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NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

ALSEP
FLIGHT CONTROL EXPERIMENTS OPERATIONS PLAN

FIRST MANNED LUNAR MISSION

SEPTEMBER 6, 1967

PREPARED BY
FLIGHT CONTROL DIVISION

MANNED SPACECRAFT CENTER
HOUSTON, TEXAS

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ALSEP

FLIGHT CONTROL EXPERIMENTS OPERATIONS PLAN

FIRST MANNED LUNAR MISSION

PREFACE

This document has been prepared by the Experiment Operations Group, Flight Control Operations Branch, Flight Control Division, Manned Spacecraft Center, Houston, Texas, to provide Mission Personnel with overall information on ALSEP operations. This document is effective as of September 6, 1967.

Questions or comments concerning this document and requests for additional copies should be directed to Mr. Roland M. Travis, Flight Control Operations Branch, HU3-3101.

Approved by:

John D. Hodge
Chief, Flight Control Division

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SECTION 1

INTRODUCTION

1.1 PURPOSE

The ALSEP Flight Control Experiment Operations Plan has been prepared to present information on the Apollo Lunar Surface Experiments Package (ALSEP) to personnel associated with this project. This document will present the planning effort as it exists at present and should lead to more detailed documentation such as Mission Rules, Flight Plan, Systems Handbook, implementation and modification of existing handware.

1.2 SCOPE

This document contains a statement of ALSEP objectives, a description of the ALSEP and its associated subsystems, proposed lunar deployment operations, MSFN support, a description of the MCC-H/KSC interface test, a 1 year timeline of ALSEP lunar operations, and MCC-H support of the ALSEP.

1.3 UPDATES

This document will be updated by Systems Handbooks, Mission Rules, Ground Requirements, etc.

1.4 DOCUMENTATION

The documentation described below is planned for ALSEP for Flight Controller use. For the purposes of this document, Apollo X will refer to the first lunar mission which will carry the ALSEP.

A. Apollo X Flight Operations Plan (FOP)
   This plan will be prepared by Mission Operation Section (MOS) No. 4 of FCOB. It will contain a section on ALSEP which will generally consist of a functional description and how the ALSEP is integrated into the Apollo X Mission.

B. ALSEP Systems Handbook
   This handbook will be prepared by the Experiment Systems Branch (ESB) and will contain ALSEP systems drawings and

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schematics System Operations Constraints, red-line values et cetera, and will identify telemetry instrumentation.

C. Apollo X Flight Control Operations Handbook (FCOH)

This handbook will be prepared by FCOB and will contain standard operating procedures applicable to ALSEP. One portion will deal with the Apollo X Mission phase of ALSEP and another portion will then deal with the ALSEP one year mission. This handbook will be prepared and approved within FCD.

D. Apollo X Mission Rules

This document will contain mission rules applicable to ALSEP up to the time of ALSEP deployment on the lunar surface. This document will be compiled by FCOB of the FCD and will be approved by the Director of Flight Operations.

The mission rules for the extended ALSEP Mission will be contained in an addendum to the Apollo X Mission Rules and will also be approved by the Director of Flight Operations.

E. Flight Plan

The Apollo X Flight Plan will contain plans for ALSEP up through ALSEP lunar deployment. This document will be prepared by the Flight Crew Support Division (FCSD).

The extended portion of the ALSEP Mission, after deployment, will be detailed in a documentation titled "ALSEP Lunar Operation Procedures" and will be prepared by FCOB of the FCD.

F. Flight Control Data Requirements

1. Basic implementation and modification requirements, which are program oriented, will be submitted by the Statement of Requirements (SR) procedure.

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2. The operational requirements, which are mission oriented, will be supplied in the Data Pack format by the individual flight control areas. These statements will cover both the MCC-H and the MSFN requirements.

G. Simulation Plan

The plans for simulations of ALSEP will be given in the Apollo X Simulation Plan. This plan will be prepared by the Mission Simulation Branch of FCD.

1.5 FACILITIES REQUIREMENTS

A. MSFN Support

ALSEP support will require certain MSFN sites to continually recover, record, and playback ALSEP data. Continual data recording will be required for the entire ALSEP support lifetime. All sites will be scheduled so that no conflict will arise with a manned mission. If a conflict arises between the ALSEP data recovery and operation and a manned mission, the manned mission requirements will take precedence.

B. MCC-H Support

During the 45-day monitor phase of ALSEP, the SSR support facilities will be manned 24 hours per day. ALSEP data processing and display at the MCC-H will be required. Data display characteristics have not been completely defined.

During the 1 to 2 year phase, after the initial 45 days of operation, MCC-H will be manned only 2 or 3 hours per day unless otherwise needed such as during periods of lunar sunrise/sunset and eclipses. This manning requirement will be conducted from SSR's and should have no effect upon future mission preparations.

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SECTION 2

ALSEP OBJECTIVES

2.1 GENERAL

The objectives of the ALSEP are the collection and transmission of data from the lunar surface to the MCC-H via the MSFN. Areas of particular interest are the fields of geophysics and particles/fields. Data to be collected and techniques of collection are given in Table 2-I and Table 2-II.

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TABLE 2-I.- GEOPHYSICAL OBJECTIVES

Objective	Technique Used
Natural Seismology (moonquake, meteoroid impacts and lunar surface disturbances)	Passive Seismic Experiment using both long and short period seismometer instruments.
Properties of Lunar Surface	Passive Seismic Experiment using both long and short period seismometer instruments.
Rigidity of Lunar Surface	Passive Seismic Experiment using both long and short period seismometer instruments.
Elastic properties of shallow depths of Lunar Surface	Active Seismic Experiment employing mortar package, thumper device, and geophones.
Chemical properites of Lunar Subsurface material	Heat Flow Experiment using two heat flow probe assemblies.
Insulating Properties of the Lunar Surface	Heat Flow Experiment using two heat flow probe assemblies.
Chemical sorting of Lunar Surface material	Samples to be gathered and returned to earth by the astronauts.
Lunar Dust Accretion	Dust detector (based on solar cell output degradation).

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TABLE 2-II.- PARTICLES/FIELDS OBJECTIVES

Objective/Measurement	Technique Used
Effects of Moon on the Solar Wind.	Solar Wind Spectrometer Experiment.
Magnetic Field Intensity and variations at Lunar Surface.	Lunar Surface Magnetometer Experiment.
Composition of electron/proton energy levels in the lunar atmosphere.	Charged particle Lunar Environment Experiment.
Lunar Ionosphere Positive Ion Detection.	Suprathermal Ion Detector used to detect positive ions and the effects of the Solar wind.
Pressure of lunar atmosphere and rate loss of contaminants left by astronauts and the LM.	Velocity selector analyzer to measure particle velocities and energies Cold Cathode Ion Gage to determine total pressure of lunar atmosphere.

The above will be discussed in detail in subsequent sections.

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SECTION 3

ALSEP DESCRIPTION

3.1 GENERAL

The ALSEP is a package of scientific instruments designed to be transported to the moon aboard a Lunar Module (LM) and deployed by the flight crew on the lunar surface for the purpose of collecting scientific data and transmitting this data to the earth via the MSFN for a period of approximately one year. It is composed of seven experiments with various supporting subsystems. ALSEP experiments are divided between two arrays as shown in Table 3-I.

Supporting subsystems include the following:

A. Electrical Power Subsystem (EPS)

B. Data Subsystem (DSS)

C. Structural/Thermal Subsystem (STS)

Through the Data Subsystem, the ALSEP will be capable of receiving earth commands for experiment control in addition to those required for ALSEP operational control. The Electrical Power Subsystem and experiments are so constructed that operation of individual ALSEP components will not present a source of electromagnetic interference which might degrade the overall operation of the system. The Structural/Thermal subsystem, in addition to providing structural support for the ALSEP, will enable the ALSEP to survive in a lunar environment by use of thermal controls consisting of heaters and sun shades. In addition, dust covers are provided to protect the particle measuring experiments against dust and debris blown about by the ascent of the LM. The covers are removed after LM ascent by earth command with an automatic timer serving as a backup system.

In addition to the experiments and supporting subsystems, the astronauts will use the Apollo Lunar Geological Equipment (ALGE)

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TABLE 3.I.- ALSEP FLIGHT ARTICLES

EXPERIMENT	FLIGHT ARTICLE 1	FLIGHT ARTICLE 2	BACKUP	BACKUP
Passive Seismic (PSE)	X	X		
Active Seismic (ASE)		X	X	
Lunar Surface Magnetometer (LSM)	X			X
Solar Wind Spectrometer (SWS)	X			X
Suprathermal Ion Detector and Cold Cathode Ion Gage (SIDE/CCIG)	X	X		
Heat Flow Experiment (HFE)		X	X	
Charged Particle Lunar Environment (CPLEE)		X	X	X

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to collect and return samples of the lunar surface to the earth for subsequent detailed analysis. In the event a decision is made not to deploy the ALSEP, the ALGE may be removed from the LM Scientific Equipment Bay without removing the ALSEP experiments and subsystems.

The ALSEP/ALGE Scientific Equipment Bay, located in the descent stage of the LM, is shown in Figure 3.1a, with Compartments 1 and 2 identified. Compartments 1 and 2 contain ALSEP subpackages 1 and 2 respectively. Reference Figure 3.1b for a diagram of the contents of these two subpackages. A cask, used for shipment of the radioisotope for the electrical power system, is carried external to the LM adjacent to Compartment 1.

At this time, the four experiments comprising Flight Article #1 have been selected to fly on the first lunar mission to carry the ALSEP. If, for some reason, an experiment is not ready in time for the first ALSEP launch, Flight Article #1 will fly without it. There is no plan at present to substitute an experiment from Flight Article #2 on the first ALSEP launch.

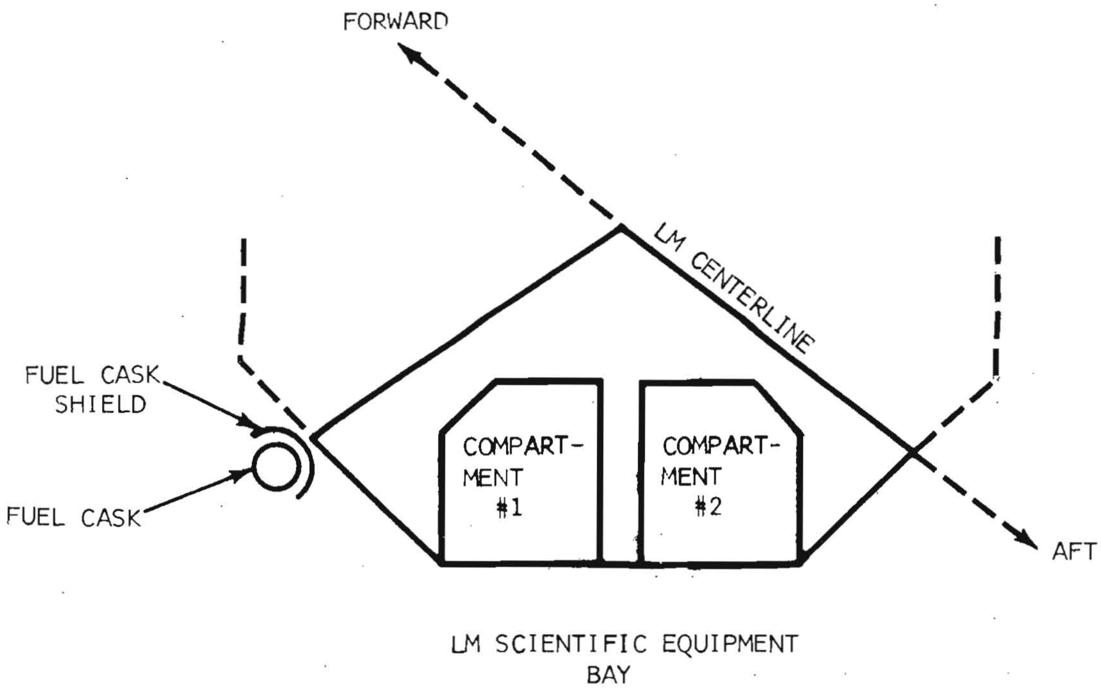

Figure 3-1a.- ALSEP location in the LM.

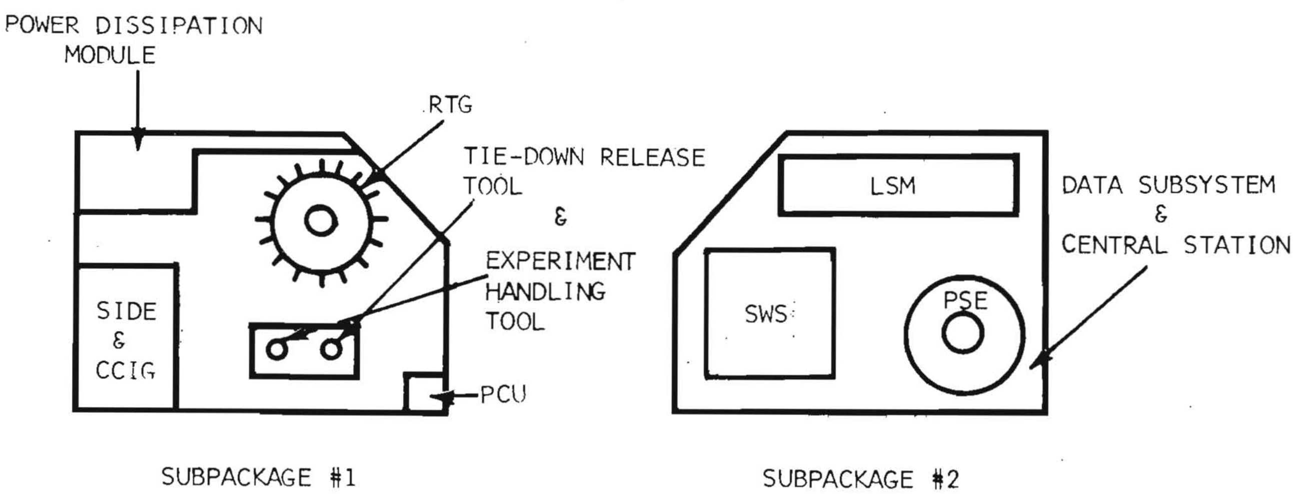

Figure 3-1b.- ALSEP pallet arrangement flight article #1

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3.2 SUBSYSTEM

3.2.1 Electrical Power Subsystem

The purpose of the Electrical Power Subsystem (EPS) is to provide all of the power requirements of the ALSEP during its period of lunar operation. Components of the EPS that, together, produce dc power for the ALSEP (via the Data Subsystem's Power Distribution and Signal Conditioning Unit) are as follows:

A. Fuel Capsule Assembly
B. Radioisotope Thermoelectric Generator (RTG)
C. Power Conditioning Unit (PCU)
D. Interconnecting Cable
E. Power Dissipation Module (PDM)

An integration of a plutonium fuel capsule and the RTG comprise the Integrated Power Unit (IPU). Heat generated by the plutonium fuel capsule is transmitted to a bank of hot junctions in the RTG which maintain a temperature of approximately 1100°F. Cold junction temperature is maintained at approximately 550°F by radiation of heat to space and the lunar surface. This thermopile produces a minimum of 56 watts (dc) of useful power. The IPU provides this minimum of 56 watts at a nominal 17 Vdc to the PCU and will radiate up to 1500 watts of waste heat to space and the lunar surface. Thermal equilibrium of the RTG is achieved approximately 1.5 hours after the fuel capsule has been placed in the RTG.

The remaining major section of the EPS is the PCU. This assembly performs three main functions:

A. It accepts the power output of the RTG and acts as a variable load regulator to maintain stable operating conditions. Accomplishment of this task is achieved by maintaining a sufficient amount of load current drainage to keep the thermopile temperature within limits.

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B. It regulates the RTG output voltage to a nominal 17 Vdc, providing the power converter with a fixed input voltage. This fixed input voltage enables the converter to output voltages of +29 Vdc, +15 Vdc, +12 Vdc, +5 Vdc, -6 Vdc, -12 Vdc to the Data Subsystem. The +29 Vdc is supplied to the experiments via the Power Distribution and Signal Conditioning Unit.

C. It accepts command data for switching between redundant units and provides status monitoring of the EPS. RTG temperature sensor outputs go directly to the DSS.

The interconnecting cable is used to transfer power from the RTG to the Power Distribution and Signal Conditioning Unit (located in the ALSEP Central Station some 10 feet from the RTG).

3.2.1.1 Operational modes of EPS.-

A. Design Requirements
   1. Full power on all voltage lines
   2. Maintenance of RTG within design loads
   3. Loss of selected RTG thermal sensors
   4. Loss of redundant RTG thermoelectric generator modules, however, there is no way to determine how many have been lost.
   5. Loss of selected PCU thermal sensors
   6. Loss of one redundant PCU.

B. Operational Constraints
   1. Loss of all thermal sensors in RTG and PCU
   2. Loss of current and voltage sensors in the PCU
   3. Loss of additional redundant RTG thermoelectric generator modules.

C. System Failure
   1. Loss of sufficient additional redundant IPU thermo-

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electric generator modules such that the output of the IPU is less than 12 volts

2. Loss of capsule in transit to lunar surface
3. Inability to remove the fuel capsule from the fuel cask or mate it to the RTG
4. Loss of both redundant PCU's.

D. Crew Safety Implications of the RTG

The RTG Fuel Capsule Cask is transported to the moon via an external attachment to the LM. Reference Figure 3-2. The cask has a very high temperature (approximately 870°F) which exists from the time of prelaunch installation (T-12-1/2 hours) to lunar surface deployment. This high temperature has several crew safety implications.

1. The location of the fuel cask is off-centered 27 inches from a LM RCS quad. The possibility of a LM fuel leak in the vicinity of the high temperature fuel cask presents a potential hazard. This item is presently under consideration in studies being conducted jointly by MSC and KSC.
2. During the launch phase of the mission, SLA temperature will increase due to atmospheric thermal loads. Above this normal heating, the fuel cask will add a small amount of heat to that of the SLA. How this temperature will affect LM structure and LM and SLA pyrotechnics is unknown at this time. Since the fuel cask temperature is monitored through the LM data subsystem, there will be no monitoring of fuel cask temperature after liftoff until the LM is activated during translunar coast.

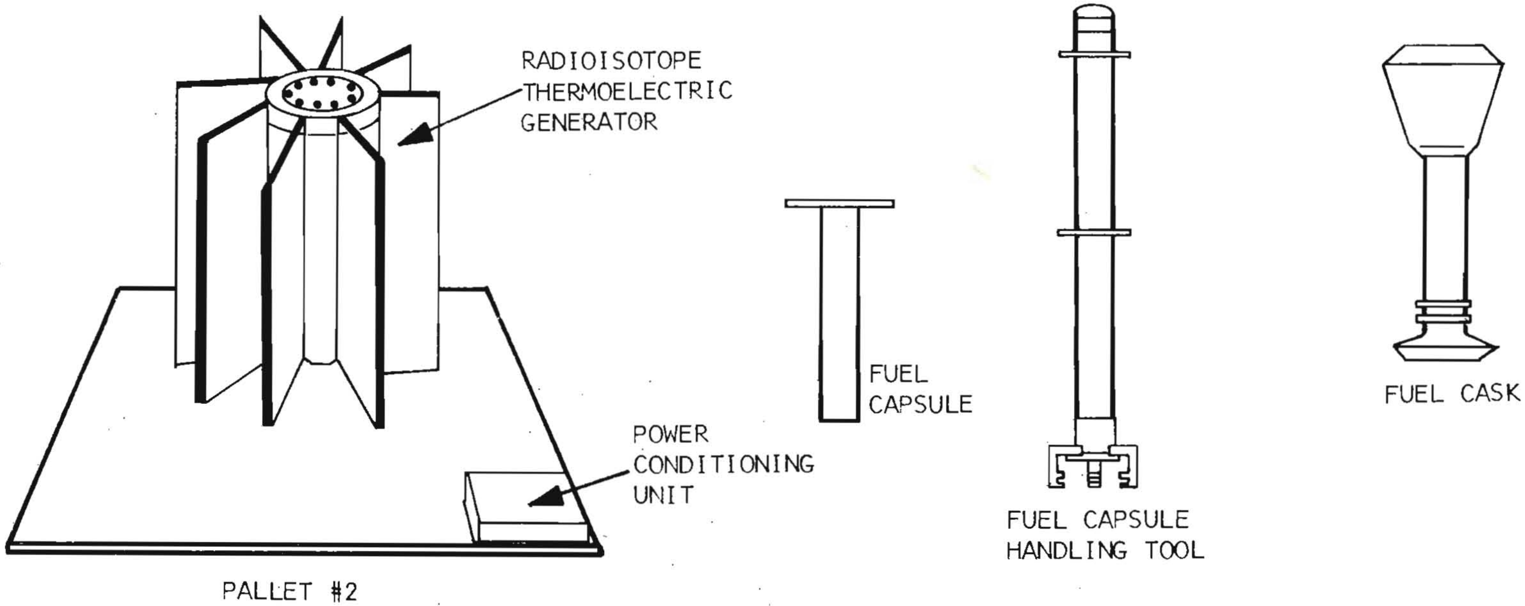

Figure 3-2.- Electrical power generation components.

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Once on the lunar surface, the astronaut must remove the fuel capsule from the fuel cask and mate it to the RTG by use of a special fuel handling tool. Should the astronaut touch the fuel capsule or the fuel cask, he could be burned in one of two ways.

A. A short contact with the fuel capsule/cask could burn the astronaut through his spacesuit even though the suit itself would not burn.

B. A longer contact with the capsule/cask would burn a hole in the suit. The exact times required for the suit to burn through are:
   1. 950°F - instantaneously
   2. 650°F - 3 second contact

If the decision is made to have the ALSEP deployed by two crew members instead of one, one of the crew members will act as a safety monitor while the other crew member removes the ALSEP subpackages and the fuel capsule.

After the fuel capsule has been mated with the RTG, the RTG fins will begin to heat up. Present studies indicate that 20 minutes after the capsule/RTG mating, the fins will obtain a temperature above 250°F. Therefore, the astronaut must make every effort to deploy the RTG and keep a safe distance from it (approximately 5 feet) after it has been fueled over 20 minutes. These fins radiate up to 1500 watts of waste energy after the RTG has reached its operating temperature (approximately 1-1/2 hours after fueling).

3.2.2 Data Subsystem

Primary functions performed by the Data Subsystem are as follows:

A. Receives, decodes, and distributes commands from the MSFN to the deployed units of the ALSEP.

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B. Accepts and processes experimental data and housekeeping information in 10-bit words (most significant bit first) from the ALSEP experiments and housekeeping data from the thermal, data, and power subsystems, processes this information into a digital telemetry format, and transmits this information to earth in the form of an S-Band signal.

C. Provides distribution of conditioned power to the ALSEP.

D. Provides circuit overload protection for the ALSEP.

E. Provides a means of terminating ALSEP operation after a period of 13 months. The timing equipment has recently been altered to allow the ALSEP to operate up to 2 years if desired.

The data Subsystem contains the following interconnected units:

A. Antenna

B. Diplexer and RF Switch

C. Command Receiver

D. Command Decoder

E. Data Processor

F. Transmitter

G. Power Distribution and Signal Conditioning Unit

Uplink utilizes (A) through (D) and (G). Data transmission uses (A), (B), (F), and (G).

The Data Subsystem uses one antenna for both up and down links with the MSFN. Positioning of the antenna is manually accomplished by the astronaut during ALSEP lunar deployment. Due to the rotation of the moon, the earth's motion in the lunar sky appears to be contained within a rectangle as seen from the lunar surface. It will be the task of the astronaut to point the antenna at the center of this apparent motion so that the antenna beamwidth (23 degrees) will cover the extremes

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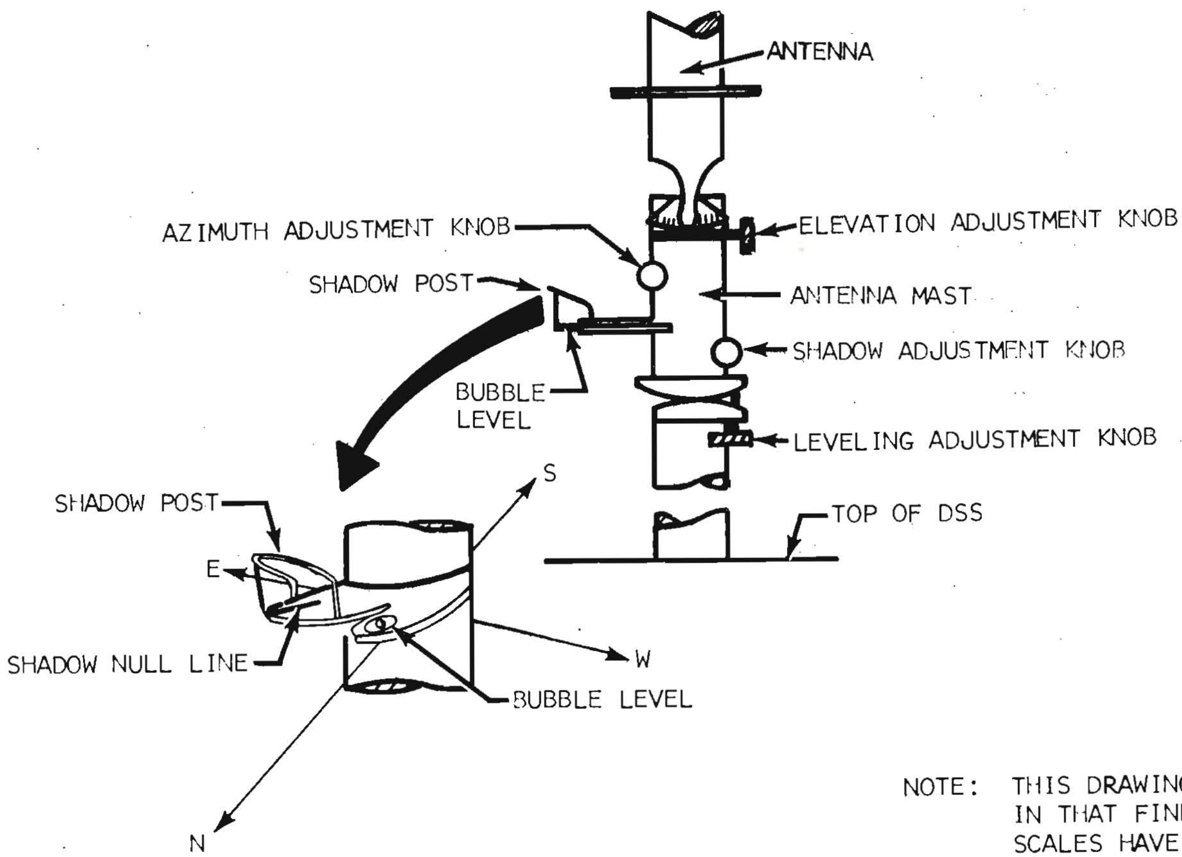
of the earth's motion and assure a continuous data link for the period af ALSEP operation. Assuming that the ALSEP will be deployed between 1968-1973, the allowable pointing error is ±2.7 degrees for a -2.7 db antenna loss. Should the astronaut position the antenna with greater than ±2.7 degrees error, the possibility of a data dropout sometime during the year is greatly increased.

Positioning of the antenna will be accomplished by use of the antenna aiming mechanism. Reference Figure 3-3.

The antenna aiming mechanism has a three gimbal aiming system. The astronaut will use the shadow post to properly align the instrument in an E-W direction and the bubble level mechanism to properly level it. He will then use the fine adjustment knobs to properly align the antenna in azimuth and elevation. (The azimuth and elevation values will be determined by the astronaut prior to leaving the LM. It is necessary that he know the position of the LM on the lunar surface within a five mile radius. Using this information, he will enter a chart which relates LM position with antenna azimuth and elevation values. The ALSEP antenna will be properly adjusted using these values. It is planned that Flight Controllers at MCC-H will confirm the values determined by the astronauts). Constraints governing antenna alignment are as follows:

A. The mechanism must be leveled before the shadow null position is set.
B. The mechanism must be set in elevation before being set in azimuth.

The diplexer and RF switch provide isolation between the transmitter and receiver at the ALSEP antenna junction point and provides RFI protection by isolating the receiver local oscillator from the antenna. The switch section provides for



NOTE: THIS DRAWING IS SIMPLIFIED IN THAT FINE ADJUSTMENT SCALES HAVE BEEN OMITTED.

Figure 3-3.- ALSEP antenna aiming mechanism.

the alternate connection of either of two transmitters to the antenna.

The command receiver is a narrow band FM receiver incorporating an output integrator for PM detection.

The command decoder processes the signals received from the command receiver to convert the command information into any one or more of a possible 128 discreet commands. (This is the total number of commands used by both ALSEP's, not just one of them.)

Data flow from each experiment is scheduled into the moon-to-earth telemetry link by the data processor Both analog and digital data are processed by the unit. It has three modes of operation:

A. Normal Mode - Accepts scientific and engineering data in accordance with preprogramed instructions. Each analog housekeeping input is sampled once every 90 telemetry frames. The data is then formatted into a 1060 bps serial bit stream. In this mode of operation, an MSFN 30 foot dish would be sufficient to receive the data.

B. Slow Mode - Identical to Normal Mode except that bit stream data rate is 530 bps. As in the Normal Mode, use of a 30 foot dish is adequate. This mode of operation is considered to be a contingency mode.

C. Active Seismic - Accepts seismic data in serial form which occurs at 10,600 bps rate. No other experiment data is collected during operation in this mode. The bit rate in this mode constitutes a definite constraint on the MSFN in that use of an 85 foot antenna is mandatory to receive data in this mode, however, this mode will not be used on Array "A".

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The transmitter is a narrow band unit which accepts a split phase modulated input from the data processor and provides phase modulation on its output carrier.

Functions of the Power Distribution and Signal Conditioning Unit are as follows:

A. Switching and distributing power to experiments and other operational units of ALSEP.
B. Conditioning housekeeping data sensor signals for telemetry inputs to the analog-to-digital converter.

Secondary functions include circuit protection for distribution lines and ALSEP shutdown on command from the timer.

To support the initial period of operation of ALSEP, a number of backup measures have been incorporated into the system. Among these backup systems are:

A. Provisions for the astronaut to turn on the transmitter, data processor, and experiments manually (if necessary).
B. A timed series of commands, starting 96 hours after the coupling of the RTG to the central station, to initiate the removal of dust covers from the CPLEE (on Flight Article #2 or Flight Article #1 backup), Solar Wind, and SIDE experiments.
C. Generating a signal every 12 hours for resetting the circuit breaker in the power line to the receiver.
D. After 108 hours, generating at 12-hour intervals a sequenced pair of commands to:
    1. Initiate the FLIP/Calibrate function of the magnetometer (reference Paragraph 3.3.1).
    2. Six minutes later to insure that the power distribution relay of the fourth experiment is in the Operational Power ON position. (A system power overload could exist in which the total power demanded by all experiments, at any one time, would exceed the RTG

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capability. To protect against this, up to three experiments can be rippled off the line when reserve power at the input to the PCU drops below 0.5 watts. Reference Table 3-II for the order of experiment ripple-off. Function D2 places the experiments back on the line. (They can, however, be reset at any time by sending an ON command from earth).

3. After 2 years, generate a command to turn the ALSEP transmitter off. Transmitter operation can be terminated earlier by earth command.

A Dust Detector, containing three photocells and three thermisters, will measure the effects, if any, of lunar dust accretion over the ALSEP Central Station (reference Figure 3-4). The package is mounted on top of the Central Station sunshield with the photocells oriented with the Sensor unit on the three sides facing the ecliptic path of the Sun. Dust accretion will be measured as a function of the output degradation of the photocells.

3.2.2.1 Modes of success.-

A. Design Requirements

Full success of the Data Subsystem is defined as complete up and downlink telemetry information. This success can be achieved with loss of one or all of the following:

1. One transmitter
2. One Local Oscillator of the Command Receiver
3. One Digital Section of the Command Decoder
4. One Processor Unit of the Data Processor

B. Operational Constraints

1. Loss of 1-65 commands from the Command Decoder (Array A)

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TABLE 3-II.- EXPERIMENT RIPPLE-OFF ORDER

Flight Article #1

First	SIDE
Second	SWS
Third	PSE

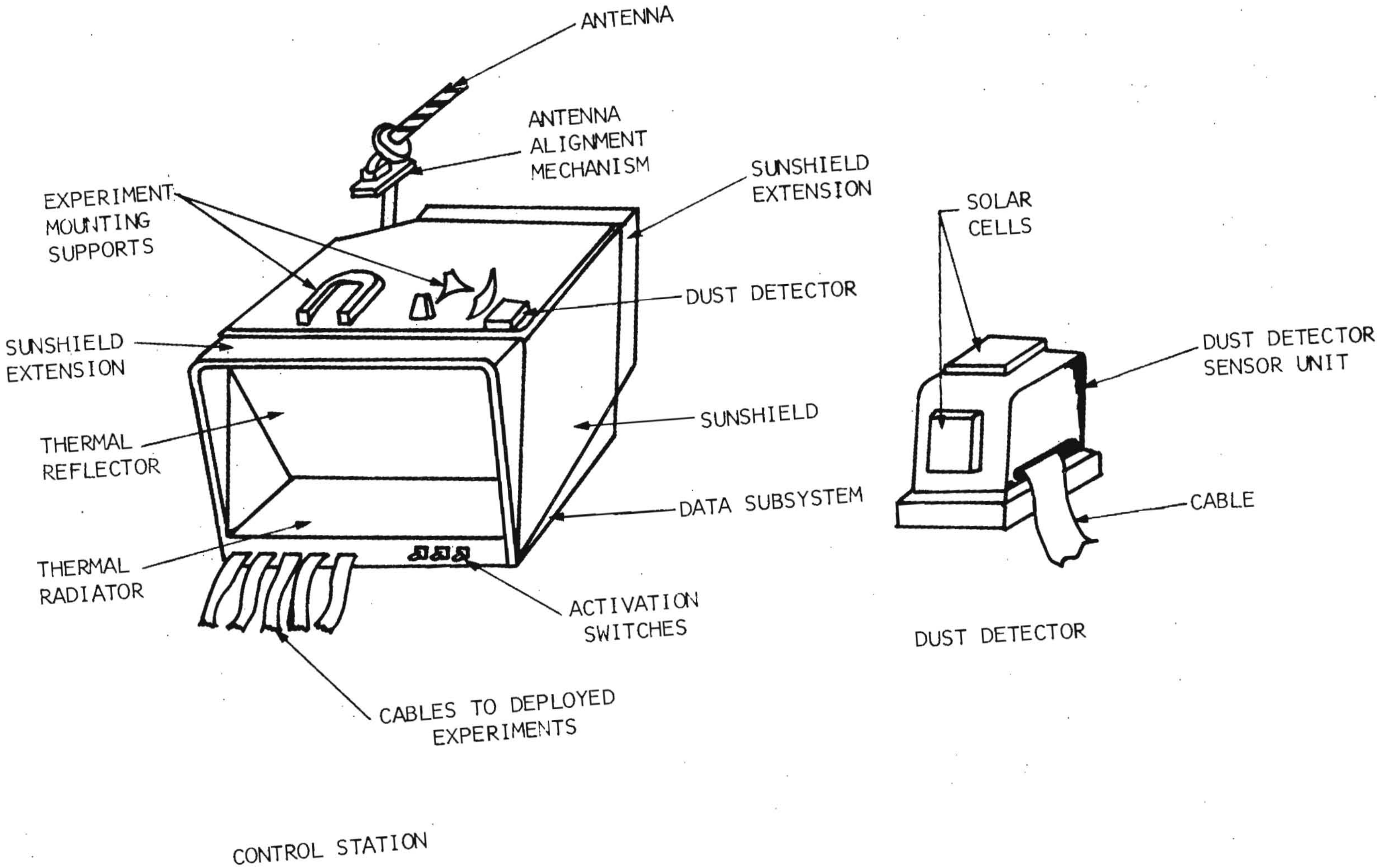

Figure 3-4.- Data subsystem (central station) and dust detector.

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2. Loss of 1-81 commands from the Command Decoder (Array B)
3. Loss of one command receiver
4. Loss of the command decoder demodulator circuit
5. Loss of 1-189 channels of the analog multiplexer (Data Processor)
6. Loss of the Frame Counter (Data Processor)
7. Excessive insertion losses within the diplexer filter
8. Loss of undetermined number of sensors in signal conditioning.

C. System Failures

Single point failures which could cause complete loss of downlink telemetry are as follows:

1. Antenna Assembly
2. Diplexer Low Pass Filter
3. Diplexer Reversible Circulator

3.2.2.2 Electrical power requirements.- Eighteen watts (average) operating power, 24 watts peak power.

3.2.3 Structural/Thermal Subsystem

The structural/thermal subsystem has the purposes of holding the ALSEP functional equipment within the confines of a predetermined space allocation in the LM, providing the necessary thermal control for the data subsystem and those experiment electronics not deployed with the experiment, that is, the Central Station, and providing a means for deploying the ALSEP. It includes the elements of the ALSEP required to perform the following functions:

A. Carry the structural loads of the experiment, data and power subsystems, LGE, and the RTG fuel cask.

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B. Control the operating temperature limits of the Central Station electronics in the deployed modes.

C. Shield the LM and the astronaut from the RTG thermal loads.

D. Provide the special tools required by the astronaut in the ALSEP deployment, that is, the Experiment Handling Tool, the Tie-Down Release Tool, and the Fuel Transfer Tool.

The structural subsystem contains two enclosures designated as Subpackages 1 and 2. Housed in Subpackage 1 are the LSM, PSE, and SWS experiments. In addition, Subpackage 1 contains the data subsystem and Power Conditioning Unit. Subpackage 2 contains the SIDE/CCIG experiment, Experiment Handling Tool, RTG, Power Dissipation Module. External to the subpackages, mounted on the outside of the LM, is the Fuel Cask for the RTG. Figure 3.1a gives the location in the LM of both subpackages and the fuel cask.

The primary structure in Subpackage 1 is a riveted aluminum forging which supports the Central Station and the sunshield and, in the flight and carry modes, three of the experiments. After the experiments have been deployed, it then serves as the base for the antenna in addition to supporting the Central Station and sunshield. The sunshield is an essential element in the design of the thermal control system. The equipment in Subpackage 2 is supported on a 1-inch thick structural honeycomb pallet which provides the primary structural support for the stowed configuration, and serves as a base for the RTG in the deployed configuration. In addition, it serves as a temperature barrier between the astronaut and the fueled RTG during deployment. (This protection is necessary due to the fact that the RTG is fueled by the astronaut immediately after ALSEP is unstowed from the LM).

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The two structural support systems are interconnected by the antenna mast which interfaces the systems into a barbell arrangement. This is the primary method of carrying ALSEP from the LM to the deployment site some 290-300 feet from the LM. The method of carry is shown in Figure 3-5 on the following page. An alternate suitcase carry mode is provided as a backup.

The temperature of the Central Station electronics is controlled, in the deployed mode, by a passive system consisting of a Thermal Plate, Sunshield, Awnings, Side Curtain, Reflector and Electronic Equipment Containers. The Thermal Plate radiates energy to space and is shielded from direct solar energy by the Sunshield Awnings, and Side Curtain. Lunar surface radiation is minimized by the Reflector. Heat flow from the electronics to the lunar surface is minimized by the Electronic Equipment Containers.

When Subpackage 2 is deployed, the astronaut must remove the experiment handling tool (which is used to deploy all experiments) and the SIDE/CCIG experiments. Finally, it is necessary that the RTG Shield Assembly be detached and lowered away from the RTG to provide a clear hemisphere into which the RTG can radiate excess heat.

3.2.3.1 Mode of success.-

A. Design Requirements

1. Provide structural integrity sufficient to transport and deploy ALSEP on the lunar surface and maintain the Central Station components in the proper attitude during lunar operations.
2. Provide thermal control for the Central Station components during lunar operations, that is, regulate temperatures between 0°F and 125°F during all mission phases.

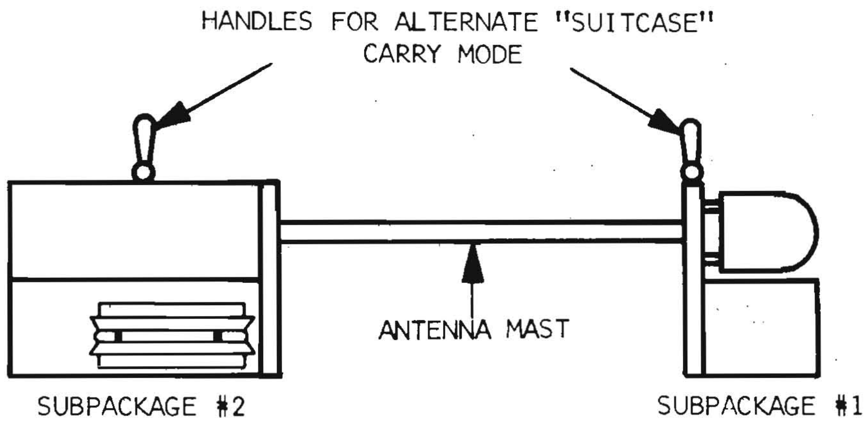

Figure 3-5.- ALSEP barbell carry mode.

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B. Operational Constraints

Sufficient loss of structural integrity to prohibit some experiments from being deployed.

C. System Failure

1. Loss of structural integrity sufficient to preclude the possibility of performing the following functions:
   a. Removal of the ALSEP from the LM
   b. Mounting of the antenna
   c. Deployment of all experiments
2. Loss of thermal integrity sufficient to cause thermal runaway in the data subsystem.

3.2.3.2 Electrical power requirements.- The only power requirements are associated with the thermal control functions of the data and electrical subsystems and the experiments. These values are given in the description of each experiment/subsystem. Reference Figure 3-6 for subsystems interface.

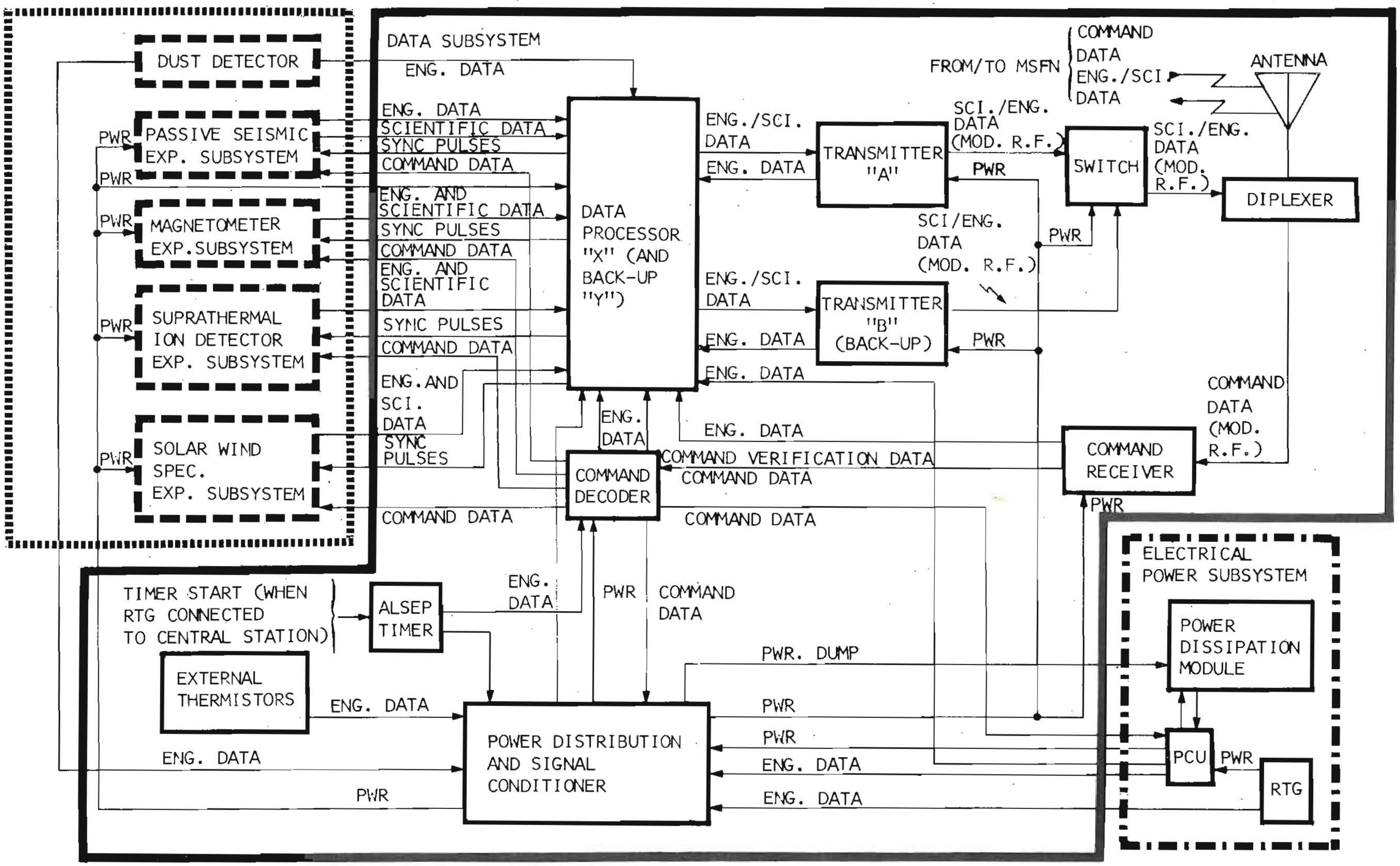

Figure 3-6.- ALSEP system functional block diagram; flight article #1 configuration.

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3.3 EXPERIMENTS

3.3.1 Lunar Surface Magnetometer (LSM)

3.3.1.1 Purpose.- The purpose of the LSM is to provide data pertaining to magnetic fields at the lunar surface. In particular, it will measure the magnitude of the lunar surface equatorial magnetic field and its variations with time.

3.3.1.2 Experimental approach.- Three flux-gate magnetometers, mounted on a single base, will be used to measure the lunar magnetic field.

3.3.1.3 Experimental system.- Reference Figure 3-7 for a diagram of the LSM. The major components of the LSM are as follows:

A. Support Arms
B. Thermal Shrouds
C. Sensors
D. Electronics Package
E. Leveling Legs

Functions of the support arms are to provide sensor support, sensor alignment, sensor/sensor separation, sensor/lunar surface separation, and sensor/electronics separation. The support arm/axes form an orthogonal system which is the instrument based (internal) coordinate systems. Radiative heat loss from the sensor support arms is held to a minimum by the use of fiberglass insulation jackets. The flat upper surface serves as a radiating plate for thermal control. The flat upper surface of each sensor arm is protected from solar flux by a thermal shroud or sunscreen.

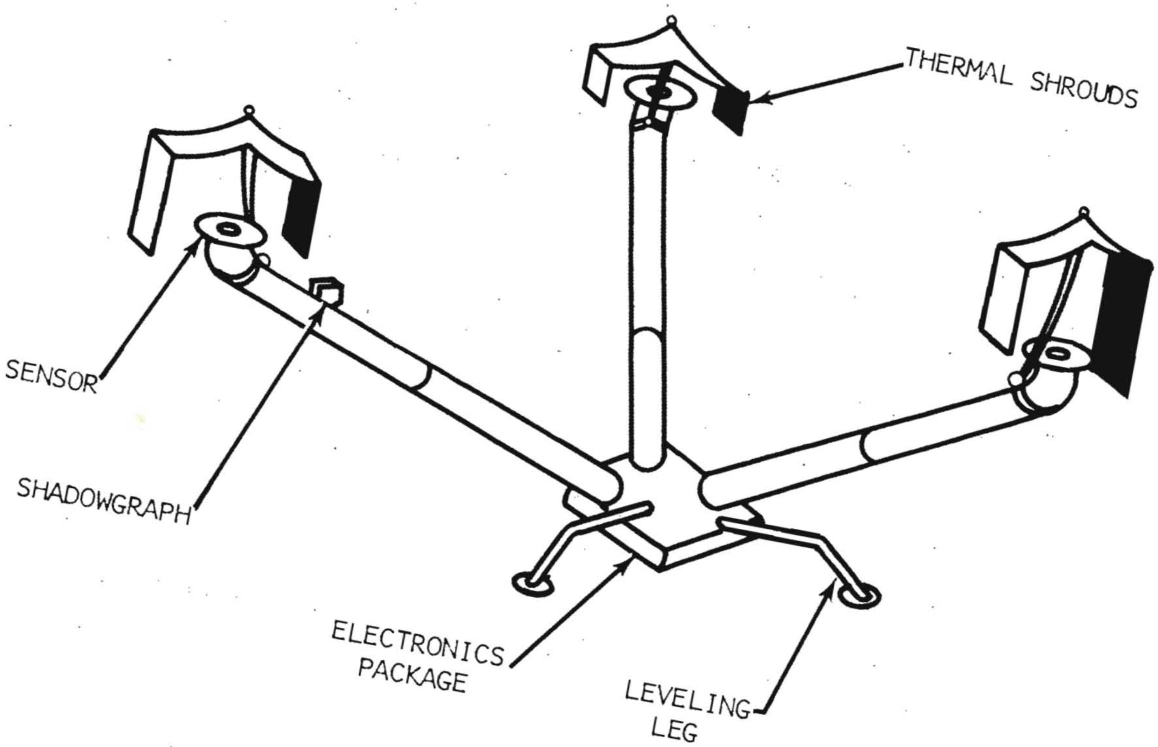

Figure 3-7.- Lunar surface magnetometer (LSM).

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There is a total of three flux-gate magnetometers, one at the end of each support arm. These magnetometers are referred to as sensors. They provide signal outputs proportional to the incident magnetic field components parallel to the respective sensor axes. In the normal, or scientific mode, the sensors are aligned along the support arm/axes (reference Figure 3-8). Sensor output is a function of temperature, hence accurate knowledge of sensor temperature is required. The measurement range of the magnetometer is adjustable with the maximum value being 400 gamma. The equatorial magnetic field of the Earth is approximately 35,000 gamma, (1 gauss = 10^5 gamma)

The electronics package consists of the following systems:

A. Sensor Electronics Assembly
B. Data Handling Assembly
C. Calibration and Sequencing Assembly (CSA)
D. Electronics/Gimbal - Flip Unit (EGFU)

The sensor electronics assembly converts the incident magnetic field intensity at the respective sensor into analog voltages. Three orthogonal sensors are employed with three identical processing channels.

Functions of the Data Handling Assembly include processing both scientific and engineering data, making it compatible with the digital data output requirements.

Calibration and sequencing assembly functions are:

A. Provide calibration and offset biases and maintain correct offsets during site survey and calibration.
B. Generate the sequence of flipper motor power switching necessary to accomplish site survey and flip-calibration.
C. Synchronize data processing and sequencing via ALSEP supplied timing signals.

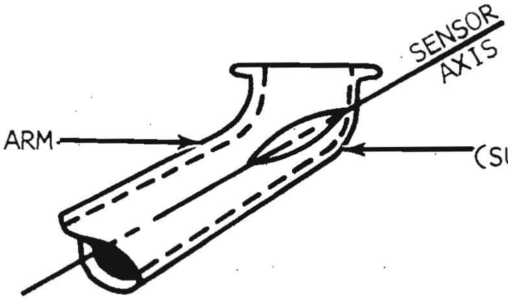

Figure 3-8.- LSM sensor arrangement.

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D. Convert and regulate the input power from the ALSEP to provide required voltages.

Housed in the upper portion of the Electronics Package, from which the three arms extend, is the EGFU. Flipper drive motors, housed in this unit, provide motive power for 90 degree and 180 degree rotation of the sensors. The 180 degree rotating (flipping) of the sensors is required for calibration purposes. A 90 degree flipping, together with 90 degree rotation (gimbaling) of the sensor axes is required to perfrom the site survey. Gimbal drive power is supplied by a spring. Flipping torque is transmitted to the sensors via a drive/toggle-over arrangement.

3.3.1.4 Electrical power requirement.-

3.5 watts normal operating power
3.5 watts maximum thermal control power
3.5 watts flipping power for 4 minutes. Maximum one each 12 hours.

3.3.1.5 Ground support systems.- See Section 6.

3.3.1.6 Deployment.- See Section 4.

3.3.1.7 Crew safety implication.- Crew safety implications concerning the LSM are unknown at the time this document was prepared, but none are anticipated. Should any hazards to the crew develop as a result of this experiment, the information will be supplied in a later update.

3.3.1.8 Real-time command/control.- See Sections 4, 5, 6.

3.3.1.9 Command requirements.- See Section 6.

*

3.3.1.10 Telemetry requirements.- See Section 6.

3.3.1.11 Flight plan integration.- See Section 4.

3.3.1.12 Constraints.-

A. The LSM should be placed 50 feet from the Central Station.

B. It should be leveled to within ±3 degrees of the vertical and aligned with the long axis of the sunshade E-W. The final E-W alignment should be reported to MCC-H giving alignment within ±1 degree.

C. It should be placed a maximum possible distance from the RTG and in a direction "away" from the LM.

D. The shadowgraph shadow indicator should be within the tolerance limit lines.

3.3.1.13 Weight.- The weight of the LSM is 14.5 pounds earth weight.

3.3.1.14 Principal investigator.-

Dr. Charles P. Sonett
Space Sciences Division
NASA/Ames Research Center
Moffett Field, California

3.3.1.15 Modes of success.- No information available

3.3.2 Suprathermal Ion Detector (SIDE) And Cold Cathode Ion Gage Experiment (CCIG)

3.3.2.1 Purpose.- The purpose of the SIDE/CCIG is to provide data concerning the density, temperature, and variations of these parameters of the lunar atmosphere.

*

3.3.2.2 Experimental approach.- Data pertaining to the density and temperature of the lunar ionosphere, as it exists near the lunar surface, will be gathered by the SIDE. In particular, the SIDE measurements will include an ion count as well as measurements of the velocity and energy associated with the detected particles. The CCIG will determine the neutral particle density at the lunar surface and any variation in that density associated with solar activity (solar wind). Specifically the CCIG will measure the pressure of the ambient lunar atmosphere.

3.3.2.3 Experimental systems.- The instrument used for SIDE has a velocity selector composed of crossed electric and magnetic fields followed by a curved plate analyzer. Reference Figure 3-9. The velocity selector passes ions with proper energy. The particles that pass through the curved plate analyzer are detected and counted. Ions with velocities ranging from 4×10^4 to 9.35×10^6 cm/sec are passed by the velocity filter. The curved plate analyzer covers an energy range of 0.2 ev to 48.6 ev. Also contained in SIDE is a second curved plate analyzer without a velocity filter that detects solar wind particles in the range of 10 ev to 3500 ev.

In order to overcome the electric fields that may be present at the lunar surface, the instrument rests on a ground plane. This plane consists of a wire mesh which is spread out on the lunar surface by the astronaut. A power supply in the instrument applies voltage between the SIDE electronics and the ground plane to investigate any electric field effects.

The CCIG consists of a cold cathode ion gage and its associated electronics. These are mounted in the same package as the SIDE during flight. During ALSEP deployment, the CCIG is

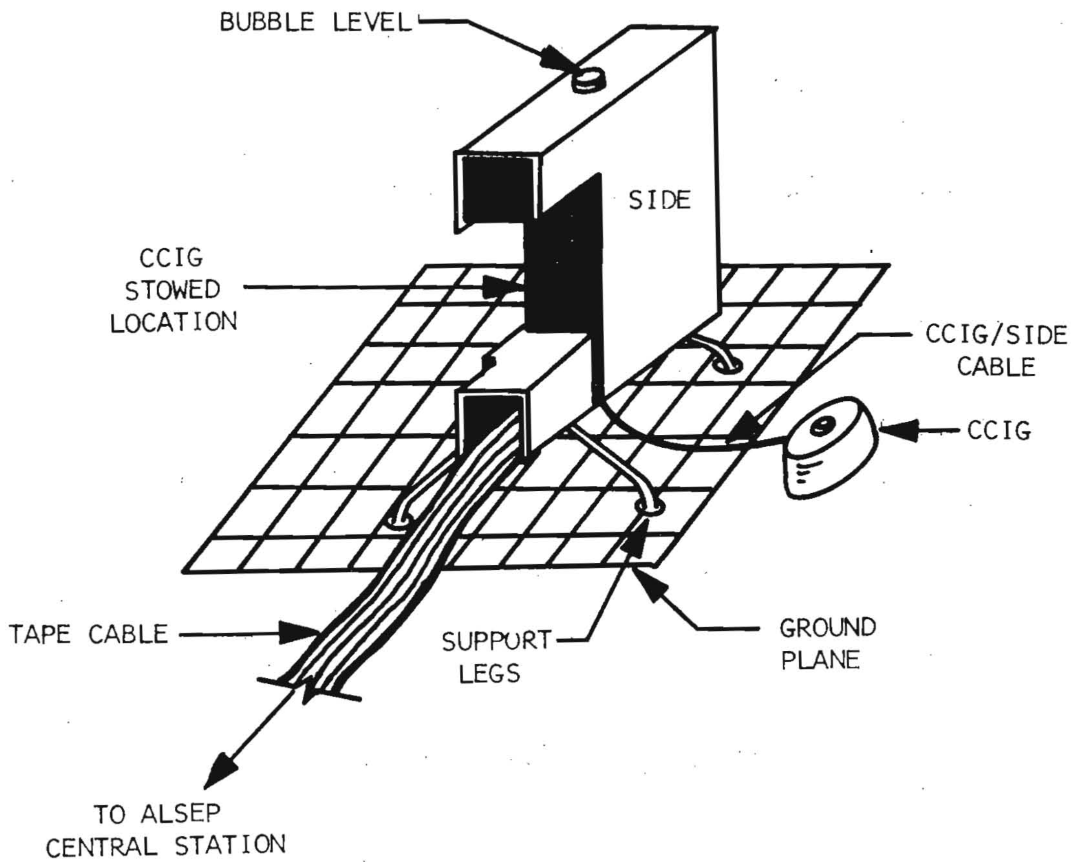

Figure 3-9.- Superthermal ion detector/cold cathode ion gage experiment (SIDE/CCIG).

*

removed by the astronaut and placed a few feet away from the SIDE. The ion gage produces an electrical current that is proportional to the measured pressure over the desired pressure range of 10^{-6} torr to 10^{-12} torr. The current is amplified and read out as experiment data. Prior to deployment, the CCIG is stored as part of the SIDE package.

3.3.2.4 Electrical power requirement.-

5 watts normal operating power

1.5 watts thermal control power

6.5 watts maximum operating power

3.3.2.5 Ground support systems.- See Section 6.

3.3.2.6 Experiment operation.-

3.3.2.7 Deployment.- See Section 4.

3.3.2.8 Crew safety implication.- The electrically charged ground plane is not expected to endanger the crew in any way. Also, the wire mesh from which the plane is constructed does not appear to have any jagged edges. Therefore, the chances of the astronaut ripping or tearing his spacesuit are minimal.

3.3.2.9 Real-time command/control.- See Section 6.

3.3.2.10 Telemetry requirements.- See Section 6.

3.3.2.11 Flight plan integration.- See Section 4.

3.3.2.12 Constraints.-

A. The SIDE should be located 55 feet ± 5 feet from the Central Station.

*

B. The entrance aperture should be leveled to ±5 degrees of the vertical and the side entrance aperture should be aligned to the E-W axis.

C. It should be placed as far as possible from the LSM. (At least 80 feet.)

D. Align the instrument with the aperture pointing away from a subearth point.

E. The CCIG must not point at any experiment, the sun, earth, or the LM.

3.3.2.13 Weight.- The weight of the SIDE/CCIG is approximately 12 pounds Earth weight.

3.3.2.14 Principal investigator for SIDE.-

Dr. John Freeman
Rice University

CCIG

Dr. Francis Johnson
Southwest Center for Advanced Studies

3.3.2.15 Modes of success.-

A. Design Requirements

Two energy levels and one velocity level and a pressure measurement.

B. Operational Constraints

Any one or more of the following:

1. Two or more energy levels
2. One energy level
3. Any velocity level
4. Pressure data only.

C. System Failure

No data at all.

*

3.3.3 Solar Wind Spectrometer (SWS)

3.3.3.1 Purpose.- The SWS will provide data pertaining to certain properties of the solar wind plasma as it exists at the lunar surface. This data should aid in determining the electromagnetic properties of the moon. The SWS should also give information as to whether or not the moon has retained an atmosphere. Reference Figure 3-10 and 3-11.

3.3.3.2 Experimental approach.- By the use of seven Faraday Cups (sensors), the SWS will measure the flux and energy of the positive ions and the electrons that strike the lunar surface and their variations with time and direction.

3.3.3.3 Experimental systems.- Measuring equipment for the SWS is composed of a total of seven sensor ports. Faraday Cups are used as the SWS sensors (reference Figure 3-11). These sensors measure the charged particle flux entering the cup by collecting the ions and using a very sensitive current amplifier to determine the resultant current flow. The energy per unit charge (E/Q) and polarity of the particles are determined by placing a retarding potential (v) upon a screen grid at the cup entrance and measuring the change in current (Δi) with a known change in retarding potential (ΔV). This current (Δi) is then, a result of the flux of particles which possess the proper polarity and are within the portion of the energy spectrum associated with voltages V and ($V + \Delta V$). Using a series of ΔV's, the entire range of voltage (both positive and negative) can be swept out to give a complete energy spectrum of the charged particles. Refer to Figure 3-10.

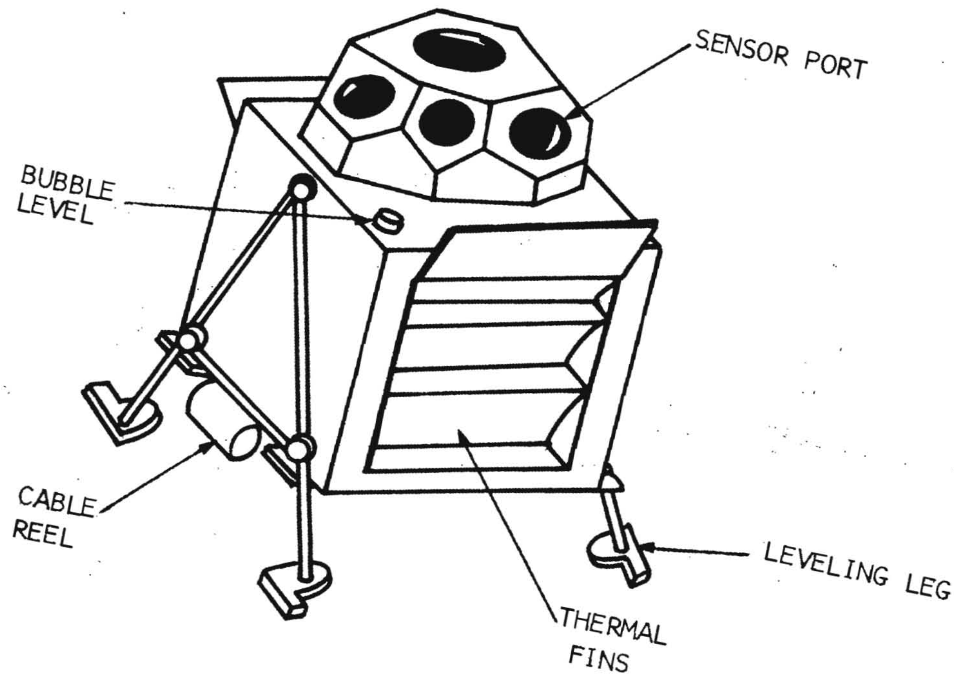

Figure 3-10.- Solar wind spectrometer (SWS)

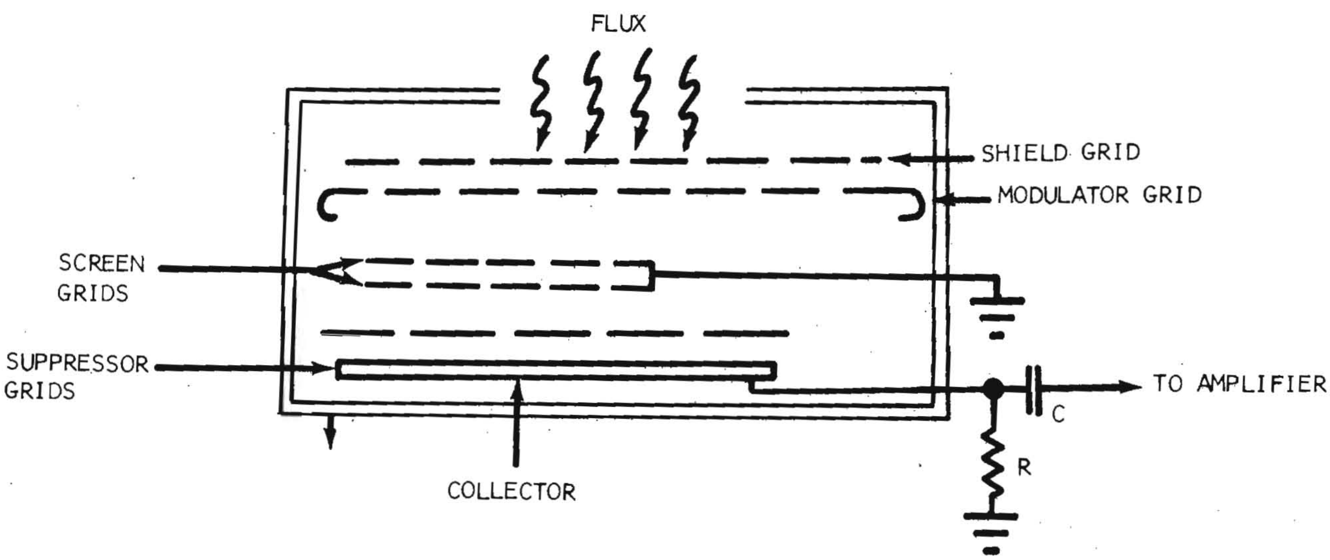

Figure 3-11.- SWS sensor.

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To be sensitive to solar wind plasma from any direction (above the horizon of the moon) and to otherwise ascertain its angular distribution, the SWS sensor is an array of seven Faraday Cups oriented so that one cup faces the vertical. The other six symmetrically surround this vertical cup so that the angle between the perpendicular of any two adjacent cups is approximately one radian. The integrated acceptance angle of all cups is 2π steradians. Each cup has a circular opening, five grids, and a circular collector. Reference Figure 3-10. Unidirectional solar wind will be detected by one to four cups, depending upon its incident angle.

In addition to the insulation and heating elements contained in the package for thermal control, the SWS utilizes metallic fins to control the heat dissipation from the SWS package to the lunar surface and to space.

3.3.3.4 Electrical power requirements.-

3.5 watts - normal operating power

3.5 watts - maximum thermal control power

7.0 watts - maximum operating power

3.3.3.5 Ground support system.- See Section 6.

3.3.3.6 Experiment operations.-

3.3.3.7 Deployment.- See Section 4.

3.3.3.8 Crew safety implication.- The experiment has a dust cover which is blown off by a small explosive charge after LM ascent. Inadvertent detonation of this charge is unlikely and should present no problem.

*

3.3.3.9 Real-time command/control.- See Section 4, 5, 6.

3.3.3.10 Command requirements.- See Section 6.

3.3.3.11 Telemetry requirements.- See Section 6.

3.3.3.12 Flight plan integration.- See Section 4.

3.3.3.13 Constraints.-

A. The SWS should be placed 13 ± 1 feet from the Central Station.

B. It should be leveled with ±5 degree of the vertical and aligned to within ±5 degree of the ecliptic plane.

C. No experiment should subtend an angle greater than 0.03 steradian at the SWS.

D. The SWS should be placed N or S (±10 degree) of the Central Station so when the experiment is aligned to the ecliptic, the Central Station is in an area of reduced sensitivity.

E. The SWS should be placed in a directional quarter opposite the RTG to insure a 2π steradian field of view.

F. The louvered side of the experiment must point N or S.

G. Dust covers cannot be removed before LM ascent.

H. Heaters must be on prior to lunar sunset.

3.3.3.14 Weight.- The Earth weight of the SWS is 10 pounds.

3.3.3.15 Principal investigator.-

Dr. Conway W. Snyder
Jet Propulsion Laboratory

*

3.3.3.16 Modes of success.-

A. Design Requirements

Ten voltages in four directions or fewer than ten voltages in five directions.

B. Operational Constraints

None

C. System Failure

Any information output less than full success

3.3.4 Passive Seismic Experiment (PSE)

3.3.4.1 Purpose.- The PSE will provide data pertaining to the seismic activities of the moon and to the physical properties of the lunar interior.

3.3.4.2 Experimental approach.- A long-period and short-period seismometer, incorporated into the same package, will be used to monitor both long-period (low frequency) and short-period (high frequency) energy associated with lunar quakes and meteroid impacts as well as measuring the direction and distance to the center of the seismic disturbance.

3.3.4.3 Experimental systems.- This experiment instrument consists of two parts mounted in the same package. Reference Figure 3-12. One is a 10-15 second long period, 3-axis, orthogonal seismometer used to monitor long-period (low frequency) seismic energy. Contained in the system are a vertical and two horizontal seismometers mounted on a platform.

Motion of the inertial mass of each seismometer is sensed by a variable capacitor displacement transducer which converts the motion into an electrical signal. This signal is amplified and filtered before appearing as an output. Before final

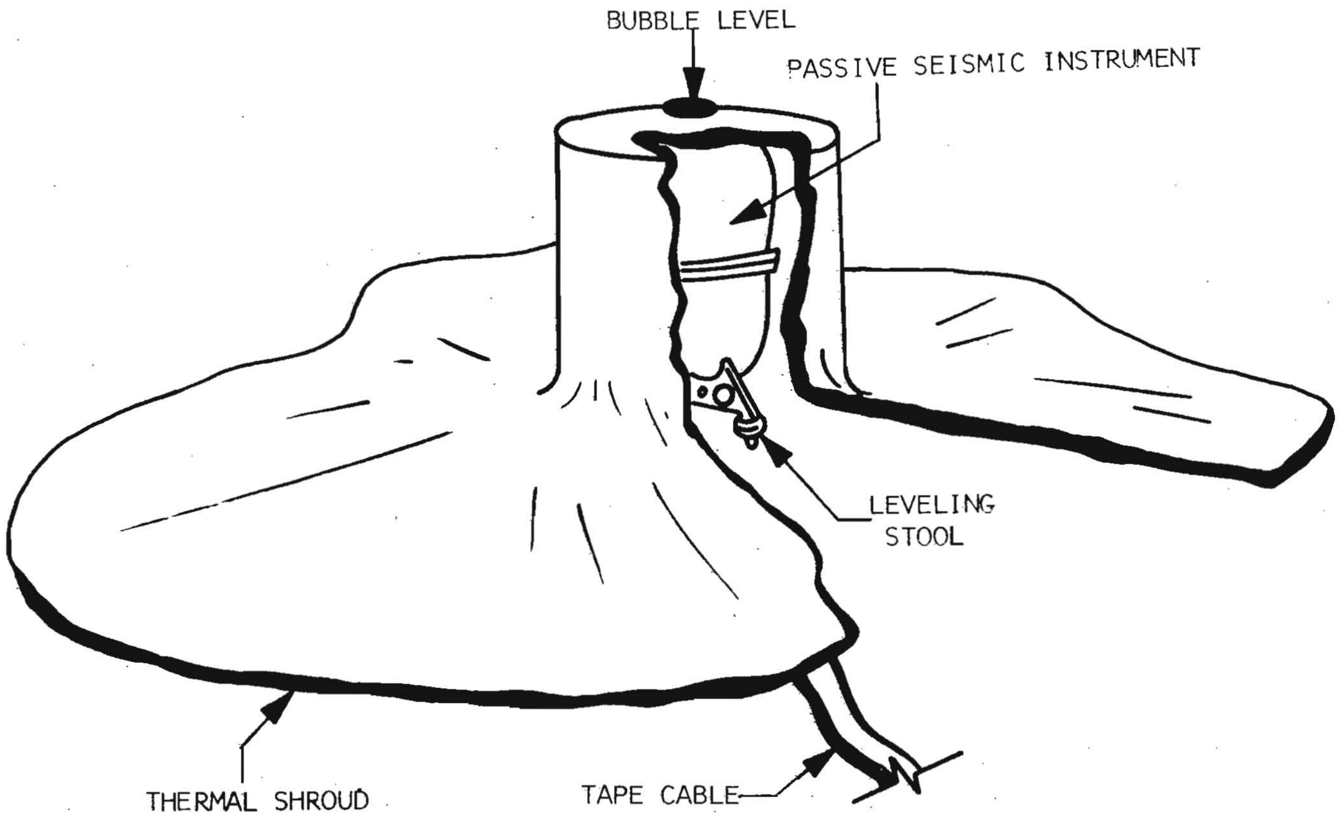

Figure 3-12.- Passive seismic experiment.

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amplification and filtering, however, a portion of the signal is fed back through a feedback filter to a coil and magnet assembly attached to the mass.

The short-period seismometer consists of a moving-magnet mass, circular flexures or delta rod suspensions with circular leaf springs, and an output coil. The magnet assembly serves as the mass in order to attain as heavy a mass as possible and yet keep the weight of the instrument to a minimum. The transducer of the short-period seismometer is a coil and magnet, producing an output proportional to velocity. A thermal shroud is placed around the instrument to minimize temperature fluctuations within the instrument. Caging of the seisomometer elements uses a pneumatic device, bled off by command.

3.3.4.4 Electrical power requirement.-

Operating Power - 7.5 watts

Thermal Control Power - 0.5 watts

Leveling Power - 3 watts

Peak Power - 10.5 watts

3.3.4.5 Command support system.-See Section 6.

3.3.4.6 Experiment operation.-

3.3.4.7 Deployment.- See Section 4.

3.3.4.8 Crew safety implication.- Unknown at this time, however, none are expected.

3.3.4.9 Real-time command/control.- See Sections 4, 5, 6.

3.3.4.10 Command requirements.- See Section 6.

*

3.3.4.11 Telemetry requirements.- See Section 6.

3.3.4.12 Flight plan integration.- See Section 4.

3.3.4.13 Constraints.-

A. The PSE should be deployed 11 ± 1 feet from the Central Station.

B. The instrument should be leveled to within ±5 degrees of the vertical and aligned within ±5 degrees of a predetermined azimuth.

C. The instrument should be deployed in a "quite" location. (No less than 10 feet from other subsystem and at least 15 feet from the RTG.)

3.3.4.14 Weight.- Earth weight of the PSE is 25 pounds.

3.3.4.15 Principal investigator.-

Dr. Gary Latham
Lamount Geological Observatory
Columbia University
Palisades, New York

3.3.4.16 Modes of success.-

A. Design Requirements

Data in three axes with thumper in a primary mode with long period seismic information in three axes and short period seismic information as a secondary mode.

B. Operational Constraints

Loss of the following:

1 of 3 long-period axes

Short-period sensor

1 or 2 long-period axes and short-period sensor

C. System Failure

No information available.

*

SECTION 4

ALSEP LUNAR DEPLOYMENT

4.1 GENERAL

One of the first scientific objectives to be accomplished by the astronauts after lunar landing is the deployment of the ALSEP. Refer to Figure 4-1 for a pictorial diagram of the ALSEP Flight Article #1 in the deployed mode.

The primary purpose of this section is to define MCC-H's actions during ALSEP deployment and to present constraints which will govern ALSEP deployment. No attempt is made to define crew procedures or functions since they will be presented in detail in the Apollo X Flight Plan prepared by the Flight Crew Support Division of the Flight Crew Operations Directorate.

Several assumptions were made in the writing of this section and they are as follows:

A. The decision to use one or both crew members to deploy the ALSEP had not been made at the time this document was prepared. Therefore, the lunar deployment section will be confined to sequences of events which will occur regardless of the number of crew members engaged in deployment.

B. The LM will remain on the lunar surface for a period of approximately 22 hours during which time two EVA's will be made by the astronauts.

C. Deployment of the ALSEP will occur on the first EVA. Geological exploration and sample collection will be conducted on the second EVA, however, "grab" samples will be collected by the astronauts during ALSEP deployment.

D. Prior to leaving the LM, the astronauts will determine the correct antenna pointing data by use of mathematical tables carried aboard the LM. These values will be checked and confirmed by MCC-H Flight Controllers.

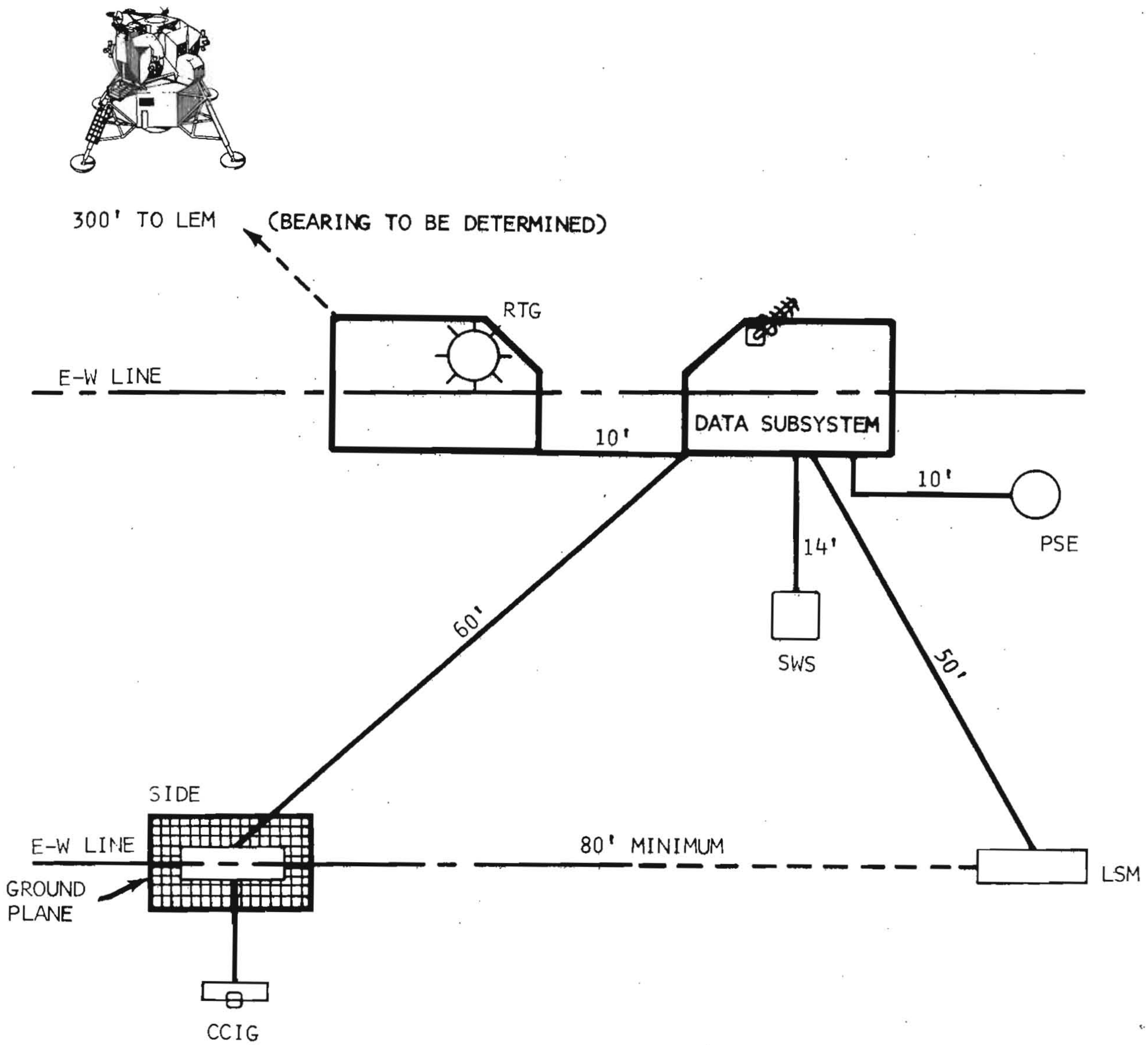

Figure 4-1.- ALSEP flight article #1 deployment.

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The astronauts will hand carry ALSEP to the deployment area 290-300 feet from the LM. This distance was selected to provide maximum protection to the experiments from shock, flying debris, and dust blown about by the ascent of the LM.

4.2 ALSEP FLIGHT ARTICLE #1 DEPLOYMENT

Astronaut(s) Action	MCC-H Action	Comments and/or Constraints
(Prior to ALSEP deployment, the astronauts will conduct a post-landing check of the LM, erect the S-Band antenna, and possibly gather a few samples of the lunar surface material)		
A. Remove the ALSEP subpackages from the LM Scientific Equipment Bay and reseal the compartments.	1. Monitor CSM, LM and space-suit telemetry.	1. The astronaut(s) must walk approximately 20 feet from the boarding platform to the LM Scientific Equipment Bay. 2. The Scientific Equipment Bay door is opened by "peeling" the Velcro attached soft thermal door from the opening. At present, the door is attached at the top and will open upward. Upon reaching the top position, the door will automatically lock in place. The door is constructed of a metal frame covered with Mylar fabric. 3. The astronaut(s) must exercise extreme caution when removing the ALSEP subpackages from their stowage compartments as he will be in close proximity to the fuel cask assembly. Should the astronaut(s) come in contact with the fuel cask, there is considerable danger that the PGA will be burned (cask temperature approaches 870°F) If the deployment is conducted by both astronauts, one of them will

(Continued)

*	Astronaut(s) Action	MCC-H Action	Comments and/or Constraints
			act as a safety monitor to insure that the other maintains sufficient clearance from the cask.
			4. The stowage compartment is resealed by lowering the door and applying pressure to the Velcro sealing material.
	B. Fuel the RTG		1. For a two-man deployment, the SIDE/CCIG, TDRT, EHT, and LGE would be removed from the RTG pallet before the RTG is fueled. Otherwise the equipment would not be removed until the astronaut reached the ALSEP deployment area some 300 feet from the LM.
			2. To fuel the RTG, the astronaut must first assemble the fuel handling tool. This is accomplished by inserting the TDRT into the hollow antenna mast and attaching a G.E. fuel capsule handling head to the other end of the TDRT. Then the fuel cask is rotated to an angle which will allow the astronaut to use the fuel capsule handling tool to unscrew the top of the cask and then withdraw the capsule from the cask. The capsule is then lowered into the RTG and the tool is rotated to lock the capsule in place. Once the RTG has been fueled, the astronaut should make every attempt to deploy it within 20 minutes as RTG thermal loads will have increased to a hazardous level after this time period.

(Continued)

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Astronaut(s) Action	MCC-H Action	Comments and/or Contraints
C. Assemble the ALSEP into the desired carry mode and transport it to the ALSEP deployment area some 300 feet from the LM. (Two rest periods will probably be taken by the crew during this traverse.)		1. For a two-man deployment, one astronaut will carry the SIDE, TDRT, EHT, and the LGE while the other astronaut carries the remainder of the system in either the primary "barbell" carry mode or the secondary "suitcase" carry mode.
		2. To assemble the ALSEP into the "barbell" carry mode, the ends of the antenna mast are inserted into apertures in the bottom of each subpackage and locked into place. The mast is removed from the subpackages after the traverse by use of a "trigger" mechanism located on the mast.
		3. If the ALSEP is deployed by one man, the ALSEP will probably be deployed on a bearing directly out from the LM's Z-axis so that the astronaut will always be in view of the other astronaut in the LM. For a two-man deployment, this constraint will not exist and the ALSEP may be deployed out any bearing from the LM.
		4. The ALSEP deployment area is located approximately 300 feet from the LM. This distance will either be estimated by the crew or will be found by use of a small sight ring. (When the LM "fills" the sight ring, the correct distant will have been reached.)
D. Place subpackages on the lunar surface and remove experiments from both pallets. Connect RTG power cable to the Central Station and align the RTG and Central	1. Begin checking out the ALSEP subsystems and experiments as soon as possible.	1. The experiments are removed by using the TDRT to unfasten CALFAX retaining fasteners which hold the experiments to the pallets. The EHT is then used to lift the experiments from the pallets and

(Continued)

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Astronaut(s) Action	MCC-H Action	Comments and/or Constraints
Station pallets parallel to the East-West line.	2. This will minimize the crew non-activity time for the astronaut(s) while waiting for MCC-H to complete its functions. 3. Send and verify execution of DSS turn-on command by reception of RF signal from ALSEP. 4. Start data recorders.	place them on the lunar surface. 2. It is presently planned to have the astronaut read to MCC-H via voice link the value indicated on a power cable ammeter prior to connecting the cable to the Central Station to check that current is flowing. 3. There is a good possibility that the RTG will not be up to operational power at the time the power cable is connected to the Central Station, however, operational power should be reached before the ALSEP is fully deployed by the astronaut(s). 4. Reference Figure 4.1 for a diagram of the ALSEP in the deployed mode.
E. Deploy the ALSEP experiments. (No attempt is made here to define the order or sequence of experiment deployment since the sequence of events will differ depending on whether or not the ALSEP is deployed by one or both astronauts. For a detailed sequence of events, reference the AS-XXX Flight Plan.) Deployment distances will be estimated by the crew. 1. Passive Seismic Experiment deployment. 2. Lunar Surface Magnetometer deployment.	1. Advise astronaut via voice link that ALSEP transmitter is functioning. (From this point until experiments are deployed, the activities of MCC-H and the astronaut are independent.) 2. Check clock rate of downlink telemetry. Proceed to Step 6. 3. If no data rate is indicated, send command to turn Active Seismic mode off.	1. General Deployment Constraints - Care must be taken in deployment not to exert much pressure on the cables connecting the experiments to the Central Station as very little force is needed to topple the Central Station, especially after it has been erected. 2. PSE Deployment Constraints - a. The PSE should be deployed 11 ± 1 feet from the Central Station at a bearing of 345 degress. b. It should be placed at least 15 feet from the RTG. c. It should be leveled ±5 degrees of the vertical and aligned to ±5 degrees of a predetermined azimuth. (The instrument is bidirectional.)

(Continued)

Astronaut(s) Action

3. Deploy Central Station and align the antenna. If antenna mechanism is incapable of adjustment, see Contingency Procedure #1.

4. Solar Wind Spectrometer Experiment deployment.

5. Superthermal Ion Detector and Cold Cathode Ion Gage Experiment deployment.

MCC-H Action

4. Verify transmission of 1060 bps telemetry.

5. Check signal/noise ratio as received at MSFN.

6. If marginal, initiate Slow Data Rate command.

7. Verify that system is operating on PCU Power Oscillator #1.

8. Check PCU temperature.

9. Check PCU operating parameters.

Comments and/or Constraints

d. Since the instrument requires as quiet a location as possible, it should be placed at least 10 feet from other experiments.

3. General Information on Deployment -
   a. Leveling is accomplished by rotating the instrument within its yoke-shaped support leg assembly.
   b. A thermal shroud is folded around the PSE until it is deployed. Deployment of the shroud consists of slipping the TDRT through preformed holes in the shroud, pulling the shroud down and away, and spreading it over the lunar surface. It's function is to minimize temperature fluctuations within the instrument.

4. LSM Deployment Constraints -
   a. The LSM should be deployed 50 feet from the Central Station at a bearing of 225 degrees.
   b. It should be placed as far as possible from the RTG and other ALSEP experiments.
   c. It should be leveled ± 3 degrees of the vertical and aligned with the long axis of the sunshade E-W. Final E-W alignment (± 1 degrees) will be reported to MCC-H via voice link.
   d. Shadow indication must be within tolerance limit lines on the shadowgraph.
   e. The site must be as flat and free from minor rocks, craters or depressions, sand, and dust as possible. Care must be exercised not to raise sand or dust which might settle on the instrument.
   f. No leg must rest on a raised portion of the surface or within a depression or crevice.

(Continued)

Astronaut(s) Action

MCC-H Action

10. If either the temperature of Step 8 or the parameters of Step 9 are out-of-limits, switch to secondary PCU and shunt regulator current and voltages.

11. If telemetry indicates the need for adjustment of the dc load, the necessary control can be accomplished by switching power dumps in or out through use of appropriate commands.

12. Monitor telemetry for temperature of Transmitter A crystal and heat sink, respectively.

Comments and/or Constraints

5. General Information -
   a. The function of the shadowgraph is to align the instrument parallel to the ecliptic plane. If the shadowgraph is damaged, there is no way the astronaut can properly orientate the LSM.
   b. The instrument is leveled by means of leveling screws and a bubble level.

6. Central Station Constraints -
   a. The antenna aiming mechanism must be leveled before the shadow null position is set.
   b. The mechanism must be set in elevation before being set in azimuth.

7. General Information -
   a. The mechanism is leveled by use of two adjusting screws and a bubble level.
   b. The antenna is aligned to the ecliptic plane by use of a shadowgraph.
   c. Pointing data for the antenna will be determined by the astronauts prior to leaving the LM and backed up by MCC-H flight controllers.

8. SWS Experiment Deployment Constraints -
   a. Deploy the SWS 13 ± 1 feet from the Central Station.
   b. Level the instrument ±5 degrees of the vertical and align ±5 degrees of the ecliptic plane. (The instrument is bidirectional).
   c. Deploy opposite the RTG to insure a 2π steradian field of view.
   d. No subsystem should subtend an angle greater than 0.03 steradian on the SWS, therefore it should be deployed approximately N or S (±10 degrees) of the Central Station so when the SWS is aligned to the ecliptic, the Central Station is in an area of reduced sensitivity.

(Continued)

Astronaut(s) Action	MCC-H Action	Comments and/or Constraints
	13. Monitor telemetry for RF output power and RF level of second PA, respectively. If either the temperature or power levels are outside limits, switch to backup transmitter. Check temperature and RF levels as in Steps 12 and 13. 14. Check telemetry channels for pertinent temperature measurements:	e. The louvered side of the instrument must point N or S. SIDE/CCIG 9. Deployment Constraints – a. Deploy 55 ± 5 feet from the Central Station. b. Level entrance aperture of SIDE to ±5 degrees vertical and align wide-entrance aperture of SIDE to E-W axis. (The instrument is not bidirectional.) Align with apertures pointing away from a subearth point. The CCIG aperture must point away from all experiments, the sun, the earth, and the LM. c. The SIDE/CCIG package should be placed at least 100 feet away from the LSM. 10. General Information – a. Prior to deployment the CCIG is stored as part of the SIDE package. It is removed and placed on the lunar surface approximately 5 feet away from the SIDE (just off the SIDE's ground screen.) b. The purpose of the SIDE ground screen is to overcome electrical fields that may be present at the lunar surface. This is done by the SIDE electronics applying a known potential to the screen. Failure of the screen will not constitute failure of the experiment or render it useless, however, it will affect the experimental data to some extent as yet undefined. c. The CCIG electronics are contained in the SIDE package.

(Continued)

Astronaut(s) Action	MCC-H Action	Comments and/or Constraints
	15. If necessary, turn Central Station Backup heater ON or OFF by initiation and verification of appropriate commands.	
	16. Check level of received power at MSFN station and compare against theoretical.	
	17. With ground transmitter radiating at rated power level, monitor telemetry for prelimiting signal level of command receiver.	
	18. Determine and record the center frequency of the ALSEP receiver pass band.	
	19. Monitor telemetry for RF level of ALSEP receiver local oscillator.	
	20. Check for indication of availability at the command decoder of 1 KH_z when it is transmitted from the ground.	

(Continued)

Astronauts(s)	MCC-H Action	Comments and/or Constraints
	21. Check telemetry for cell voltages of Dust Detector.	
F. Request MCC-H to activate the ALSEP. Standby Central Station until MCC-H has checked out the system.	1. Acknowledge astronaut's request for experiment turn on via voice link 2. Initiate command to turn Experiment 2 Power ON. 3. Verify reception of command. 4. Check telemetry to confirm power load and reserve power status. 5. Initiate, and verify reception and execution of Experiment 1 Power ON. 6. Check power status as in Step 5 above. 7. Initiate, and verify reception and execution of Experiment 4 Power ON. 8. Check power status as in Step 5 above. 9. Initiate, and verify reception and execution Experiment 3 Power ON. 10. Check power status as in Step 4 above.	

(Continued)

Astronaut(s) Action	MCC-H Action	Comments and/or Constraints
	11. If sufficient reserve power is available, initiate, and verify reception of Command to activate Dust Detector.	
	12. Check power status as in Step 5 above.	
	13. Check SIDE and SWS scientific data and compare against ground test results.	
	14. Advise astronaut via voice link that experiments have been turned on.	
G. Return to LM gathering geological samples.		

(Concluded)

4.3 FLIGHT ARTICLE #1 CONTINGENCY PROCEDURES

Procedure Number	Event	Astronaut Activity	MCC-H Activity
1	Emergency Alignment of Antenna	A. Point antenna in general direction of Earth, using remaining adjustments; tilt Central Station, if necessary, to point antenna.	1. Proceed with normal turn on of transmitter. 2. Monitor level of signal received at MSFN.
		B. Adjust antenna pointing angle in small increments, stepping back after each adjustment to avoid distortion of antenna beam pattern.	1. Advise astronaut regarding results of each adjustment until optimum pointing is achieved. 2. Determine current libration position and advise astronaut to offset slightly to improve long-term performance.
		C. Perform required offsets under MCC-H direction.	
2	Backup Turn on of ALSEP Transmitter	A. Actuate ALSEP Backup Switch #2 with following functions: 1. Select Transmitter B 2. Turn on Transmitter 3. Reset Receiver Circuit Breaker 4. Select and turn on Data Processor Y.	1. Select Tx "B". 2. If no response advise astronaut via voice link to turn on transmitter.

Procedure Number	Event	Astronaut Activity	MCC-H Activity
2 Continued		B. Advise MCC-H via voice link that backup switch #2 has been actuated.	
			1. Acknowledge backup switch #2 actuation via voice link. 2. Verify turn on of transmitter by reception of RF signal from ALSEP. 3. Advise astronaut via voice link whether transmitter is functioning.
		C. Acknowledge MCC-H transmitter message via voice link. D. If transmitter is not functioning actuate ALSEP Backup Switch #1, permitting PCU to operate on marginal voltage output of RTG.	
3	Backup Turn on of experiments	A. Actuate Backup switch #3, energizing all experiments, sequentially. B. Advise MCC-H via voice link that switch #3 has been actuated.	1. Reinitiate normal transmitter turn on sequence.
			1. Acknowledge astronaut's switch #3 actuation via voice link. 2. Confirm power turn on by telemetry indication. 3. Advise astronaut via voice link that all experiments have been turned on.
		C. Acknowledge turn on message via voice link and return to LM.	

Procedure Number	Event	Astronaut Activity	MCC-H Activity
4	Turn on of Dust Detector		1. Initiate and verify reception and execution of Experiment 4 Power STANDBY command. 2. Proceed with normal Dust Detector turn on sequence.

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SECTION 5

ONE YEAR TIMELINE

5.1 GENERAL

The ALSEP is designed to function on the lunar surface for a period of one year. During this period of time, ALSEP operations will be monitored and commanded from the MCC-H. The requirements for MCC-H activity may be divided into four time periods within the one year:

A. Initial Checkout - This is the period between LM departure from the lunar surface until the ALSEP is completely activated, systems are checked out, and baseline data is taken. It is expected that initial checkout will require approximately 20 hours. Initial checkout procedures probably will not commence until the CSM has been safely injected into a transearth orbit.

B. First 45 days of operation - During this period the requirement has been placed on MCC-H to monitor continuously ALSEP data. The purpose of this 45-day continuous data monitoring is to develop confidence in the ALSEP system and to make whatever adjustments in the system that become necessary. In addition, this time period will include the onset of both lunar sunrise and sunset and the associated operations of the ALSEP thermal control system connected with the change in lunar surface temperature.

C. ALSEP operation between the first 45 days and the end of the one-year period - During this period ALSEP data will be monitored twice per day at MCC-H. This requirement is presently under review and may change by the time of the first ALSEP mission.

D. ALSEP turnoff during the thirteenth month of operation

E. General Notes on ALSEP Operations -

   1. The reserve power status must always be observed before initiation of any command which results in an increase of operating power. If inadequate reserve power is

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available to accommodate the increase, the lowest priority experiment must be placed on STANDBY to release additional power. The automatic timer will restore this experiment to ON at 12-hour intervals after 4 days and 7 minutes. This action must be anticipated during ALSEP operations.

2. The LSM must be kept ON continuously as it has no STANDBY provisions and might suffer damage from temperature excursions if its power is interrupted.
3. It is not possible to "flip" the LSM sensors during the period of lunar night without rippling off an experiment to release additional power.

In addition to the four time periods given, additional call-up activity will be required during periods of unusual inter-planetary activity (solar flares, large moonquakes, etc.) and periods of lunar sunrise/sunset.

The remaining portions of this section will present a one year timeline for ALSEP Flight Article #1 Operations and Lunar Sun-rise/Sunset Operations. Decisions concerning periods of inter-planetary activity will be made real time on an "as required" basis.

It should be noted that the information in this section is not to be used for planning purposes but rather to give some indi-cation of the work load that might exist. Detailed procedures for systems operation will be prepared by the Experiments Systems Branch.

5.2 FROM LM DEPARTURE THROUGH INITIAL EXPERIMENT CHECKOUT

Event	MCC-H Activity
A. Initial Checkout of Passive Seismic Experiment	1. Spot check telemetry transmission of Passive Seimsmic Scientific Data as follows:

<u>Parameter</u>

Long Period X-Axis
Long Period Y-Axis
Long Period Z-Axis
Long Period X-Axis, Tidal
Long Period Y-Axis, Tidal
Long Period Z-Axis, Tidal
Instrument Temperature
Short Period

2. Spot check engineering data as shown below:

<u>Parameter</u>

Long Period X & Y Amplifier Gain
Long Period Z Amplifier Gain
Level Direction and Speed
Short Period Amplifier

Event	MCC-H Activity
	Parameter Leveling Mode and Coarse Sensor Mode Thermal Control Status Calibration Status (LP and SP) Uncage Status
B. Leveling of Passive Seismometer	1. Initiate and verify Command to uncage instruments. 2. Confirm uncaging by change of telemetry of scientific data per Step 1 of Event A above, and status indication on telemetry. 3. Verify that Feedback Filter is switched OUT (preset position) by comparing LP Seismic and LP Tidal Data. 4. Check status of Coarse Level Sensor. If OUT (preset position) switch IN by execution of appropriate command. 5. Verify that Leveling Mode is in AUTO (preset position) by checking telemetry. 6. Initiate and verify Commands to place Experiments 3 and 4 Power STANDBY.

Event	MCC-H Activity
	7. Verify execution of commands.
	8. Execute Command for Leveling Power X Motor ON.
	9. Monitor Long Period, Tidal, X-Axis data as in Step 1 of Event A above as leveling progresses.
	10. When leveling stops, switch Leveling Power to X Motor OFF.
	11. Repeat Steps 8-10 for Y- and Z-Axes, respectively.
	12. Switch Coarse Sensor OUT and verify mode change.
	13. Repeat Steps 8-10 for each of the 3 axes to accomplish fine leveling.
	14. Switch Feedback Filter IN.
C. Calibration of Passive Seismometer	1. Initiate and verify Calibration SP and check mode change.
	2. Monitor SP data as in Step 1 of Event A above.
	3. Terminate SP Calibration and check mode change.
	4. Initiate and verify Command to calibrate LP and check mode change.
	5. Monitor LP data as in Step 1 of Event A above.
	6. Terminate LP calibration.
D. Thermal Check of Passive Seismometer	1. Check instrument.

Event	MCC-H Activity
	2. Compare against value obtained in Step 1 of Event A above, noting effects of subsystem operation **NOTE** If necessary, bypass subsystem automatic thermal control.
	3. Continue to monitor temperature and execute commands as required to keep within limits.
E. Collection of Baseline Passive Seismic Data	1. Record data, without further transmission of commands, for determination of background noise level, frequency, and magnitude of detectable seismic events.
F. Initial Checkout of Magnetometer	1. Display and check following telemetered engineering data: Parameter X sensor temperature Y sensor temperature Z sensor temperature Level sensor Level sensor DC Supply Voltage Gimbal Flip Unit Base Temp. Internal

Event

MCC-H Activity

Parameter

Electronics
Temperature
Sensitivity
Range
X Flip Position
Y Flip Position
Z Flip Position
X Gimbal Position
Y Gimbal Position
Z Gimbal Position
Thermal Control
Address
X-Axis Field
Offset

Y-Axis Field
Offset

Z-Axis Field
Offset

Calibration Mode
Offset Ratchet
Address
Filter Status
Calibrate Inhibit
Status

2. Display and check Scientific Data outputs of three magnetic field sensors.

Parameter

X sensor
output

Event	MCC-H Activity
	Parameter Y sensor output Z sensor **NOTE** If telemetry indicates no sensor output, (or erratic output) by-pass the Data Filter.
G. Sensitivity Range Adjustment of Magnetometer	1. If Scientific Data outputs of Event F are low switch amplifiers from 400-gamma to 200-gamma range. 2. Display and check telemetered range status to verify switching from 400-gamma to 200-gamma range. 3. Display and check sensor outputs as in Event F above. 4. If further sensitivity is required switch to 100-gamma range. 5. Check telemetry for confirmation of switching.

Event	MCC-H Activity
H. Flip/ Calibration of Magnetometer	1. Check telemetry for status of calibration inhibit gate. 2. If necessary, remove inhibit by initiation and verification of appropriate command. 3. Check telemetry for removal of inhibit. 4. Initiate and verify Flip/Calibrate Initiate command.

NOTE

Check PSE Scientific Data during flip period for cross-talk and detection of motion.

5. Display and check telemetry indication for turn ON of calibration electronics package.
6. Display and check sensor outputs, as in Event F above, during automatic calibration cycle.
7. During "Flip/Calibrate" period, also check following telemetered parameters.

   Parameter

   X Flip Position
   Y Flip Position
   Z Flip Position

8. Check telemetry for subsystem temperatures as in Event F above, noting effect of Flip/Calibrate operation.

NOTE

If sensor Temperatures indicate malfunction of the thermal control, the backup control can be substituted by transmission of appropriate command. Check telemetry for change of thermal control address.

Event	MCC-H Activity
I. Collection of Magnetometer Baseline Data	1. Record data, without further transmission of Commands, to establish background magnetometer data.
J. Initial Checkout of SWS	1. Initiate and verify command for Experiment 3 Power ON. Check status. 2. Confirm proper functioning of SWS telemetry by checking A/D converter calibration voltages. 3. Display SWS Scientific Data and verify performance by comparing against ground test results. 4. Initiate and verify command to remove Dust Cover. NOTE Check PSE Scientific Data for detection of removal operation. 5. Verify removal of dust cover by noting change of Scientific Data in SWS telemetry.
K. Thermal Check of SWS	1. Monitor temperature sensor telemetry and verify that temperatures have stabilized.
L. Collection of Baseline SWS Data	1. Record data without further transmission of commands to establish background noise level and frequency and magnitude of plasma current peaks.
M. Flip/Calibration of Magnetometer	1. Repeat steps of Event H above.
N. Initial Checkout of SIDE	1. Initiate and verify commands for Experiments 1 and 3 Power STANDBY.

Event	MCC-H Activity
	2. Confirm Power status by checking telemetry. 3. Initiate and verify command to turn Experiment 4 Power ON. 4. Confirm status. 5. Check SIDE frame counter telemetry. 6. Check the following engineering data parameters: MEASUREMENT +5v Temp #1

Event	MCC-H Activity
	Temp #2 Temp #3 +4.5Kv (CCIG) Temp #4 Temp #5 +60v +30v +12v -5v -30v Temp #6 -3.5Kv (Channeltron) +1.0v +30mv Cal +12v Cal -A/D Ref Voltage 0v Ground Plane Voltage +A/D Ref Voltage -30 mv Cal -1.0v Cal -12v Cal
N.	7. Check functioning of the following status indications: Parameter CCIG Range Pre-regulator Duty Factor Solar Cell
	8. Check functioning of CCIG calibration sequence: Parameter Electrical zero, uncorrected

Event | MCC-H Activity

Parameter

Electrical zero, partially corrected
Electrical zero, corrected
Toward cal Current #1
Cal Current #1
Toward cal Current #2
Cal Current #2

9. Check the following status parameters.

Parameter

Ground Plane Step
Dust Cover & Seal
Mode Register
Electrometer Range

10. Check Scientific Data telemetry against results of ground tests as follows:

Measurement

HE. CPS Voltage
HE. Data
Velocity filter voltage
LE CPA Voltage
LE Data

11. Check analog telemetry against data of Step 10:

LE Count Rate
HE. Count Rate

Event MCC-H Activity

12. Initiate and verify Master Reset Command.

NOTE

When this command is executed for the first time, it also removes the SIDE dust cover.

13. Check command Input Register Telemetry for proper decoding of command.
14. Execute command, removing dust cover.

NOTE

Subsequent to this step, whenever SIDE operation is critical, carefully monitor PCU switching status by observing Shunt Regulator Current #1 or #2. Switchover of the PCU, either by command or automatically, will result in momentary loss of the +5 volt supply; this, in turn, results in resetting of the Delayed Command Sequencer and repetition, 96 hours later, of the Remove Dust Cover and Break CCIG Seal commands, with their associated mode switching within the experiment. If adequate reserve power is not available, the excessive power demand of the SIDE Dust Cover Blow circuitry may cause the automatic turnoff of the experiment. SIDE operation should, thus, always be checked 96 hours after a known excessive power demand, whether PCU is switched or not.

15. Check Status Telemetry as in Step 9 above for confirmation of dust cover removal.
16. Initiate and verify command to turn Experiment 1 Power ON. Check Status.

Event	MCC-H Activity
O. Thermal Check of SIDE	1. Repeat temperature measurements of Event N, and verify that temperatures have stabilized.
P. Calibration of SIDE	1. Initiate and verify command for Force Continuous Calibration. 2. Check CIR telemetry, as in Step 13 of Event N, for proper decoding of command. 3. Execute command. 4. Print out (or display) and check telemetry for SIDE. Parameter Calibration Rates Velocity Filter Voltage Step High-Energy Curved Plate Analyzer Voltage Low-Energy Curved Plate Analyzer Voltage Low-Energy Data High-Energy Data 5. Conclude calibration by initiation, verification, and execution of Master Reset Command.
Q. Collection of Baseline SIDE Data	1. Record data, without further transmission of commands, to establish background noise levels and frequency and magnitude of sporadic plasma currents.
R. Flip/Calibration of Magnetometer	1. Repeat steps of Event H above.
S. Initial Checkout of CCG	1. Initiate, verify and execute command for SIDE Frame Counter to reset automatically at each count of ten and breaking seal on

Event	MCC-H Activity
	NOTE Check PSE Scientific Data for evidence of seal break.
	2. Check telemetry for confirmation of short cycle mode. 3. Check telemetry for confirmation of seal rupture. 4. Check CCG Scientific Data.
T. Collection of Baseline CCG Data	1. Record data, without further transmission of commands, for one hour to establish background noise level, and frequency and magnitude of sporadic plasma currents. 2. Terminate CCG data collection period by initiation, verification, and execution of Master Reset command.
U. Flip/Calibration of Magnetometer	1. Check magnetometer sensor temperatures, as in Event F above, continuously for one hour. If variations in any one temperature do not exceed 3°C, proceed to Step 2. Otherwise continue to monitor temperatures until stabilization is confirmed. 2. Repeat steps of Event H above.
V. Site Survey with Magnetometer	1. Initiate and verify Site Survey command. 2. Display and check Flip Position Parameters, as in Event H above, during survey. 3. Display and check Gimbal Position Telemetry during survey. **Parameter** X Gimbal Y Gimbal Z Gimbal 4. Display sensor Outputs as in Event F above.

Event | MCC-H Activity

NOTE

Check PSE Scientific Data during Site Survey for evidence of mechanical operation.

5. Repeat Steps 1 - 4 for each of the other two axes.
6. Initiate and verify Experiment 3 Power ON Command.

NOTE

In the event of complete loss of the uplink, the ALSEP backup timer automatically:

a. Resets receiver circuit breaker, every 12 hours.
b. Breaks seal on CCG at 4 days plus 3 minutes.
c. Removes dust covers from SWS and SIDE after delays of 4 days, plus 4 and 5 minutes, respectively.
d. Initiates Flip/Calibrate Magnetometer sequence every 12 hours after 108 hours (one minute after receiver reset). Site Survey is then automatically initiated after fourth Flip/Calibrate.

W. Check Dust Detector

1. Check the following parameters:
   a. Cell voltages
   b. Temperatures
2. Compare results against those obtained in Phase I.

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5.3 FROM INITIAL CHECKOUT THROUGH 45th DAY (ALSEP Systems Engineer Activities)

MCC-H Activity	Frequency
Monitor telemetry and compare against limits.	Continually
Check Magnetometer sensor temperatures: a. X Sensor b. Y Sensor c. Z Sensor	Once per hour
If the temperatures of Step 2 has changed more than 3°C since the last Flip/Calibration, perform the following routine: a. Initiate and verify Flip/Calibrate Initiate Command. b. Monitor sensor outputs: X-Axis Y-Axis Z-Axis c. Monitor Experiment Power Status during Flip/Calibrate. If any experiments were switched to STANDBY, restore to ON by appropriate command.	As required
Check Magnetometer level: Gravity Sensor #1 Gravity Sensor #2	
Report overall status to EAO	Once per day
Check Passive Seismic Scientific Data per Step 1 or Event H, Section 5.2.	Continually

NOTE

If Tidal Data indicates instrument has shifted off level, relevel per Event B of Section 5.2.

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MCC-H Activity	Frequency
Check SIDE Engineering Data and compare against limits.	Continually

NOTE

SIDE dust cover will be removed and CCG seal broken by ALSEP Delayed Command Sequencer at approximately 96 hours after ALSEP activation, if these functions have not already been accomplished by ground command. The experiment is susceptible to mode switching associated with these commands. Interruption of +5 volt supply, for example, by switching PCU's causes DCS to reset and repeat commands 96 hours after reset. Thus, during this phase, SIDE operation must always be checked 96 hours after a known excessive power demand.

Check HE. and LE SIDE data alternately for one-hour periods.	Continually
Check SWS temperatures and calibration voltages.	Continually
Check Dust Detector per Event W of Section 5.2.	Once per week

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5.4 FROM 46th DAY TO END OF FIRST YEAR (ALSEP Systems Engineer Activities)

MCC-H Activity	Frequency
Monitor telemetry and compare against limits.	Twice per day
Check SIDE Engeering Data and compare against limits.	Twice per day
Check HE. and LE SIDE data alternately for one-hour periods.	Each, one hour per day
Check SWS temperatures and calibration voltages.	Twice per day
Check Passive Seismic Scientific Data per Step 1 of Event A, Section 5.2.	Twice per day

NOTE

If Tidal Data, indicate that instrument has shifted off level, relevel Passive Seismometer per Event B of Section 5.2.

Check Dust Detector per Event W of Section 5.2.	Once per week
Report overall status to EAO.	Once per day

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5.5 THIRTEENTH MONTH OF ALSEP LIFE (ALSEP Systems Engineer Activities)

MSFN Activity	Frequency
Check for presence of RF signal from ALSEP	Once per day
At the end of thirteeth month, if ALSEP transmitter is still functioning, that is, automatic timer has not shut down the transmitter, initiate command to turn transmitter off. Execution of command is indicated by loss of ALSEP RF carrier at MSFN station.	

NOTE

The decision to turn the ALSEP transmitter off will be made real time. It is possible to continue operations if the gathering of additional data is deemed necessary.

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5.6 SPECIAL PROCEDURES

During periods of lunar sunrise/sunset and/or lunar eclipses, MCC-H must monitor closely all TM temperature for the ALSEP. As lunar sunrise approaches, an increase in ALSEP temperature should be noticed. MCC-H will then send commands to turn ALSEP heaters off. As lunar sunset approaches, a decrease in ALSEP temperature should appear on the TM. At this time, MCC-H will send commands to turn ALSEP heaters on. It is expected that the time required to adapt ALSEP to lunar day/night operations will require approximately 24 hours with the last 12-15 hours being the most critical period of time.

At the present time, the periods of MCC-H MOCR manning and procedures for ALSEP failure to execute commands has not been defined. However, these procedures will be contained in the Apollo X Mission Rules and will be complied by the Flight Control Operations Branch of the Flight Control Division.

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SECTION 6

MSFN REQUIREMENTS

6.1 GENERAL

ALSEP communications consists of an earth-moon command link for control of post deployment functions and a moon-earth telemetry link for transmission of scientific and engineering (housekeeping) data. The data from individual experiments will be combined into a single telemetry link by the ALSEP Data Subsystem and then transmitted to the MSFN. The MSFN will receive and record all telemetry data. All pertinent engineering and scientific parameters will be "through-putted" for real-time analysis at MCC-H during continuous data periods or during tape playback.

Data recorded at the MSFN sites will be sent to MSC (CAAD) for decommutation and reduction. The data tapes at the MSFN sites should contain up to four channels of data: one channel will contain timing information put on at the MSFN site, and the other channels will contain the data from ALSEP 1, 2, and 3, respectively.

Three ALSEP missions are planned, and eventually three separate systems will be operating on the moon simultaneously. The telemetry links of each ALSEP will operate at a different frequency (2276.5, 2278.5 and 2275.5 MH_z or mc). The format of commands is such that each ALSEP can be addressed specifically.

6.2 MSFN SUPPORT REQUIREMENTS

Generally, the MSFN will be required to receive ALSEP data, record the data, and transmit it to MCC-H for analysis.

Specifically, the MSFN will:

A. Provide continuous acquisition of telemetry data from three separate ALSEP's for up to two years following activation of each ALSEP.

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B. The MSFN will record all ALSEP data received.

C. Simultaneously bulk record up to three channels of telemetry data and record on each tape the GMT (in year, month, day, hour, minute, and second) of data received by a site.

D. Provide the capability to play back the recorded telemetry data, along with its GMT of receipt through the PSDP for transmission to MCC-H.

E. Provide data processing, display, and recording at MCC-H for ALSEP data from remoted sites. The present RTCC work load and scheduling problems indicate that an additional computer may be necessary to support the ALSEP. All implications are that the RTCC work load will be greatly increased by the time of the ALSEP mission. No MSFN station will be required to support an ALSEP and a space vehicle simultaneously.

F. During ALSEP control and display periods at MCC-H, provide data streams from two active ALSEP's, or full data stream from one active ALSEP along with selected data from a maximum of two additional ALSEP's.

6.3 SITES REQUIRED

Certain stations of the MSFN have been recommended to support ALSEP; primarily due to the orbit of the moon and the intended landing sites of the LM. The sites recommended are Carnarvon, Ascension Island, Hawaii, Guam, and KSC. Distribution of receivers in latitude about the equator is reasonably good. Three receivers are located in the northern hemisphere while two are in the southern hemisphere. There is, however, a wide gap in longitudinal coverage between Ascension Island and Carnarvon amounting to almost 128 degrees and requires transfer between two receiving stations that are almost at opposite limbs of the earth as viewed from the lunar surface. In this condition, both receiving antennas are at low elevation angles and have a near maximum communications path through the earth's atmosphere. Studies are required before definite commitments are made.

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6.4 REAL-TIME TELEMETRY REQUIREMENTS

The R/T support at MCC-H is to be for the first 45 days of operation on each ALSEP and at least 2 hours per day thereafter until the end of the mission. Also, R/T support is required during lunar sunrise/sunset. It has been mentioned, however, that the two hours per day requirement is not firm and may change prior to the ALSEP mission.

The R/T telemetry analysis at MCC-H is required for support of commanding the ALSEP. All of the commands used on ALSEP are predetermined and can be loaded or programed into the appropriate computers prior to the ALSEP mission; no commands will have to be generated in R/T.

The type telemetry data required by the contractor and the PI's at MCC-H for real-time analysis are as follows:

A. ALSEP Systems Measurements (housekeeping):

The capability to monitor all of the system measurements continuously is required R/T when data is being received at MCC-H. This data is to be displayed in engineering units for TV display or H/S printouts. "Out-of-limits" indications are to be provided for all system measurements, regardless of whether the word is being currently displayed or not. In addition to the system measurements, the command word and verification word are to be displayed.

B. PSE

The data to be analyzed in R/T at MCC-H consists of four seismic outputs, three feedback (tide) outputs, one temperature output, and the eight channels of engineering data included in the ALSEP systems data. The seismic outputs, feedback outputs, and temp. outputs should be displayed on a chart recorder with timing information. The engineering data could be displayed on TV displays or H/S

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printouts and would not be required by the PI on a continuous basis but would have callup capability.

C. SWS

The SWS data uses four words out of each frame of data. The SWS cannot be manipulated in R/T; however, a computer printout of the SWS data, with two types of formats, will be required for information purposes. The two formats are:

1. One when the computer can recognize the SWS data sequence.
2. One when the computer cannot recognize the SWS data sequence.

D. LSM

The LSM uses seven words out of each frame of data. The data to be analyzed in R/T at MCC-H consists of the seven LSM data words in each frame (six words of scientific data and one word of engineering data). The scientific data is to be displayed on either analog chart records and/or H/S printouts; the engineering data in the same manner.

E. SIDE

The SIDE uses five words out of each frame of data. The data to be analyzed in R/T at MCC-H consists of the five scientific data words in each frame and the two channels of engineering data included in the ALSEP systems data. The scientific data is to be displayed on either TV Display or printout in engineering units with provisions for comparison of accumulated data. The engineering data could be displayed on a TV Display or analog chart recorder.

F. CCIG

CCIG data is included in the SIDE data and is to be displayed for R/T analysis with the SIDE data at MCC-H.

SECTION 7

MCC-H SUPPORT REQUIREMENTS

7.1 MCC-H MANNING

7.1.1 General

The flight control positions for ALSEP will vary according to the phases of:

A. Lunar Mission Phase

B. Forty-five day continuous data phase

C. One year ALSEP mission phase

7.1.2 Lunar Mission Phase

The lunar mission phase for ALSEP is considered to be the phase from countdown through completion of "return to earth." The lunar mission and the ALSEP mission will be conducted from the third floor of the MCC-H. After lunar mission ALSEP operation control will shift to the SSR's after recovery of the crew. MCC-H positions peculiar to ALSEP which will be manned for this phase are:

A. Experiment Room - Science and Applications Directorate personnel and ALSEP Principal Investigators (PI). See Paragraph 7.2 for equipment configuration.

B. Experiment Activity Officer (EAO) - This position will be manned by personnel from the Flight Control Operations Branch (FCOB) of FCD. This position will function as the EAO position in the Mission Operations Control Room (MOCR) through "return to earth" but will use the Experiment Activities support console in the Flight Director SSR for the extended portion of the ALSEP mission. See Paragraph 7.3 for specific EAO functions.

C. ALSEP Systems Engineer (MOCR position) - This position will be manned by personnel from the Experiment Systems Branch during lunar flight and ALSEP lunar deployment. Their primary function during lunar flight will be the monitoring of fuel cask temperature. During ALSEP lunar deployment, the ALSEP Systems Engineer will conduct ALSEP systems checkout.

D. ALSEP Systems Engineer (SSR position) - This position will be located in the Experiment Systems Staff Support Area and will be manned by personnel from the Experiment Systems Branch. It is the prime position for all ALSEP telemetry data and all ALSEP ground commands. For general configuration of the console, see Paragraph 7.2. This position may include Bendix personnel assigned to FCD as specified by ESB.

E. Experiment Activity Support (SSR position) - This position will be located in the Flight Director SSR and will be manned by personnel from the FCOB of FCD and will support the EAO only during the lunar mission phase. (After lunar mission splashdown, the EAO will occupy this console).

F. Space Environment Specialist (SES) - The SES, a flight controller from the FCOB, and appropriate personnel from the Space Physics Division, will occupy the Space Environment console located in the Weather Room in the MOW. During the Lunar Mission Phase and the 45 day period of continuous real-time ALSEP monitoring, the SES will provide solar flare information support to the EAO, the ALSEP Systems Engineer, ALSEP PI's, Flight Surgeons, Flight Director, and other Flight Controllers as necessary. EAO support information shall consist of the energies of particles ejected into space as a result of solar flares and an estimated time of arrival of these particles on the lunar surface, see Paragraphs 7.3 and 7.4. Array "A" experiments requiring this support are the LSM, SIDE/CCIG, and the SWS.

7.1.3 Forty-five Day Continuous Data Phase

After completion of "return to earth" of the lunar mission, the ALSEP mission commences the phase of continuous data and MCC-H flight control positions will be as follows:

A. Flight Director - The direct conduct of the ALSEP mission after lunar mission splashdown, will be specified by the Flight Director or an Assistant Flight Director (AFD) assigned to the task by the Flight Director. For planning purposes, the responsibility for the conduct of the ALSEP mission after splashdown will be delegated to the AFD. The AFD will then conduct the mission until such time as confidence is gained with the ALSEP systems and at this time the EAO will assume mission conduct. The Flight Director and AFD will be on call for the remainder of the mission.

B. Operations and Procedures Officer - Support by the O&P will be as necessary to coordinate a timeline schedule including equipment, sites, and data flow routes with both the MCC-H and GSFC. Since minimum site acquisition time will be 6-1/2 hours, the O&P will probably be able to accomplish his duties on a weekly basis. The O&P will also prepare the FCOH to be used during the mission and keep the document updated.

C. Network Controller - A network controller/M&O will be required during those times when ALSEP real-time date is required.

D. Experiment Room - The experiment room will be manned as required during this phase by the Science and Applications Directorate and PI's and their personnel. It is not expected that this room will be manned around the clock except during the first several days of the 45 day period.

E. Experiment Activities Officer - After completion of "return to earth" the EAO position will shift to the Experiment Activities Support console in the Flight Director SSR. It is presently planned that this position will be manned 24 hours each day during this phase, however, the work load will be evaluated during the initial period and the manning adjusted as required.

F. ALSEP Systems Engineer - As mentioned above, this position will be the ALSEP systems data and command center and will be manned 24 hours each day unless the ALSEP activities dictate otherwise. This position will also shift to an SSR after the lunar mission "return to earth." Manning requirements for this area have not been defined at this time.

7.1.4 One Year ALSEP Mission Phase

A. Operations and Procedures (FDSSR) - The duties of the O&P officer for this phase will generally consist of those specified in Paragraph 7.1.3.B. However, the frequency of duty will decrease considerably. The O&P officer will establish site availability via the network controller on a weekly basis. Requests for site and MCC-H activation will be given to the O&P with an attempt to forecast ALSEP activity periods for each week. This forecast will include:

1. Expected periods of activity.
2. Types of data expected and data routing.
3. Anticipated data playback requirements.
4. Expected commanding activity or work load.
5. Special confidence testing, if any.
6. Special PI or program office facility needs.

During the extended ALSEP mission, O&P duties will include maintenance and assessment of flight controller procedures and keeping the overall log of descrepancies in ground support equipment including the MCC-H and network.

Two O&P officers (one man prime; one backup) will be assigned to the ALSEP mission. However, during non-activity periods this duty will be "standby".

B. Network Controller - Similar to the O&P officer, the network controller duties for the one year ALSEP mission will generally consist of those specified in Paragraph 7.1.3.C. This position will also require personnel (estimated to be two), assigned to ALSEP but on a standby basis except during site preparation periods and periods of real-time data transmission. The network controller will implement MCC-H and site requirements scheduled by O&P and will provide inputs to the overall site readiness status.

C. EAO - This position will have two flight controllers assigned, however, one man is backup. The EAO serves as the team leader during the extended ALSEP phase and will report testing progress and problems to the flight director or his representative on a daily basis. He will be charged in conjunction with the O&P officer to maintain a complete history of the ALSEP mission progress and problem areas.

D. ALSEP Systems Engineer - The duties of the systems engineer for the one year ALSEP phase will include those of Paragraph 7.1.2C. It is expected that three engineers will be trained as ALSEP flight controllers which will allow two backup engineers, and an assisting engineer when real-time data periods are heavy. The systems engineer, in conjunction with the EAO, will provide briefings daily to the flight director on past ALSEP problem areas and the plan.

7.2 MCC-H CONSOLE CONFIGURATION

This paragraph is included in the first issue of the Experiment Operations Plan only. It is included to assist in early ALSEP planning but will be removed from updated issues after the Flight Control Data Acquisition Requirements document (or Data Pack) has been published.

A. EAO (MOCR) Console - This console will be similar to that used for all Apollo mainline flights and no new requirements are known at this time.

B. ALSEP Systems Engineer (MOCR) - Information to be supplied at a later date.

C. EAO SSR Console - This console will be similar to that used on all Apollo mainline flights.

D. ALSEP Systems Engineer SSR Consoles - Information to be supplied at a later date.

E. Experiment Room - The following capabilities have been proposed:

   1. Access to all computer driven data by D/TV displays - Consoles will have data callup capabilities through TV channel attaching and latching.
   2. Communications Facilities (monitors all prime mission loops and talks to all experiment areas).
   3. Black phones for outside call for off-center coordination with PI's respective organizations, that is, observatories, laboratories, consulting scientists, et cetera. (Reference Figure 7.1).
   4. Data reduction tables and work areas for the PI.
   5. Principal Investigator's normally will occupy this room except when called to other areas such as the ALSEP Systems Area and the Flight Director SSR.

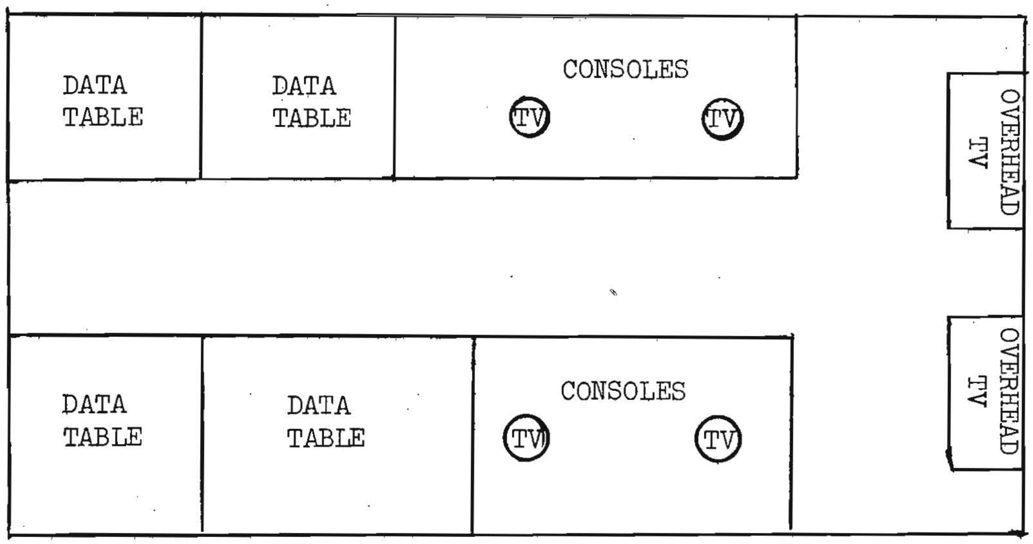


Figure 7.1.- Experiment room layout.
(No. of tables and consoles to be specified by SR)

6. Room managed by S&AD officer (this position makes management decisions affecting experiment priorities and experiment deviations). See Figure 7.2 for a description of EAO/ALSEP Systems Engineer/S&AD/ALSEP PI interface.

F. Experiment Systems Support Area - This will be defined at a later date.

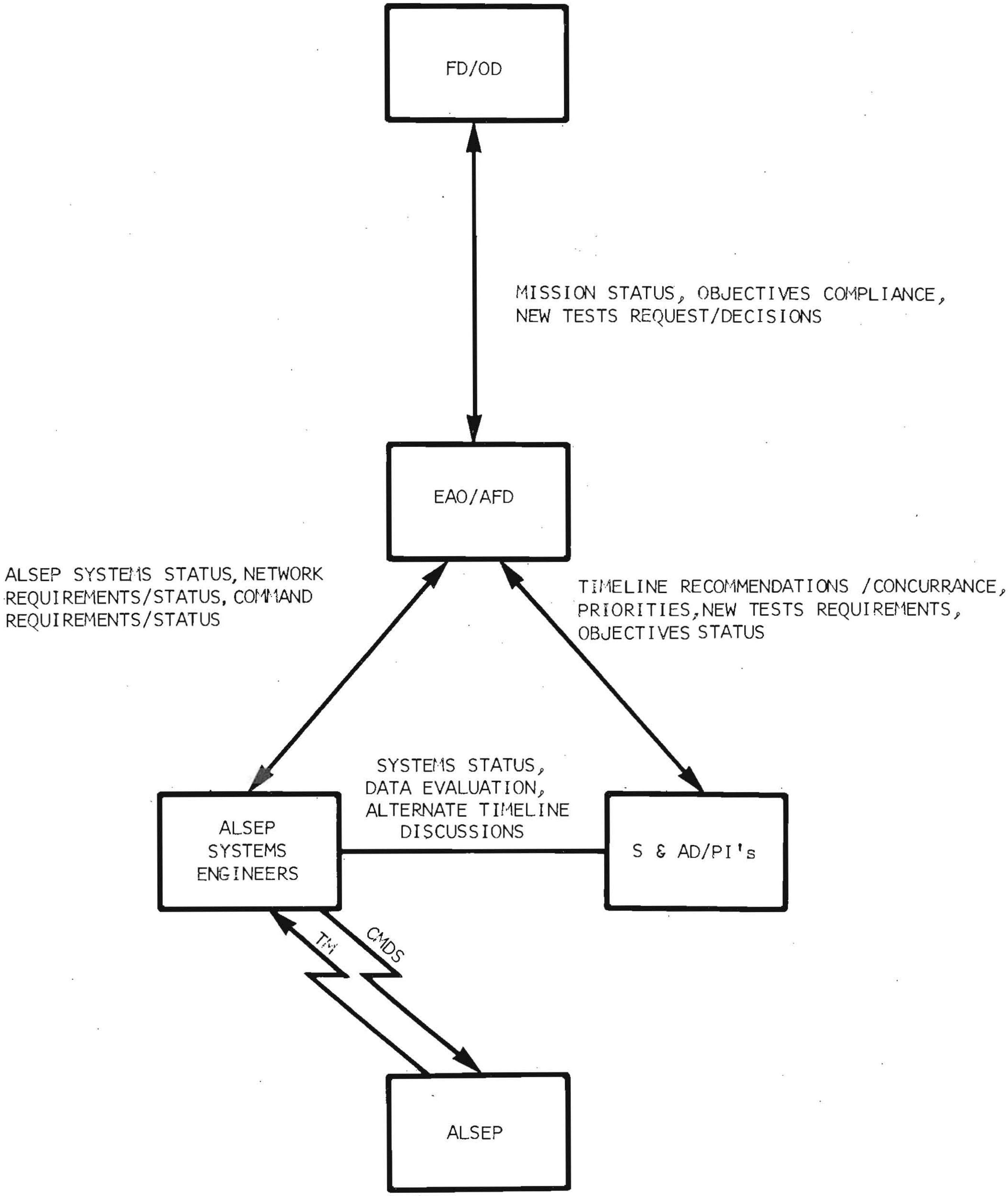


Figure 7-2.- ALSEP flight controller information flow chart.

*

TABLE 7-I.- PHASE ORIENTED MANNING

	FD	AFD	O/P	NET	MOCR EAO	SSR EAO	MOCR SYSTEMS	SSR SYSTEMS
Lunar Deployment	X	X	X	X	X	X	X	
Post Lunar (TEI to recovery)		X	X	X	X		X	
45 Day Continuous (post recovery)			X	X**		X		X
One-Year Phase*				X**		X		X

*During one-year phase activities and prior to actual support times, approximately a one-hour support count will be required to change over facilities and also conduct abbreviated end-to-end confidence tests between MCC-H and the supporting sites.

**The network controller will control all facilities, MCC-H and MSFN, scheduling during these periods. He will also act as test conductor for all support counts prior to handing over to flight controllers.

7.3 EAO FUNCTIONS

The EAO, as the Flight Director's representative for experiments, will coordinate the operations of the Science and Applications Directorate personnel, Principle Investigators, and the ALSEP Systems Engineer throughout the entire operation of the ALSEP, from lunar deployment to transmitter shutdown. Actions affecting ALSEP operations will be coordinated through the EAO if time permits. In situations requiring a quick real-time decision, based on preplanned mission rules and systems constraints, the ALSEP Systems Engineer may operate independently, however, the EAO should be notified as soon as possible.

The EAO will have the capability of receiving information from the Solar Particle Alert Network (SPAN) which will enable him, the ALSEP Systems Engineer, and the Principle Investigators (primarily the LSM, SWS, and SIDE/CCIG on Flt. Art. #1) to make real-time decisions to vary experiment status or sensitivities, based on solar activity.

In addition, a timeline defining the extended portion of ALSEP lunar operations will be prepared by the EAO. Systems data inputs will be supplied by the Experiment Systems Branch.

7.4 ESE FUNCTIONS

The Experiments Systems Engineer for ALSEP will have primary responsibility for real-time monitoring and analysis of all ALSEP systems and experiments data and for initiating all ALSEP commands, planned or required by any contingency situation. He will maintain a file of appropriate real-time data to reflect system status and trends as the year progresses, and will be aware of possible problems which could develop within a system or as a result of systems interactions, as well as command action required or prohibited by such situations.

The ESE will be responsible to the EAO for direction or decisions involving overall conduct of the mission, accomplishment of objectives, priorities, and scheduling.

During commanding operations specifically addressed to a system or experiment, the ESE will maintain close contact with the appropriate contractor/PI representative.

7.5 SOLAR FLARE ALERT PROCEDURES

7.5.1 General

Three experiments (LSM, SIDE/CCIG, and SWS) will use solar flare alert procedures. This support will be provided by the Space Environment Specialist (from the Experiments Operations Group of the FCOB) in conjunction with the Space Physics Division personnel.

7.5.2 Support Scope

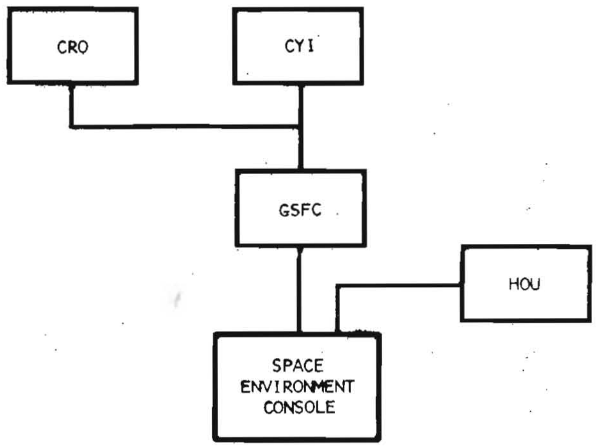
7.5.2.1 Space environment console.- The Space Environment Console will be located in the MCC-H Weather Room. Full-time support will commence at T-4 hours and will terminate at the end of the lunar mission. Part-time support will continue through the

ALSEP mission and will be performed by the EAO. He will receive the data coming into the MCC-H and will work with the Space Physics Division in analyzing the data for ALSEP PI's use.

7.5.2.2 Flare status reporting.- Flare Status reporting will consist of two types.

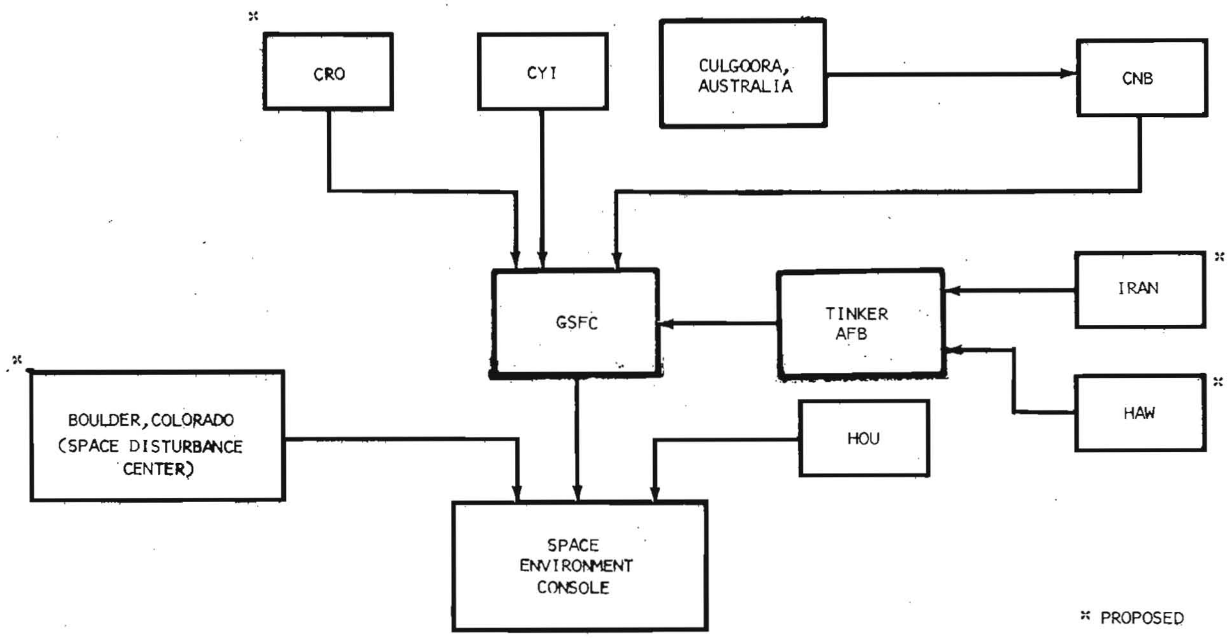
A. A Status Report prepared and distributed by the Space Environment Specialist (SES) consisting of information from the SPAN optical sites shown in Figure 7-3. This report will be prepared when flares have been detected which are greater than Class 2 or once every 24 hours. The distribution of this report will be Surgeon, AFD, EAO, LSM PI, SWS PI, and the SIDE PI. The SES will maintain a file of these reports throughout the SES supporting period. A sample status report is shown in Figure 7-3.

B. Administrative Space Disturbance TWX - This TWX will originate at the Space Disturbance Center, Boulder, Colorado. The SES will maintain a file of these messages and will distribute one copy to each of the persons listed in Paragraph 7.4.2.2A. The frequency of this TWX will be each 6 hours, commencing at T-4 hours and terminating at splashdown. (reference Figure 7-4)



SPAN RF INFORMATION FLOW

(TELETYPE FLOW)



*
SPAN OPTICAL SITES INFORMATION FLOW

(THIS INFORMATION IS RELAYED TO MCC-H OVER A GOSS LINE)

Figure 7-3.- SPAN information flow.

NOTE: THE SPAN ON-SITE COMPUTER IS LOCATED IN BLDG. 31.

Date ________

GMT of Report ________

Space Environment Specialist ________

Site Reporting	GMT of Site Report	Flare Class	Remarks

Figure 7.4.- Sample space disturbance TWX.

*

SECTION 8

MCC-H/KSC INTERFACE TEST

8.1 GENERAL

At present, plans for a MCC-H/KSC Interface Test are being formulated. The completed details of this test will be included in the update to this document. Certain facts, requirements, and desired operations are known and are presented in this section.

The MCC-H/KSC Interface Test will be designated ALSEP Software Integration Test 9SIT). In general, the test will involve the KSC facilities, ALSEP, the MILA USB site, and MCC-H. The MCC-H facilities involved include the Experiment Systems SSR, Flight Director SSR, Experiment Room, and the Flight Director's Console. The conduct of the test will be the responsibility of the mission Flight Director who will either conduct the test himself or appoint someone from FCOB to conduct it.

8.2 TEST PROCEDURES

It is planned that fabrication of the ALSEP will begin in January, 1967. After fabrication, the ALSEP will be shipped to KSC for checkout and testing at the systems level prior to its insertion into the LM. No testing of the ALSEP is possible after LM insertion. Preinstallation testing will be initiated by manual turn-on of the Receiver and Command Decoder. External power and RF commands are then inserted into the power and coaxial connectors to test all components except the basic experiment sensors. Present plans schedule this test to be conducted at approximately F-70 days.

Through the RF Command Link, the remaining equipment will be turned on and "built-in" single point calibration circuits are activated. All command functions are then exercised while monitoring the demodulated RF output. It is highly

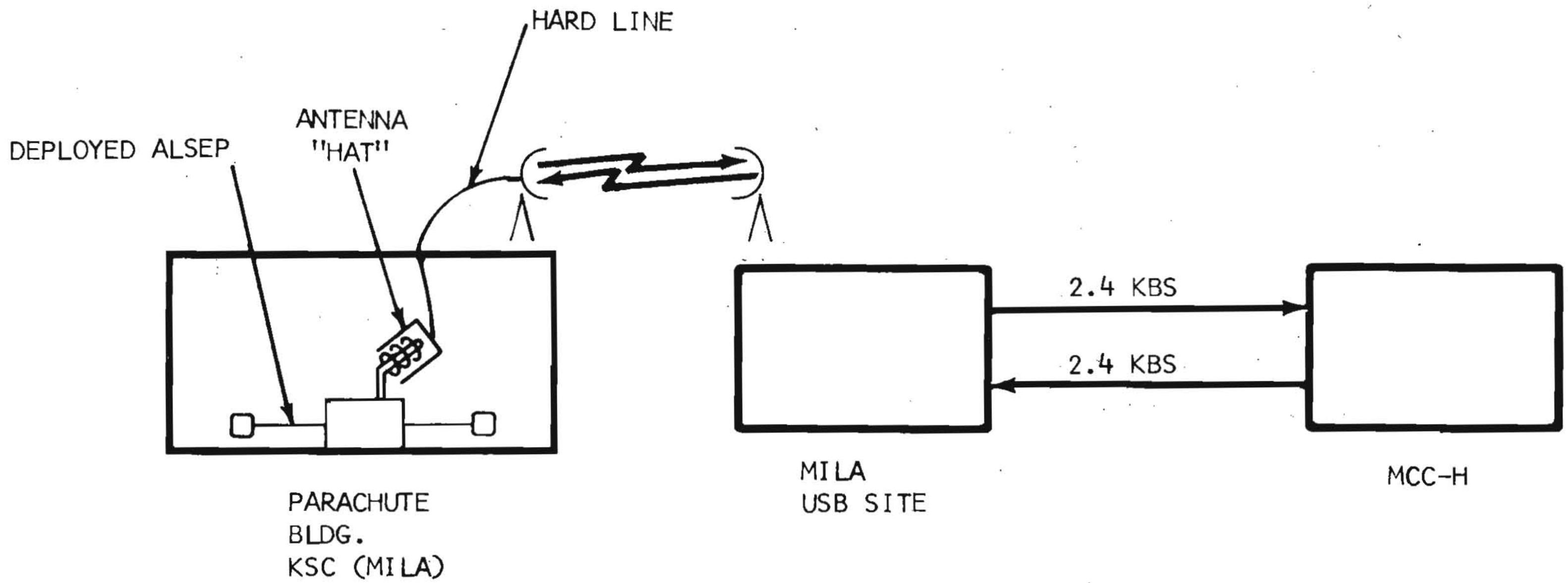
*

desirable that MCC-H transmit commands and receive telemetry data during this period of the test. Reference Figure 8-1 for a pictorial representation of the proposed test.

8.3 TEST AREAS REQUIRING EMPHASIS

Plans are to insert the ALSEP in the LM at T-50 to T-60 days. It is highly desirable that the ALSEP command consoles, located in the Experiment Systems SSR at MCC-H/MOCR, be in operation prior to ALSEP checkout at KSC and subsequent insertion into the LM. This will enable MCC-H to transmit commands to the ALSEP and receive simulated telemetry data from the ALSEP system (primarily the data subsystem) and to test MCC-H's data and command capabilities, and the MILA remote site capabilities. At present, it is planned that the ALSEP will be deployed in the Parachute Building on MILA at KSC. There it will undergo four separate tests. The first three tests will utilize a Systems Test Set furnished by Bendix. The fourth test (Software Integration Test) will use an RF link between the ALSEP and the MILA USB site. From there, the signals will be relayed to MCC-H via a hardline arrangement. Reference Figure 8-2.

The ALSEP experiments are composed of highly sensitive scientific instruments designed to function in an environment much different from that of the earth. Because of their delicate sensitivities, it will be impossible to test some of the experiment sensors, and procedures are still not firm. It is desirable, however, that provisions to transmit some sort of simulated data to MCC-H for checkout purposes be made.



NOTE: 1. PARACHUTE BLDG. TO MILA USB SITE- RF LINK
2. MILA USB SITE TO MCC-H - 2.4 KBS HARDLINE

Figure 8-1.- ALSEP configuration for MCC-H/KSC interface test.

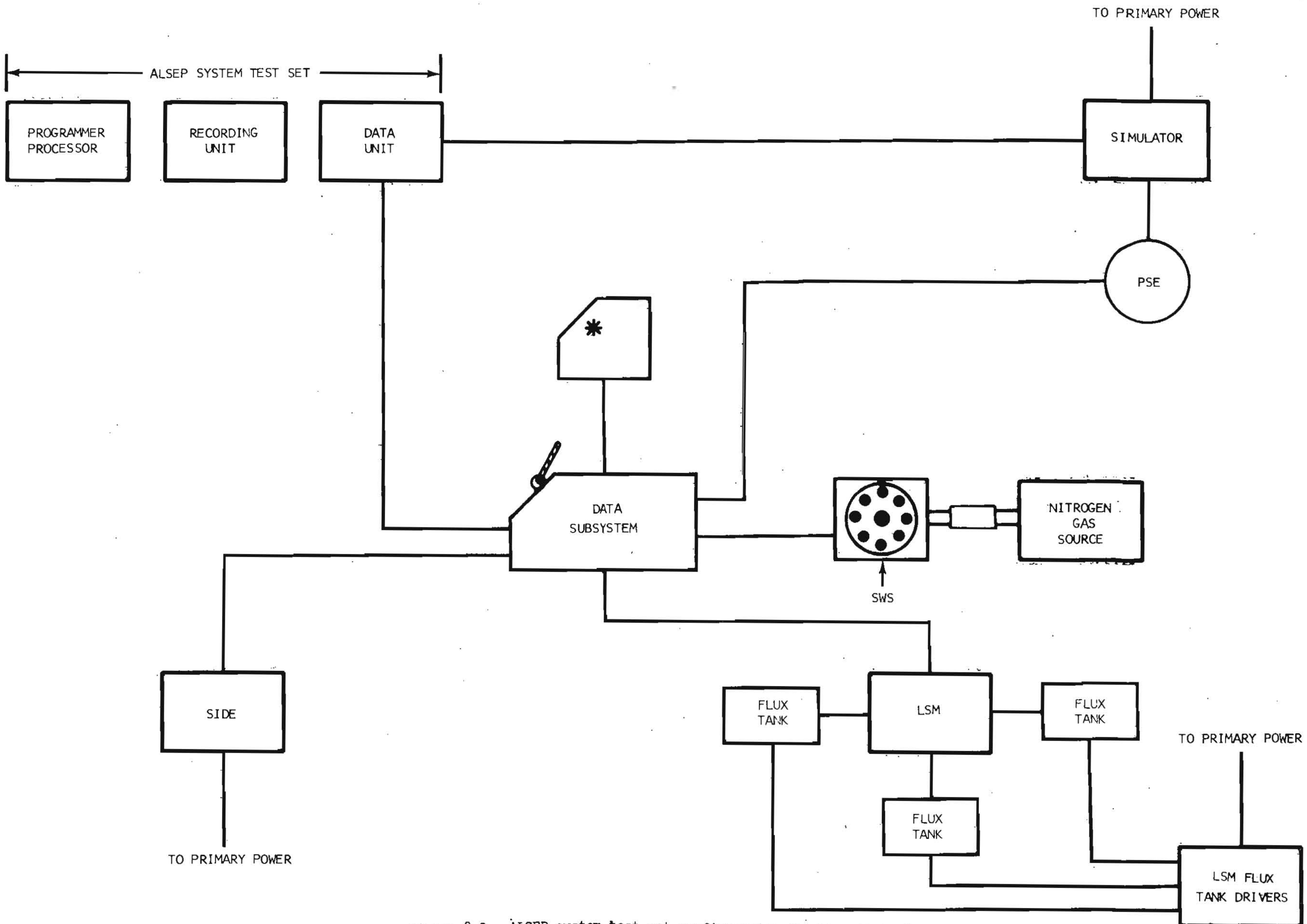


Figure 8-2.- ALSEP system test set configuration flight article #1.

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APPENDIX A

ACRONYMS

ALGE/AGE	Apollo Lunar Geological Equipment
ALSD	Apollo Lunar Surface Drill
ALSEP	Apollo Lunar Surface Experiments Package
ASE	Active Seismic Experiment
ASI	Apollo Standard Initiator
bps	bits per second
CCIG	Cold Cathode Ion Gage
CDR	Critical Design Review
CPLEE	Changed Particle Lunar Environment Experiment
CSA	Calibration and Sequencing Assembly
CSM	Command/Service Module
DSS	Data Subsystem
EAO	Experiment Activities Officer
EGFO	Electronics/Gimbal Flip Unit
EHT	Experiment Handling Tool
EPS	Electrical Power System
ER	Experiment Room
EVA	Extravehicular Activity
FCD	Flight Control Division
FCDAR	Flight Control Data Acquisition Requirements
FCOB	Flight Control Operations Branch
FCSD	Flight Crew Support Division
HFE	Heat Flow Experiment
IPU	Integrated Power Unit
KSC	Kennedy Space Center
LM	Lunar Module
LSB	LM Systems Branch
LSM	Lunar Surface Magnetometer
MCC-H	Mission Control Center-Houston
MCRB	Mission Control Requirements Branch

*

MILA	Merritt Island Launch Area
MOCR	Mission Operations Control Room
MOS	Mission Operations Section
MOW	Mission Operations Wing
MSFN	Manned Spaceflight Network
O&P	Operations and Procedures Officer
PCU	Power Conditioning Unit
PDM	Power Dissipation Module
PI	Principal Investigator
PSE	Passive Seismic Experiment
RCS	Reaction Control System
RTG	Radioisotope Thermoelectric Generator
SIDE	Suprathermal Ion Detector
SIT	Software Integration Test
SLA	Spacecraft/LM Adapter
SPAN	Solar Particle Alert Network
SSR	Staff Support Room
STS	Structural/Thermal Subsystem
SWS	Solar Wind Spectrometer
TDRT	Tie-down Release Tool
TM	Telemetry
USB	Unified S-Band

*

APPENDIX B

FLIGHT CONTROL EXPERIMENT OPERATION PLAN DISTRIBUTION LIST

Director of Flight Operations

Kraft, C. C., Jr. (2) FA

Flight Control Division

Hodge, J. D. (1) FC

Owen, D. H., Jr. (1) FC

Pendley, D. B. (1) FC

Kranz, E. F. (1) FC

Flight Control Operations Branch

Roach, J. W. (1) FC

Harlan, C. S. (1) FC

Fendell, E. I. (1) FC

Lewis, C. R. (1) FC

Ealick, P. L. (1) FC

Platt, W. E., Jr. (1) FC

Lowe, M. A. (1) FC

Duval, J. D. (1) FC

Travis, R. M. (1) FC

Fisher, H. (1) FC

Bates, J. R. (1) FC

Miller, B. J. (1) FC

Schultheiss, R. F. (1) FC

Whitler, J. D. (1) FC

Sutton, R. H. (1) FC

Canin, L. S. (1) FC

Britton, R.E. (1) FC

CSM Systems Branch

Aldrich, A. D. (1) FC

Agena/LM Systems Branch

Hannigan, J. E. (1) FC

Experiment Systems Branch

Brooks, M. F. (1) FC

Sharpe, B. L. (2) FC

Miley, B. (1) Bendix

Flight Dynamics Branch

Lunney, G. S. (1) FC

Mission Simulation Branch

Miller, H. C. (1) FC

Mission Control Requirements Branch

Hoover, R. A. (1) FC

Landing & Recovery Division

Hammack, J. B. (1) FL

Mission Planning & Analysis Division

Mayer, J. P. (1) FM

Flight Support Division

Clements, H. E. (1) FS

Lunar Surface Project Office

Small, J. W. (5) TD

Director of Flight Crew Ops

Slayton, D. K. (2) CA

Astronaut Office

Shepard, A. B., Jr. (2) CB

Flight Crew Support Division

North, W. J. (1) CF

Kuehnel, H. A. (1) CF

Director of Engineering & Development

Faget, M. A. (1) EA

Computation & Analysis Division

Brock, E. H. (1) ED

Apollo Spacecraft Program Office

Bolender, C. H., Gen (1) PA

Mission Operations Division

Maynard, O. E. (2) PM

Office of Manned Spacecraft

Armstrong, W. O. (1) MB

Christensen, E. E. (2) MO

Middleton, R. O., Capt. (3) MO-3

Holcomb, John, Capt. (4) MAO

Goddard Space Flight Center

Donnegan, J. (1)

Cassels, G. (1)

Wood, W. (1)

*

Kennedy Space Center

Preston, G. M. (1) DLO

Donnely, P. (3) DLO-1

Harrington, R. D. (1) DLO-2

Gruene, H., Dr. (3) LVO

Sendler, K. (3) INS

Williams, J. (3) SCO

Petrone, R. A., Col. (1) PPR

McCoy, E. (1) PPR-1

Matthews, E. (2) PPR-4

Bertram, E. (3) PPR-7

Clark, R. L. (2) SOP

Knothe, H. (1) TEC