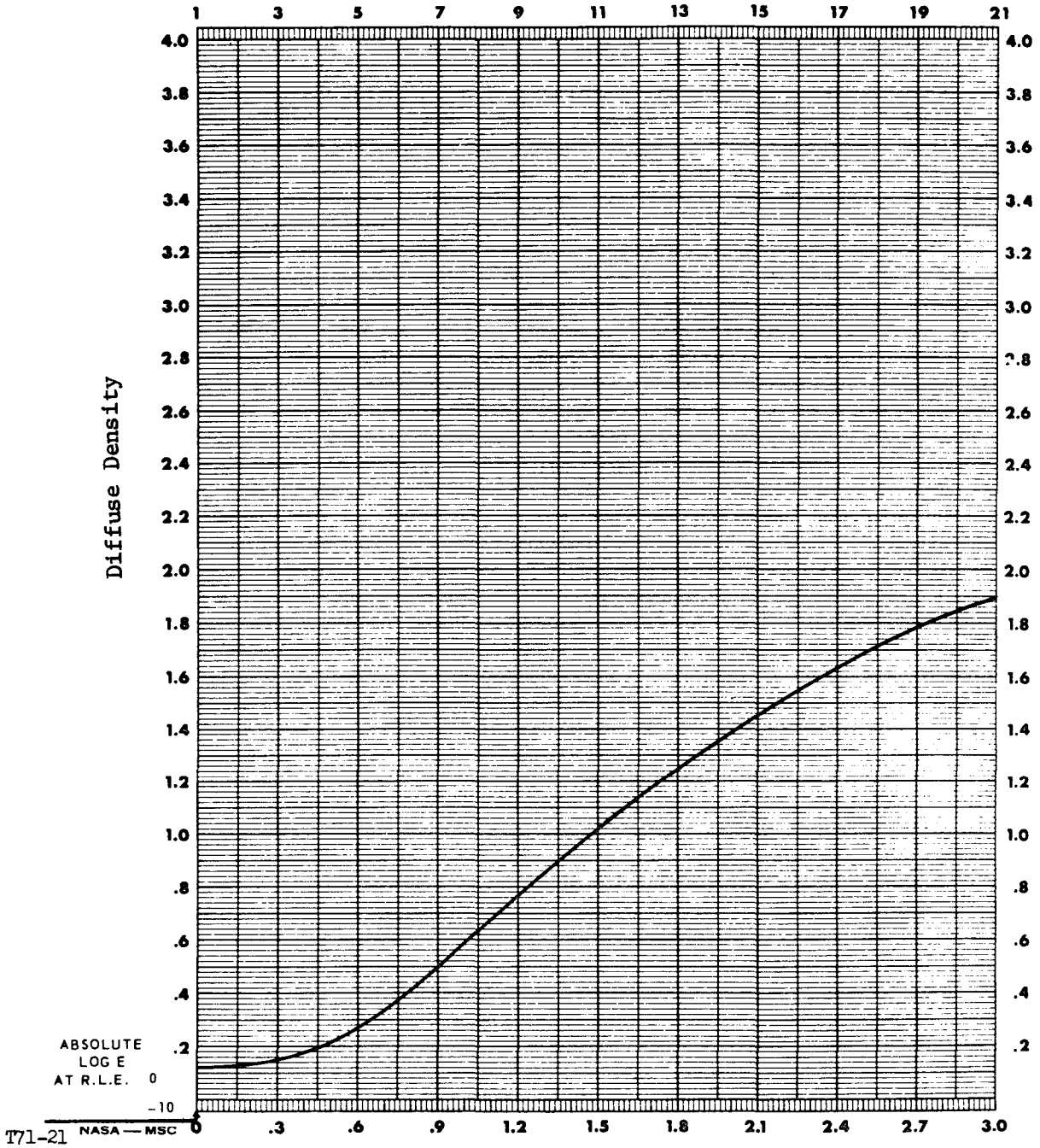
Machine Speed (feet per minute)	No. of Developer Racks	Average Gamma	Approximate Exposure Index
3.5	1	.88	ASA 600

*This material describes the general characteristics of this film type. Sensitometric curves describe the results of a specific set of processing conditions on a specific emulsion batch. Experimenters are reminded that results may change somewhat from one emulsion to the next. Specific characteristics are determined for mission films as far as possible in advance of actual mission.

DATE June 1971 CONTROL # J TASK _____ PREPARED BY _____

FILM IIa-O EMULSION # 129771 MFG _____ EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY	
SENSITOMETER	I-B	PROCESSOR	Hi-Speed	INSTRUMENT	MacBeth
ILLUMINANT	3000 °K	CHEMISTRY	D-76	TYPE	TD 217 R
TIME	1/25 SEC.	SPEED	TANKS 3.5 FPM	APERTURE SIZE	4 MM
FILTER	3750 Å	TEMP °F	76 TIME 8'50"	FILTER	Visual
				SPEED ( )	
				D-MAX	
				GAMMA	.88
				BASE + FOG	



KODAK NUCLEAR TRACK EMULSION TYPE NTB-3

(This material was obtained from manufacturer's published information unless a specific test source is referenced.)

FILM CHARACTERISTICS*
A highly sensitive spectroscopic film for recording all charged particles.

USE
Photographic applications of this film include astronomy in the far ultraviolet region of the spectrum and nuclear physics.

BASE
This film has an Estar Base.

IMAGE-STRUCTURE CHARACTERISTICS
Mean grain diameter (undeveloped) is 0.34 microns.

MECHANIZED PROCESSING**
This film can be processed in the Versamat film processor, using Kodak MX-641 chemicals.

Machine Speed (feet per minute)	Number of Tanks	Average Gamma
	2	6.1

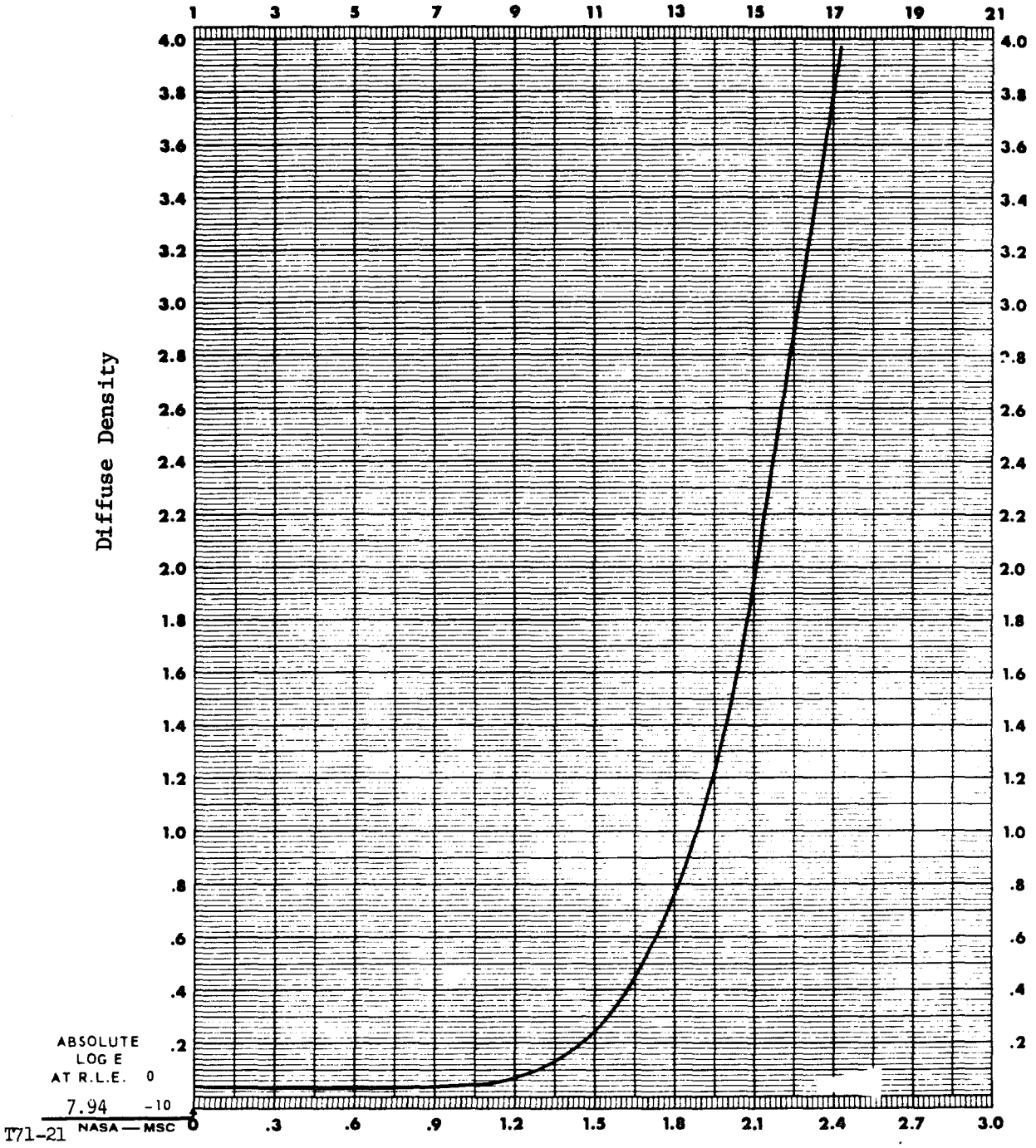
*This material describes the general characteristics of this film type. Sensitometric curves describe the results of a specific set of processing conditions on a specific emulsion batch. Experimenters are reminded that results may change somewhat from one emulsion to the next. Specific characteristics are determined for mission films as fas as possible in advance of actual mission.

**As used for preliminary processing tests in the Photographic Technology Division at MSC.

DATE 2/10/71 CONTROL # 3 TASK _____ PREPARED BY _____

FILM NTB-3 EMULSION # 08801-05 MFG EK EXPIRATION DATE _____

EXPOSURE DATA		PROCESSING DATA		DENSITOMETRY	
SENSITOMETER	1B	PROCESSOR	VII	INSTRUMENT	SPEED ( )
ILLUMINANT	2850 °K	CHEMISTRY	MX-641	TYPE	D-MAX
TIME	1/10 SEC.	SPEED	2 TANKS 8 FPM	APERTURE SIZE MM	GAMMA 6.1
FILTER	C5900	TEMP °F	76 TIME	FILTER	BASE + FOG



T71-21 NASA—MSC

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