I-MRD-001E
VOLUME II

MISSION REQUIREMENTS

MANNED SPACECRAFT CENTER

HOUSTON, TEXAS

(NASA-TM-X-68472) MISSION REQUIREMENTS: SECOND SKYLAB MISSION SL-3 (NASA) 1 Feb. 1972 228 p CSCL 22A
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GEORGE C. MARSHALL SPACE FLIGHT CENTER
HUNTSVILLE, ALABAMA

FEBRUARY 1 1972

SECOND SKYLAB MISSION
SL-3

National Aeronautics and Space Administration

FLAG SHEET

MISSION REQUIREMENTS DOCUMENT
SL-3

The purpose of the flag sheet is to identify portions of the Mission Requirements Document (MRD) which are affected by either approved changes or changes pending approval.

I. UNINCORPORATED DATA

None

II. SIGNIFICANT ITEMS UNDER REVISION

A. The functional objectives in Section 3.0 have been assigned weighted percentage values. Those weighted values without an asterisk were assigned by the Skylab Program Office at the Manned Spacecraft Center (MSC) pending receipt of official values from Principal Investigators. Functional Objectives with asterisks were assigned by the Principal Investigators.

B. The data requirements section of the DTO's has been eliminated. A summary of the Data Request Forms (DRF's) has been published under separate cover as Appendix A to the MRD.

C. ATM requirements are not included in this document because a complete revision of the ATM section of this document is currently in preparation.

D. The earth resources DTO's have been prepared with the best available data. At this time, only the EREP hardware performance verification DTO's have been defined and appear in Section 3.2.3. Detailed test objectives related to EREP applications investigations will be prepared for subsequent issues of the MRD.

E. The lunar topographic camera used on Apollo has been approved for implementation on Skylab as part of the earth resources experiments. The camera assembly has been designated the Earth Terrain Camera (ETC) and will be operated as part of the Multispectral Photographic Facility (S190). Experiment S190 has been divided into two parts: S190A Multispectral Photographic Cameras (MPC) and S190B Earth Terrain Camera (ETC). Detailed test objectives related to the ETC will be prepared for subsequent issues of the MRD.

F. The August 1, 1971 issue of the SL-3 MRD and the September 27, 1971 issue of the Skylab Flight Plan both reflected the completion of astronaut maneuvering runs for the M509 (Astronaut Maneuvering Equipment) and T020 (Foot Controlled Maneuvering Unit) experiments on the SL-3 mission. Since the above scheduling would result in SWS overpressurization with gaseous nitrogen from the experiments and exceeding medical limits on the lower partial pressure for oxygen in the SWS atmosphere, a study was conducted and a decision made to reschedule four M509 and five T020 maneuvering runs from SL-3 to SL-4. The reduced number of runs for both experiments for SL-3 are reflected in this issue of the SL-3 MRD.

G. Experiment M516 (Crew Activities/Maintenance) has been approved by NASA/ML for the Skylab Program. This experiment requires no unique or additional equipment. Data for M516 evaluation will be provided by film (three 400-foot magazines), TV, spacecraft telemetry, and recorded subjective evaluations and comments of crew activities. A DTO will be included in the MRD when additional information is available.

H. The first issue of the combined DTO for Experiments T027 and S073 included in this document is presently undergoing extensive revision. Upon approval, the revised DTO for T027/S073 will be issued as a change to this document.

I. Experiment T031 (Spacecraft Surfaces) has been given contingency approval by the MSFEB for assignment to the Skylab Program pending completion of a formal compatability study by the Skylab Program Office. A DTO will be developed for this experiment and incorporated in the MRD upon final approval.

J. Based upon inputs from the NASA Headquarters, the Program Offices are in the process of re-examining the success criteria for Detailed Test Objectives for all Skylab missions. Efforts are now underway to obtain statements of the PI's minimum essential requirements to satisfy his experiment. These data are primarily intended for real time flight planning. It is the desire and intent of the Program Offices to schedule all approved PI requirements that are feasible in the pre-mission flight plan; however, if problems or anomalies are encountered, it may become necessary to reduce and/or delete some experiments or parts of experiments. The success criteria would be used to gauge whether an experiment could be minimally successfully completed under these adverse circumstances or whether it should be discontinued. Program Office personnel will work with the PI's to determine these criteria.

I-MRD-001E
VOLUME II

MISSION REQUIREMENTS

SECOND SKYLAB MISSION
SL-3

February 1, 1972

SKYLAB PROGRAM OFFICES
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
MANNED SPACECRAFT CENTER
AND
MARSHALL SPACE FLIGHT CENTER

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DOCUMENT CHANGE RECORD

Document Title:	Mission Requirements, Apollo Applications Missions AAP-1/AAP-2, AAP-3 and AAP-4
Original Document No.:	MSC-KM-D-68-1
Original Issue Date:	June 14, 1968

<u>Revision 1</u> January 1969 (No. changed to I-MRD-001)

Complete updating of the basic document and Appendix A as originally issued and incorporates Appendixes B and C. Changes from the basic document are flagged by a vertical bar in the right hand margin.

This document supersedes and replaces MSC-KM-D-68-1 dated June 14, 1968.

<u>Revision 2</u> September 10, 1969 (No. changed to I-MRD-001A and title corrected to reflect latest mission designations)

Complete updating of the document to reflect the change from a Saturn I (wet) Workshop to a Saturn V (dry) Workshop.

This document supersedes and replaces I-MRD-001 dated January 1969.

<u>Revision 3</u> March 1970 (No. changed to I-MRD-001B)

Complete updating of Revision 2 to reflect incorporation of 50° inclination and changes in experiments.

Change 1 to Revision 3 June 30, 1970

Change pages issued to correct critical out-of-date data in Revision 3.

<u>Revision 4</u> November 2, 1970 (No. changed to I-MRD-001C)

Complete updating of Revision 3 to reflect incorporation of Detailed Test Objectives and program name change.

This document supersedes and replaces I-MRD-001B, Revision 3, dated March 1970.

<u>Revision 5</u> April 30, 1971 (No. changed to I-MRD-001D)

Complete updating of Revision 4 to reflect incorporation of revised and new Detailed Test Objectives.

This document supersedes and replaces I-MRD-001C, Revision 4, dated November 2, 1970. Changes from Revision No. 4 are flagged by a vertical bar in the right hand margin. With this revision, the MRD has been separated into three volumes, one for each mission. Issue date for Volume I, First Skylab Mission (SL-1/SL-2), is as shown above, April 30, 1971. Issue date for Volume II, Second Skylab Mission (SL-3), is August 1, 1971. Issue date for Volume III, Third Skylab Mission (SL-4), is November 1, 1971.

DOCUMENT CHANGE RECORD (Continued)

Revision 6 February 1, 1972 (No. changed to 1-MRD-001E)

Complete updating of Volume II to incorporate changes in experiments, reflect changes in experiment assignments, and to delete data requirements section of Detailed Test Objectives. This document supercedes and replaces 1-MRD-001D, Volume II, dated 1 August 1971.

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TABLES

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ILLUSTRATIONS

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NOMENCLATURE

AA	Aerosol Analyzer
ALSA	Astronaut Life Support Assembly
AM	Airlock Module
AMRV	Astronaut Maneuvering Research Vehicle
AOS	Acquisition of Signal
APCS	Attitude and Pointing Control System
ARC	Ames Research Center
AS&E	American Scientific and Engineering
ASMU	Automatically Stabilized Maneuvering Unit
ASPA	Auxiliary Storage and Playback Assembly
ATM	Apollo Telescope Mount
ATMDC	Apollo Telescope Mount Digital Computer
ATMOH	Apollo Telescope Mount Operations Handbook
β	Minimum angle between the Earth-Sun Line and the Vehicle Orbital Plane. When viewing orbital plane from direction of sun, β is positive if apparent vehicle motion is counterclockwise and negative if apparent vehicle motion is clockwise.
B&W	Black and White
BET	Best Estimate of Trajectory
BMMD	Body Mass Measurement Device
BPSS	Biopack Subsystem
CBRM	Charger/Battery/Regulator Modules
CDH	Constant Delta Height
CDU	Coupling Display Unit
CM	Command Module
CMC	Command Module Computer
CMG	Control Moment Gyro
CMGS	Control Moment Gyro Subsystem
COAS	Crewman Optical Alignment Sight
CS	Crew Station
CSI	Coeliptic Sequence Initiation
CSM	Command Service Module
DA	Deployment Assembly
DAC	Data Acquisition Camera

NOMENCLATURE (Continued)

DAP	Digital Autopilot
DBP	Descent Battery Pack
DCS	Digital Command System
DDAS	Digital Data Acquisition System
DRF	Data Requirement Form
DSE	Data Storage Equipment
DSKY	Display Keyboard
DTO	Detailed Test Objective
DT	Delayed Time
ECS	Environmental Control System
EEG	Electroencephalographic
EOG	Electro-oculographic
EOH	Experiment Operations Handbook
EPC	Experiment Pointing Control
EPCS	Experiment Pointing Control Subsystem
EPS	Electrical Power System
EREP	Earth Resources Experiment Package
ESS	Experiment Support System
ETC	Earth Terrain Camera
EVA	Extravehicular Activity
FAS	Fixed Airlock Shroud
FCMU	Foot Controlled Maneuvering Unit
FDAI	Flight Director Attitude Indicator
FM	Frequency Modulation
FMAD	Flight Missions Assignment Directive
FMS	Force Measuring System
FMSC	Film Magazine Stowage Container
FMU	Force Measuring Unit
FO	Functional Objective
FOD	Flight Operations Directorate
FOV	Field of View
FSS	Fine Sun Sensor
GMT	Greenwich Mean Time

NOMENCLATURE (Continued)

GNCS	Guidance Navigation and Control System
GSFC	Goddard Space Flight Center
HCO	Harvard College Observatory
HAO	High Altitude Observatory
HD	Highly Desirable
HHMU	Hand Held Maneuvering Unit
HPN	Heavy Primary Nuclei
HSS	Habitability Support System
ICDU	Interface Coupling Display Unit
ID	Identification
IMC	Image Motion Control
IMU	Inertial Measurement Unit
IU	Instrument Unit
IVA	Intravehicular Activity
KSC	Kennedy Space Center
LBNP	Lower Body Negative Pressure
LES	Launch Escape System
LET	Linear Energy Transfer
LIMS	Limb Motion Sensor
LO	Lift-off
LOS	Loss of Signal, also Line-of-Sight
LSU	Life Support Umbilical
LV	Launch Vehicle
M	Mandatory
MCC	Mission Control Center
MCSS	Microscopic Camera Subsystem
MDA	Multiple Docking Adapter
MDTS	Multidiscipline Test Site
MFVC	Modulating Flow Control Valve
MMRD	Medical Mission Requirements Document
MRD	Mission Requirements Document
MSC	Manned Spacecraft Center
MSFC	Marshall Space Flight Center
MSFN	Manned Space Flight Network
MSS	Motion Sickness Susceptibility

NOMENCLATURE (Continued)

MU	Maneuvering Unit
N/A	Not Applicable
NASA	National Aeronautics and Space Administration
NBD	Noncompensated Gyro Bias Drift
NC1	First Phasing Maneuver
NCC	Corrective Combination Maneuver
NM	Nautical Mile
NRL	Naval Research Laboratory
NSR	Slow Rate Phasing Mnaeuver
OA	Orbital Assembly
OGI	Oculogyral Illusion
OMSF	Office of Manned Space Flight
OTG	Otolith Test Goggles
OWS	Orbital Workshop
PAD	Program Approval Document
PCM	Pulse Code Modulation
PCU	Pressure Control Unit
PI	Principal Investigator
PIPA	Pulsed Integrating Pendulum Accelerometer
PMT	Photomultiplier Tube
POTS	Precision Optical Tracking System
PS	Payload Shroud
PSS	Propellant Supply Subsystem
PTL	Photographic Technology Lab
RCS	Reaction Control System
RF	Radio Frequency
RLC	Rotating Litter Chair
RMS	Root Mean Square
RPM	Revolutions Per Minute, also Roll Positioning Mechanism
RT	Real Time
RTCC	Real Time Computer Complex
SAA	South Atlantic Anomaly
SAL	Scientific Airlock

NOMENCLATURE (Continued)

SAS	Solar Array System
S/C	Spacecraft
SL	Skylab
SLA	Spacecraft Lunar Module Adapter
SLEENA	Skylab Electrical Energy Network Analysis
SM	Service Module
SMMD	Specimen Mass Measurement Device
sps	samples per second
SPS	Service Propulsion System
STS	Structural Transition Section
SWS	Saturn Workshop
SXT	Sextant
TACS	Thruster Attitude Control Subsystem
TBD	To be Determined
TBS	To be Supplied
TCS	Thermal Control System
TM	Telemetry
TPF	Terminal Phase Final
TPI	Terminal Phase Initiation
TR	Tape Recorder
TV	Television
UV	Ultraviolet
VCG	Vectorcardiogram
VHF	Very High Frequency
X-IOP/Z	Solar Inertial Attitude (See Note: 1, Page 2-4)
X-REA	X-Ray Event Analyzer
XUV	Extreme Ultraviolet
Z-LV	Z Local Vertical Attitude
Z-LV(E)	Earth Pointing Attitude (See Note: 2, Page 2-4)
Z-LV(R)	Rendezvous Pointing Attitude

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DEFINITIONS

The following definitions apply to usage of the terms in this document.

- Mission Objectives. Mission objectives are the ends toward which efforts are directed for each mission. Mission objectives are specified by the OMSF.
- Experiments. Experiments are planned investigations which are conducted in flight during manned space missions, or which are essentially connected with the in-flight situation. These investigations, which are approved by the Manned Space Flight Experiments Board and assigned by the Headquarters Program Office (ML), are conducted to obtain research information which can contribute to the advancement of science and technology.
- In-flight System Tests. In-flight system tests are those tests which are conducted to evaluate the performance of a particular system or subsystem to determine its suitability on future Skylab missions.
- In-flight Operational Tests. In-flight operational tests are those tests involving operational techniques or procedures which are conducted to determine the method of operating systems or subsystems to obtain optimum results.
- Extravehicular Activity. Activity performed in space or on a celestial body by an astronaut external to the space vehicle.
- Intravehicular Activity. Activity with one or more of the adverse characteristics of EVA because of reduced gravity and/or pressurized space suit, performed in space or on a celestial body by an astronaut internal to the space vehicle.
- Primary Mission. The primary mission is a planned mission that satisfies a prescribed set of objectives and requirements as defined by the Operations Directives.
- Backup Mission. A backup mission is a preplanned mission flown in place of the primary mission when the decision to change is made prior to CSM launch.
- Alternate Mission. An alternate mission is a preplanned mission flown in place of the primary mission when the decision to change is made after CSM launch.
- Detailed Test Objective. Scientific, engineering, or operational objectives which amplify mission objectives or detail a major development purpose or feature of the mission. The accomplishment of a Detailed Test Objective will be an important consideration in determining the degree of achievement of the mission objective(s).

1.0 INTRODUCTION

1.1 BACKGROUND

The Skylab (SL) Program objectives are to extend the duration of manned space flight and to carry out a broad spectrum of experimental investigations. Of particular importance are a series of medical experiments associated with the extension of manned space flight, a series of high resolution solar astronomy experiments at the short wavelengths not directly observable from the surface of the earth and a series of earth survey experiments.

The Skylab missions are designed to support these objectives. Currently, the program includes three low earth orbit missions, designated SL-1/SL-2, SL-3 and SL-4. This volume contains mission requirements for the second Skylab Mission (SL-3) only. The Skylab SL-1/SL-2 Mission Requirements are contained in Volume 1 of the Mission Requirements Document (MRD). The SL-4 Mission Requirements are contained in Volume III of the MRD. Summaries of the Data Request Forms (DRF's) associated with Skylab Detailed Test Objectives are contained in Appendix A of the MRD.

The SL-3 mission will utilize an orbiting Saturn Workshop (SWS). The SWS configuration includes a Multiple Docking Adapter (MDA), Apollo Telescope Mount (ATM), Airlock Module (AM), and an S-IVB Stage (modified as an Orbital Workshop [OWS]), previously launched and inserted into orbit on a two-stage Saturn V Launch Vehicle for the SL-1/SL-2 mission. The SL-3 configuration will be a manned Command Service Module (CSM) launched on a Saturn IB Launch Vehicle. The SL-3 CSM will rendezvous and dock with the SWS forming an Orbital Assembly (OA) to accomplish a long duration mission of up to 56 days.

1.2 SCOPE AND PRECEDENCE

The MRD is prepared in accordance with NASA Headquarters, Office of Manned Space Flight (OMSF) directives and Skylab specification documents as listed in NASA Headquarters Program Directive No. 43A, M-D ML 3200.125, dated March 26, 1971 and Cluster Requirements Specification No. RS003M00003, dated August 8, 1969, References 1 and 2 respectively. It defines the mission requirements and the functional and performance requirements for implementing the program and mission objectives specified therein. The Mission Assignments and Flight Scheduling Precedence Numbers for the experiments were assigned by OMSF, NASA Headquarters Program Directive No. 43A, Reference No. 1. The scope of this document is the definition of mission operational requirements for mission SL-3.

The MRD shall provide the basis for mission planning and design by all elements of the Skylab Program. In the event of conflict between the MRD and other mission planning documentation, the MRD shall govern with respect to mission objectives and requirements.

The relationship of the MRD with other program documentation is depicted in Figure 1-1, Skylab Program Specification Tree. Performance and design requirements for cluster systems to implement mission requirements are contained in the Cluster Requirements Specification (Reference 2).

Many subsidiary mission documents must be prepared to implement the requirements of this MRD. These documents may expand on, but must not conflict with the contents of the MRD.

1.3 PUBLICATION AND REVISIONS

1.3.1 Publication

Development of the MRD is the joint responsibility of the Skylab Program Offices at the Manned Spacecraft Center (MSC) and the Marshall Space Flight Center (MSFC). Preparation and coordination of this document will be performed under the cognizance of the Mission Requirements Panel with approval and sign-off by both program managers.

1.3.2 Revisions

The document will be revised as required to provide necessary guidelines for supporting activities. All revisions will be handled in the same manner as the basic document and will require joint sign-off by the Skylab Program managers at both the MSC and MSFC.

Requests for changes to the document shall be submitted to either of the Co-chairmen, Mission Requirements Subpanel (P. H. Allen, MSC/KM; J. W. Thomas, MSFC/PM-SL-EI).

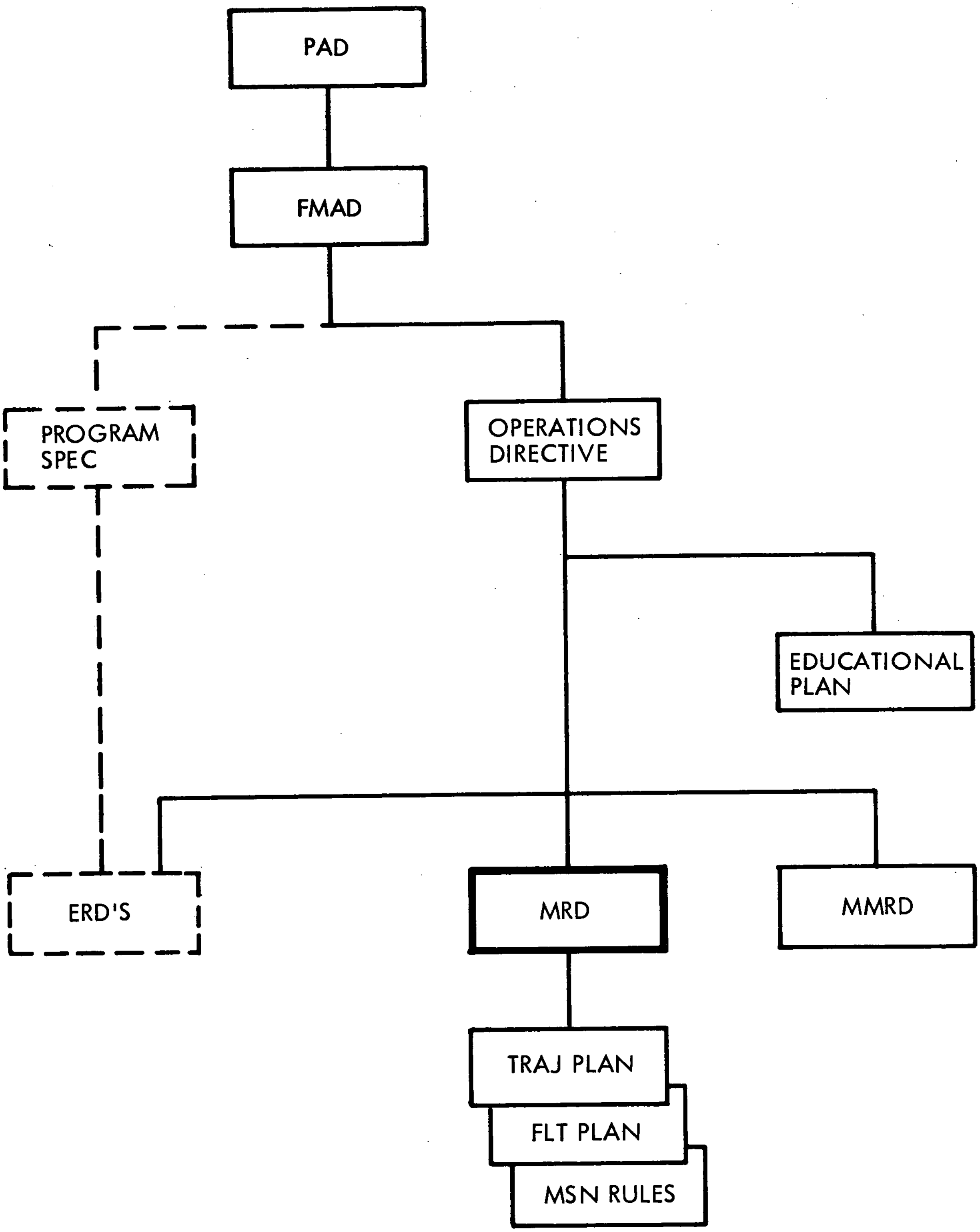


Figure 1-1. Skylab Program Specification Tree

SKYLAB MISSION SL-3
SECTION 2

2.0 SKYLAB MISSION SL-3

2.1 MISSION DEFINITION

Skylab Mission SL-3 will be the second in a series of missions which are designed to achieve long duration space flights of men and systems and to perform scientific investigations in earth orbit. The Skylab mission phases and major events are illustrated in Figure 2-1. The SL-3 mission will consist of one manned CSM launch, rendezvous and docking with the orbiting SWS, and operation of both modules as an OA for up to 56 days to accomplish the mission objectives. The SWS will then be prepared for unmanned operations and the CSM will deorbit for recovery.

The unmanned phase of Skylab Mission SL-3 will begin when the SL-2 CSM and crew separate from the SWS just prior to reentry. The unmanned portion of the mission will continue until the SL-3 CSM and crew are launched to rendezvous and dock with the SWS. The manned phase of Skylab Mission SL-3 will terminate with recovery of the SL-3 CM and crew. Unmanned SWS operations after separation of the SL-3 CSM will be included as part of the SL-4 mission.

2.2 MISSION OBJECTIVES

The objectives for the SL-3 mission, as assigned by the OMSF, NASA Headquarters Program Directive No. 43A (Reference 1), are as follows:

2.2.1 Perform Unmanned Saturn Workshop Operations

(a) Obtain data for evaluating the performance of the unmanned SWS.

(b) Obtain solar astronomy data by unmanned ATM observations.

2.2.2 Reactivate the Skylab Orbital Assembly in Earth Orbit

(a) Operate the orbital assembly (SWS plus CSM) as a habitable space structure for up to 56 days after the SL-3 launch.

(b) Obtain data for evaluating the performance of the orbital assembly.

(c) Obtain data for evaluating crew mobility and work capability in both intravehicular and extravehicular activity.

2.2.3 Obtain Medical Data on the Crew for Use in Extending the Duration of Manned Space Flights

(a) Obtain medical data for determining the effects on the crew which result from a space flight of up to 56 days duration.

(b) Obtain medical data for determining if a subsequent Skylab mission of greater than 56 days duration is feasible and advisable.

2.2.4 Perform In-Flight Experiments

(a) Obtain ATM solar astronomy data for continuing and extending solar studies beyond the limits of earth-based observations.

(b) Obtain earth resources data for continuing and extending multisensor observation of the earth from the low earth orbit.

(c) Perform the assigned scientific, engineering, technology and DOD experiments.

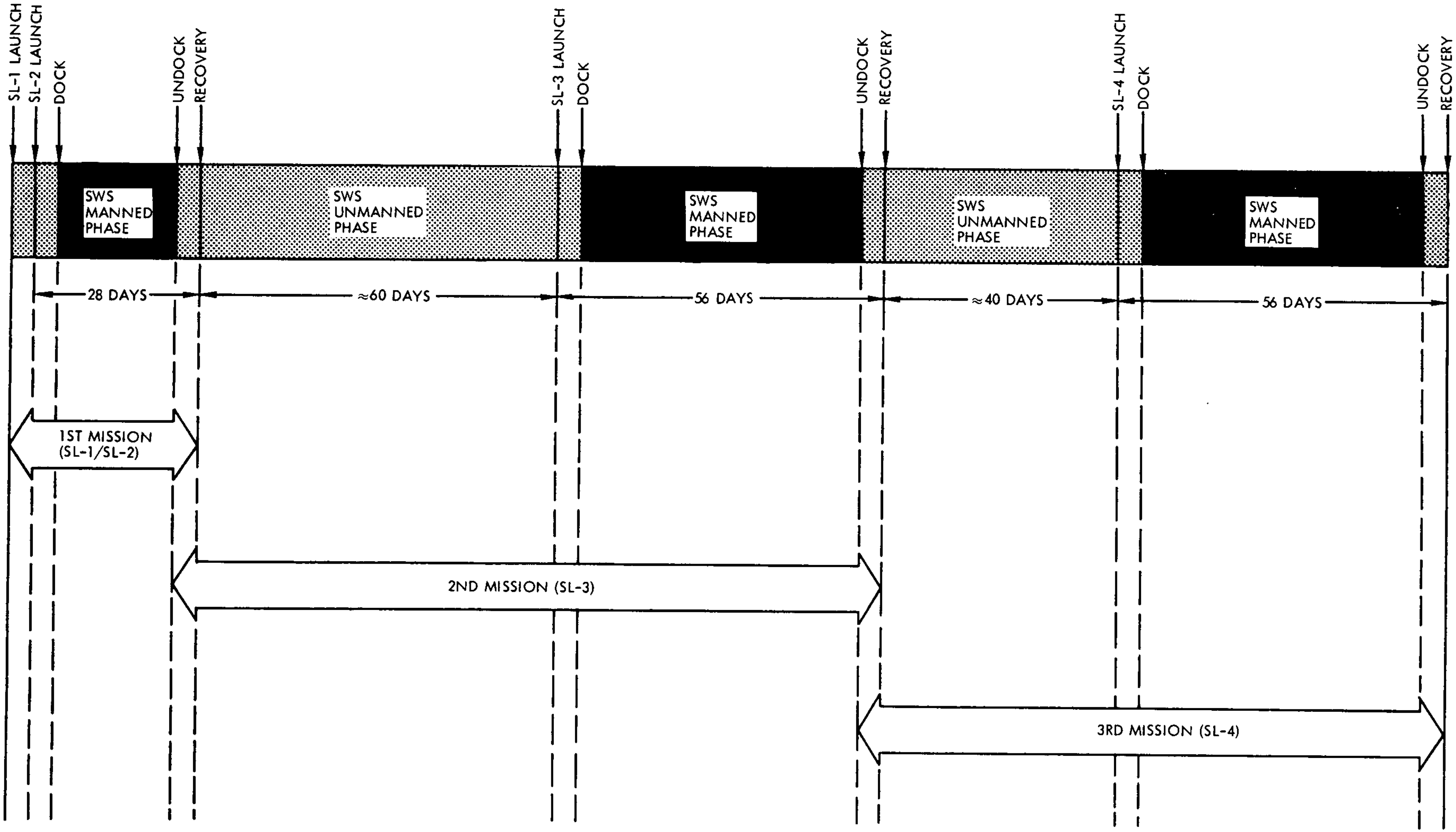


Figure 2-1. Skylab Mission Phases and Major Events

2.3 MISSION REQUIREMENTS

2.3.1 Mission Profile Requirements

2.3.1.1 Launch Date

Mission planning shall be based upon a launch readiness date for SL-3 within 90 (+6) days after the launch of SL-2.

2.3.1.2 Launch Planning

SL-3 shall not be launched until the SWS systems are judged to be operating in accordance with the criteria presented in Section 2.3.3.

Mission planning shall optimize selection of launch opportunities which will provide an "early rendezvous" (i.e., M = 5-8) capability and shall be based on a maximum of 700 pounds of SL-3 launch vehicle payload decrement for yaw steering. The basis for the "early rendezvous" requirement is the necessity for crew access to the SWS urine freezer within 24 hours of CSM launch to preserve urine samples.

2.3.1.3 Launch Complexes

SL-3 will be launched from Complex 39B at Kennedy Space Center (KSC).

2.3.1.4 Insertion Altitudes

The SWS will have been previously inserted into a circular orbit of approximately 235 n mi measured above the mean equatorial reference radius.

The SL-3 CSM will be inserted into an 81 by 120-n mi orbit (measured above the mean equatorial reference radius) by a Saturn IB Launch Vehicle.

CSM RCS and SWS TACS shall be used to perform orbit trim maneuvers for the purpose of providing controlled repeating orbits for Earth Resources experiments. Where practicable, the method utilized shall be selected to minimize contamination to the OA.

2.3.1.5 Orbital Inclination

Mission planning shall be based on a northerly launch azimuth.

The SL-3 CSM will be targeted for rendezvous with the SWS orbiting at a planned orbital inclination of 50 degrees.

2.3.1.6 Rendezvous and Docking

The SL-3 CSM will rendezvous with the SWS and will dock to the primary (axial) docking port. Launch time of day shall be optimized to obtain proper lighting in the recovery areas, provide early rendezvous for SL-3, allow approximately 90-day intervals between the manned launches, obtain sufficient deorbit tracking coverage, and to provide (as much as possible) proper lighting and tracking coverage for abort situations. The CSM VHF ranging system will be required from a maximum distance of 300 n mi to a minimum distance of 500 feet. The SWS attitude will be such to enhance VHF angular ranging requirements for CSM/SWS rendezvous. The SWS shall initiate the rendezvous pointing attitude (Z-LV[R]) rendezvous mode, with the -X axis in the direction of the velocity vector, as early in a given orbit as orbital midnight and return to the solar inertial mode at orbital midnight after a maximum of two orbits. The Z-LV(R) attitude shall be maintained within 12 degrees about the Y axis and within 6 degrees about the X and Z axes. The maximum excursion in attitude shall not occur until the end of the second orbit period. The rendezvous mode may occur at beta angles up to +73 1/2 degrees. At beta angles greater than 50 degrees, the SWS shall be biased about the X axis to a maximum of 23 1/2 degrees from the Z-LV(R) attitude.

Operational planning shall insure that the SWS Attitude and Pointing Control System (APCS) gain changes from the unmanned configuration to the CSM docked configuration are implemented within one orbit after CSM docking. Gain changes required to reconfigure the APCS for the unmanned mode shall be made prior to CSM undocking.

2.3.1.7 Orbital Attitudes

The attitude requirements for the Saturn Workshop are as follows:

a) Prior to CSM rendezvous - Solar inertial attitude (X-IOP/Z) (Note 1)

b) CSM rendezvous - Z-LV(R) (See Section 2.3.1.6)

c) CSM docking - X-IOP/Z

d) Workshop operations - X-IOP/Z

e) Earth pointing experiment operations - Earth pointing attitude (Z-LV[E]) (Note 2)

f) Inertial Measurement Unit alignment - X-IOP/Z

g) CSM undocking - X-IOP/Z

h) SWS storage - X-IOP/Z

Notes:

1. X-IOP/Z: The solar inertial attitude is defined as the principal OA X axis in the orbital plane with the Z axis coincident with the sun line. The -Z axis points directly toward the sun and, at orbital noon, the +X axis is in the direction of the velocity vector. (The OA coordinate system is illustrated in Figure 2-2.) The X-IOP/Z mode includes Control Moment Gyro (CMG) desaturation maneuvers performed each orbit on the "night" side of the orbit.

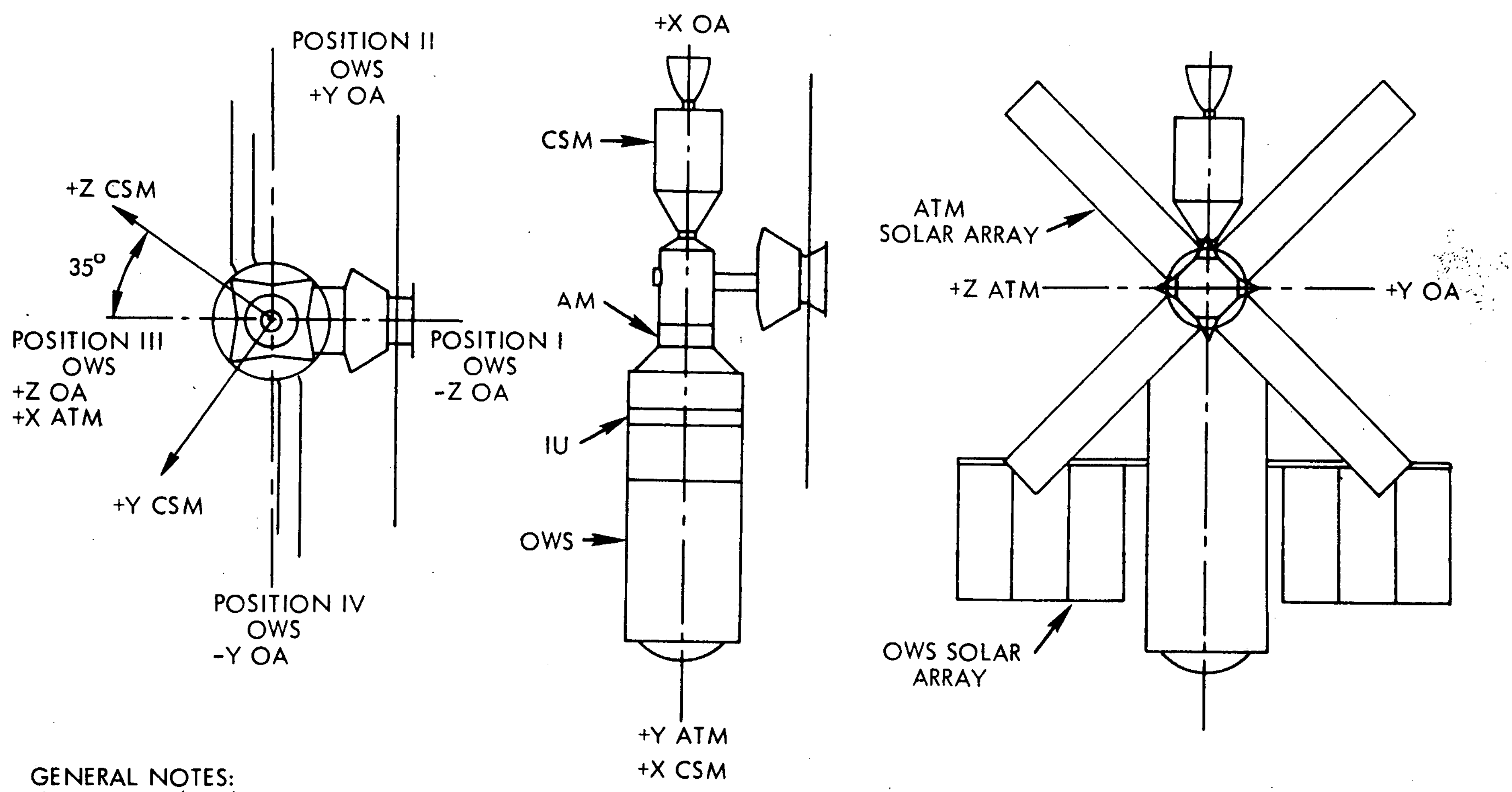
2. Z-LV(E): The earth pointing attitude is defined as the OA geometric X axis in the orbital plane with the Z axis along the geodetic local vertical. The +Z axis points directly toward the earth and the +X axis is in the direction of the velocity vector (i.e., CSM leading).

2.3.1.8 Mission Duration

The SL-3 mission duration shall be planned for 56 days from the launch of the SL-3 CSM.

2.3.1.9 Recovery Zones

It is highly desirable that the mission be planned such that nominal recovery occurs during daylight. All planned landing areas shall be in water.



GENERAL NOTES:

1) THE MDA/AM/OWS AXES POLARITIES ARE THE SAME AS THOSE SHOWN FOR THE OA.
2) THE OA Y AND Z AXES POLARITIES FOR DYNAMIC BODY AXES ARE THE REVERSE OF THOSE SHOWN.
3) THE PURPOSE OF THIS SCHEMATIC IS TO ILLUSTRATE AXES SYSTEMS ONLY.

Figure 2-2. Skylab Orbital Assembly Configuration (Mass Properties Axes System)

2.3.2 Operations Requirements

2.3.2.1 Extravehicular Activity

Three extravehicular activity periods are planned for this mission. The EVA's shall be through the AM EVA hatch. The capability shall exist to perform EVA operations during both daylight and dark periods of the orbit. Each planned operation shall be limited to three hours of actual EVA time. Two crewmen shall be capable of EVA during the period.

2.3.2.2 Rendezvous Lighting

Flashing lights on the SWS shall be used during CSM rendezvous for: (a) acquisition and tracking with the Command Module (CM) sextant to update the CSM state vector prior to rendezvous maneuvers; and (b) tracking with the Crewman Optical Alignment Sight (COAS) prior to terminal phase initiation (TPI). The lights shall provide continuous coverage through the sextant for a maximum range of 300 n mi during darkness.

2.3.2.3 CSM On-Orbit Verification

Periodic operation/monitoring of the CSM will be required to ensure a satisfactory deorbit capability.

2.3.2.4 Deorbit Capability

The SM Service Propulsion System (SPS) shall provide the primary deorbit capability for the SL-3 CSM. The RCS shall provide a backup deorbit capability.

2.3.2.5 CMG Desaturation

The CMG desaturation will be automatic (with inhibit capability by the crew or Digital Command System command) and will occur during the "night" portion of the orbit (typically about 35 percent of the orbit is required for CMG desaturation).

2.3.2.6 Venting and Dumping

During ATM and Earth Resources Experiments Package (EREP) experiment operations, all controllable OA venting and dumping will be planned to occur early during the "night" portion of the orbit.

2.3.2.7 Orbital Assembly Attitude Control and Experiment Pointing

Any OA attitude control shall be performed using either the APCS or the RCS. There shall be no maneuvering of the OA with the SPS.

The SWS will provide the capability to perform the following Z local vertical attitude (Z-LV) maneuver profiles for earth resources experiments:

a) A maximum of 60 orbital degrees of Z-LV(E) centered about any orbital location, returning to the solar-inertial attitude at the end of the pass. The 60-degrees Z-LV(E) pass may be performed during each of a maximum of two consecutive orbits. When each of the consecutive passes is contained within a 120-degrees arc centered about orbital noon, the SWS must remain in the solar-inertial mode for at least four continuous orbits before two other consecutive Z-LV(E) passes are initiated. When each of the consecutive passes is at any other orbital location, the SWS must remain in the solar-inertial mode for at least five orbits before initiating additional Z-LV(E) passes. During a given 24-

hour period, the SWS shall provide a maximum of four continuous sequences of one Z-LV(E) pass (a maximum of 60 orbital degrees contained within a 120-degree arc which is centered about orbital noon), followed by one orbit of solar-inertial mode. The Z-LV(E) pass defined herein is restricted to beta (β) angles between ±50 degrees.

b) A maximum of 120 orbital degrees of Z-LV(E) centered at any location within the orbit; returning to the solar-inertial attitude at the end of the pass. This mode may be performed for only one orbit at a time and, once completed, the SWS must remain in the solar-inertial mode for four continuous orbits before initiating another Z-LV(E) pass. The Z-LV(E) pass defined herein is restricted to β angles between +50 and -30 degrees.

The total series of EREP operations (45 passes on three missions) will consist of a combination of the above maneuver profiles according to final target selection and requirements. Approximately one-third of the total EREP passes will be of the 120-degree variety.

2.3.2.8 OA Internal Activities

Nominal mission planning shall provide for a shirtsleeve environment for initial crew entry into the MDA and the OWS, and for subsequent normal everyday activities. Auxiliary face masks and oxygen supplies shall be available, if necessary, to support initial crew entries into the MDA and OWS. Additionally, provisions and facilities shall be available to support an initial contingency suited entry (IVA) by one crewman from the CSM into the MDA, and one or two crewmen from the MDA/AM into the OWS.

There shall be no requirement that a particular module of the OA be occupied at all times; however, immediately prior to and during EVA's the non-EVA crewman shall be on the CSM side of the AM lock compartment.

2.3.2.9 ATM Film Stowage

To assure return of ATM film in the event of an abort, the ATM film shall be stowed in the CM as soon as possible following EVA.

2.3.2.10 Budgeting of Electrical Power

Planning shall provide for operation of the CSM fuel cells until cryogenic depletion; however, flight planning shall be based upon the capability of the SWS electrical power system without fuel cell operation. The additional power margin created by operation of the fuel cells may be available for nominal usage during the mission depending on the situation.

2.3.3 Launch Commit Criteria

Validation of the following SWS status will be a prerequisite to the launch of the SL-3 CSM. Limits associated with these conditions will be determined in conjunction with the development of Launch and Flight Mission Rules.

- Payload shroud position to preclude contact with the CSM during its ascent.
- S-II stage position will preclude contact with the CSM during its ascent.

- Manned Space Flight Network/SWS instrumentation and communications established.
- Pressure integrity of the SWS verified.
- APCS operating and solar inertial attitude maintained.
- OWS and ATM solar arrays operating.
- The orbital parameters of the SWS must be such that mission durations of at least TBD days based on a 2σ high density atmosphere will be possible.
- The SWS thermal control system, electrical power systems, attitude control systems and communication and data systems are operating within limits required for successful manned habitation.

In addition to the above conditions, the space radiation environment must be acceptable for manned orbital activity.

2.3.4 Guidelines for Experiments and Systems/Operational Tests

This section sets forth guidelines to govern the planning and execution of experiments, systems tests and operational tests.

2.3.4.1 Experiments Assignment

Experiment assignments for Mission SL-3 are given in Section 3, Table 3.2-1, as specified in OMSF Headquarters Program Directive 43A (Reference No. 1).

2.3.4.2 In-flight Systems/Operational Tests Assignment (TBD)

2.3.4.3 Pre-mission Planning Guidelines

The following guidelines, and those in the subsections below are repeated verbatim from NASA Headquarters Program Directive 43A and shall be used in preparing the SL-3 mission plans:

a) Approximately one of every seven mission-days shall be scheduled as an off-duty day. Each off-duty day shall include performance of Experiments M071 and M073, crew rest and recreation, nominal monitoring, crew planning, and ATM solar flare activity as required.

b) Scheduling of crew activities shall permit rapid crew response to solar flares that may occur when the ATM console is not manned.

2.3.4.3.1 Group-related Experiments

The group-related experiments comprise the ATM, EREP, and in-flight medical experiments. Those which are assigned to Mission SL-3 in Section 3, Table 3.2-1 shall be scheduled in accordance with the following guidelines:

a) The in-flight medical experiments shall be scheduled according to TBD guidelines.

b) Crew-attended ATM operations shall be scheduled for the equivalent of ten mission-hours per day, except on off-duty and EVA days.

c) Unattended ATM operations: the ATM experiments may be scheduled for operation by ground controllers during any period in which the ATM console is unattended, provided such scheduling does not contradict other requirements specified herein.

d) The ATM experiments, excluding S055, shall each utilize not more than two magazines of film.

e) The EREP group of experiments shall be scheduled for at least 15 passes in the Z-LV(E) attitude.

2.3.4.3.2 Corollary (Individual) Experiments

The individual experiments shall be scheduled on Mission SL-3 in accordance with the following guidelines and the assignment instructions set forth in Section 3.

a) The individual experiments assigned in whole or in part to Mission SL-3 shall be scheduled into those intervals of the crew timeline which have not been alloted for the group-related experiments, the necessary life-support activities (eat, sleep, off-duty, personal hygiene, systems housekeeping), and the educational activities TBD.

b) Those intervals of the timeline that remain unfilled after paragraph (a) has been satisfied shall be used for scheduling the experiments whose assignment to Mission SL-3 is optional. This procedure shall be optimized with respect to experiment constraints, the flight scheduling precedence (given in Section 3 for each individual experiment), spacecraft stowage capacity, crew training requirements, and other mission parameters.

2.3.4.4 Real Time Planning Guidelines

The guidelines set forth in this section shall apply while the mission is in progress; detailed guidelines are TBD.

2.3.5 Unmanned Operations Guidelines

2.3.5.1 Unmanned Operations

a) The SWS shall be controlled and interrogated from the ground during the unmanned period.

b) The ATM experiments shall be operated an average of eight hours per day.

2.3.5.2 Unmanned Preparations

The Saturn Workshop will be prepared for unmanned operations and for subsequent reuse at the conclusion of the SL-3 mission. Preparation for the unmanned period will be as follows:

a) Attitude. The SWS will be left in a solar-inertial stabilized mode. If attitude rates are induced upon CSM undocking, the APCS will damp these rates and return the SWS to a solar inertial stabilized mode.

b) Monitoring. The SWS communication and data systems must be capable of providing SWS status during the storage period.

c) Pressurization. The SWS habitable areas shall be depressurized after separation of the CSM. Venting shall be initiated by ground command within one orbit following CSM separation and shall be terminated by ground command when the pressure level is approximately 2.0 psia. Subsequently, the SWS internal pressure shall be allowed to decay to a minimum of 0.5 psia during the unmanned phase. The aft airlock hatch shall be in an open position during the unmanned phase.

d) Systems. Those systems necessary to support the SWS communication and data system, and those necessary to provide attitude and thermal control, will be required to operate during the storage period.

e) Experiments. Film for ATM Experiments S052 and S054 shall be loaded during the end of mission SL-3 EVA for exposure during the unmanned period of SL-4. Additionally, a set of Experiment S149 micrometeorite impact detection cassettes shall be prepared for exposure during the unmanned period of SL-4.

2.3.6 Non-Nominal Missions

All non-nominal mission planning shall be within the capabilities of cluster systems as defined in the Cluster Requirements Specification (Reference 2).

2.3.6.1 Backup Missions

The SL-3 backup missions are TBD.

2.3.6.2 CSM Crew Rescue Mission

2.3.6.2.1 Basic Considerations/Requirements

a) The mission will be committed only in response to an unplanned SL-3 mission event(s) resulting in circumstances under which the docked SL-3 CSM is disabled and cannot be used for safe return of the crew.

b) Rescue mission planning shall consider that the SL-3 CSM, docked to the axial MDA port, is totally disabled.

c) The primary objective of the mission shall be the safe return of the crew.

d) The mission flight hardware will consist of the SL-4 CSM/Launch Vehicle system, with the CM modified to permit launch and mission operations with two crewmen and return to earth with five crewmen.

e) The SL-4 CSM/Launch Vehicle system shall continue in a normal state of launch readiness preparations for the nominal SL-4 mission until a decision is made to commit the CSM rescue mission; then modification of the CM and total systems preparations for launch readiness shall be accelerated to the maximum extent practicable. The following times from rescue alarm to rescue vehicle ready to launch shall be used for mission planning:

Days From Launch of SL-3	Days to Rescue Vehicle Ready
0	48
14	34
28	26-1/2
42	16
56	10

f) A capability to jettison the disabled CSM from the SWS shall be provided. Pre-mission rescue planning shall consider three plans with respect to utilization of this jettison capability: 1) jettison the disabled CSM prior to TPI of the rescue vehicle, 2) retain the disabled vehicle until the rescue CSM docks at the MDA radial port and then jettison, and 3) leave the disabled vehicle docked to the axial port (i.e., don't jettison). For the actual rescue mission, a decision to utilize one of the aforementioned plans (or combinations thereof) will be made based on the specific situation utilizing mission rules.

2.3.6.2.2 Mission Profile Requirements

a) Trajectory planning for launch through insertion shall be similar to that for the nominal SL-4 mission, i.e., based on a northerly in-plane launch azimuth from KSC launch complex 39B for insertion into an 81 by 120-n mi orbit.

b) Total nominal mission duration shall be limited to five days from launch to recovery.

c) The OA shall be maneuvered to the Z-LV(R) mode to provide acquisition light support to the rescue CSM during rendezvous. The rescue CSM shall be capable of rendezvous without VHF ranging.

d) Maximum time from undocking to CM-SM separation shall be consistent with landing in the designated primary landing area and within available consumables.

e) The rescue SPS shall provide the primary deorbit capability with the SM RCS providing backup deorbit capability.

2.3.6.2.3 Docking and Attitude Requirements

The rescue vehicle shall dock to the axial port if the disabled CSM has been jettisoned or to the radial port if the disabled CSM has not been jettisioned. Additional docking and attitude requirements are as follows:

a) The OA shall execute two orbits of Z-LV(R) and return to the solar inertial attitude prior to docking. Axial docking of the rescue vehicle shall be performed in the solar inertial attitude. For docking at the radial port, the APCS shall roll the SWS 45 degrees clockwise (viewed in the +X direction) from the solar inertial attitude. This roll position shall be maintained for approximately 30 minutes (through completion of radial docking) and then the OA shall return to the solar inertial attitude.

b) Attitude control of the cluster during the time the rescue vehicle is docked shall be solar inertial with larger than usual attitude deadbands and/or higher than usual propellant consumption permissible. The following cluster configurations shall be considered:

   1) One CSM axially docked
   2) One CSM radially docked
   3) Two CSM's docked

   Choice of a system for cluster control during an actual rescue mission shall be made based on an assessment of the specific situation and systems capabilities.

c) The maximum length of time the rescue CSM may be docked to the MDA radial port shall be limited to 15 hours. The combined CSM/OWS shall be capable of sustaining five crewmen during this period.

2.3.6.2.4 <u>Other Mission Requirements</u>

a) Subsequent to committing the rescue mission and prior to rendezvous/docking operations of the rescue CSM, the SL-3 mission timeline for crew activities shall be re-planned to optimize the scientific data return.

b) Prioritized experimental data will be transferred to and returned with the rescue CSM consistent with time and other mission constraints including safe reentry and landing loads.

c) Provision shall be made for removal of ballast from the rescue CSM as required, transferred to and stowed in the SWS prior to undocking.

d) Circumstances permitting, the SWS shall be deactivated and prepared for nominal revisit prior to crew departure.

e) A backup capability (assumed axial CSM communications inoperative) shall be provided for communications between MCC-H personnel and crew aboard the OWS.

2.3.6.3 <u>Alternate Missions</u>

The SL-3 alternate missions are <u>TBD</u>.

DETAILED TEST
OBJECTIVES
SECTION 3

3.0 SL-3 MISSION DETAILED TEST OBJECTIVES

3.1 GENERAL

This section identifies the experiments that have been approved by the Associate Administrator for Manned Space Flight for implementation on the Skylab Program. In consonance therewith, OMSF, Headquarters Program Directive No. 43A has assigned experiments to specific missions, or, in lieu of stating specific assignments, has established other instructions for planning and performing the experiments. General guidelines for the scheduling of experiments in the mission flight plans are listed in Table 3.2-1 and are repeated verbatim from NASA Headquarters Program Directive 43A and approved changes thereto. Changes to the guidelines listed in the table require Level I (NASA Headquarters) approval.

This section shall constitute the controlling requirements necessary for fulfilling the mission objectives stipulated in Program Directive 43A. It is intended for use by those organizations concerned with flight planning, mission rules, procedures, data and support requirements and mission evaluations.

The percentages (where shown) with each Functional Objective (FO) in the DTO represent a weighted value of the FO within the DTO. The sum of FO weights totals 100 percent. The weights represent that percentage of the DTO which is completed when the respective FO has been satisfied. Where percentages are not indicated, they are TBD. Those weighted values without an asterisk were assigned by the Skylab Program Office at the Manned Spacecraft Center (MSC) pending receipt of official values from Principal Investigators. Functional Objectives with asterisks were assigned by the Principal Investigators.

3.1.2 Experiment Assignments Table

3.1.2.1 Format

Table 3.2-1 places each experiment in one of two groups: inflight experiments and pre and postflight experiments. The inflight experiments are divided further into three subgroups:

a) Passive Experiments - - experiments whose inflight crew support requirements are either insignificant or non-existent.

b) Group-related Experiments - - experiments that require significant inflight crew support and which are closely related to each other either through common study of the flight crew or by integration into a single subsystem. Three sets of group-related experiments are assigned in Table 3.2-1: Medical, Solar Astronomy (ATM) and Earth Resources (EREP).

c) Corollary (Individual) Experiments - - the remaining experiments that require significant inflight crew support and which are not as closely related to each other as are the experiments addressed in b, above.

3.1.2.2 Flight Scheduling Precedence (FSP)

The flight scheduling precedence as assigned by Program Directive 43A is a number (which ranges from 100 to 450) assigned to each of the individual experiments as a measure of that experiment's relative value to the program objectives. It has only a minor role in pre-mission planning, as Section 2.3.4.3.2 indicates. In real time mission planning, however, it may have a substantially more important function. Guidelines for the use of the flight scheduling precedence in real time planning are developed in Section 2.3.4.4.

Table 3.2-1. Skylab Experiment Assignments

Experiment Group	Experiment Number	Experiment Title	Assignment Instructions	FSP
Preflight and Postflight	M078	Bone Mineral Measurement (B)	These experiments are assigned to Missions SL-1/SL-2, SL-3, and SL-4.	N/A
	M111	Cytogenic Studies of Blood		
	M112	Man's Immunity -- In Vitro Aspects		
	M113	Blood Volume and Red Cell Life Span		
	M114	Red Blood Cell Metabolism		
	M115	Special Hematologic Effects		
Passive	M415	Thermal Control Coatings	This experiment is assigned to the SL-2 flight (the experiment hardware is mounted on the SL-2 launch vehicle).	N/A
	S071	Circadian Rhythm -- Pocket Mice	These experiments are assigned to Mission SL-3 (the experiment hardware is integrated into CSM 117).	
	S072	Circadian Rhythm -- Vinegar Gnat		
	S150	Galactic X-Ray Mapping (B)	This experiment is assigned to Mission SL-4 (the experiment hardware is mounted on the SL-4 launch vehicle).	
	T018	Precision Optical Tracking	Cancelled.	

Table 3.2-1. Skylab Experiment Assignments (Continued)

Experiment Group	Experiment		Assignment Instructions	FSP
	Number	Title		
Medical	M071	Mineral Balance	These experiments are assigned to Missions SL-1/SL-2, SL-3, and SL-4.	N/A
	M073	Bioassay of Body Fluids		
	M074	Specimen Mass Measurement		
	M092	In-Flight Lower Body Negative Pressure		
	M093	Vectorcardiogram		
	M151	Time and Motion Study		
	M171	Metabolic Activity		
	M172	Body Mass Measurement		
	M131	Human Vestibular Function	This experiment is assigned to Missions SL-1/SL-2 and SL-3.	
	M133	Sleep Monitoring	This experiment shall be performed in 15 sleep-sessions on Mission SL-1/SL-2, and in 21 sleep-sessions on Mission SL-3.	

Table 3.2-1. Skylab Experiment Assignments (Continued)

Experiment Group	Experiment Number	Experiment Title	Assignment Instructions	FSP
ATM	S052	White Light Coronagraph	These experiments are assigned to Missions SL-1/SL-2, SL-3, and SL-4.	N/A
	S054	X-Ray Spectrographic Telescope		
	S055	Ultraviolet Spectrometer (A)		
	S056	Dual X-Ray Telescope		
	S082	Ultraviolet Spectrograph/ Heliograph		
EREP	S190	Multispectral Photographic Facility	These experiments are assigned to Missions SL-1/SL-2, SL-3, and SL-4.	N/A
	S190A	Multispectral Photographic Cameras		
	S190B	Earth Terrain Camera		
	S191	Infrared Spectrometer		
	S192	Multispectral Scanner		
	S193	Microwave Radiometer/ Scatterometer and Altimeter		
	S194	L-Band Radiometer		

Table 3.2-1. Skylab Experiment Assignments (Continued)

Experiment Group	Experiment		Assignment Instructions	FSP
	Number	Title		
Corollary (Individual Experiments)	D008	Radiation in Spacecraft	Four active dosimeter surveys shall be performed on Mission SL-1/SL-2 (the experiment is integrated in CSM 116).	240
	D021	Expandable Airlock Technology (B)	Cancelled.	
	D024	Thermal Control Coatings	Two sample panels shall be retreived on Mission SL-1/SL-2; the remaining two sample panels shall be retreived on either SL-3 or SL-4.	260
	M479	Zero Gravity Flammability (B)	A total of five sets of test cycles shall be performed just prior to the termination of the SL-4 mission.	280
	M487	Habitability/Crew Quarters	This experiment shall be performed on Missions SL-1/SL-2, SL-3, and SL-4.	450
	M509	Astronaut Maneuvering Equipment	Each of three crewmen shall perform a set of four experiment runs (three unsuited and one suited). One set of runs shall be performed by one crewman on Mission SL-1/SL-2. The remaining two sets of runs shall be performed by two crewmen on SL-3, or by one crewman on SL-3 and one crewman on SL-4.	300

Table 3.2-1. Skylab Experiment Assignments (Continued)

Experiment Group	Experiment Number	Experiment Title	Assignment Instructions	FSP
Corollary (Individual Experiments)	M512 M551 M552 M553 M554 M555	Materials Processing Facility Metals Melting Exothermic Brazing Sphere Forming Composite Casting Gallium Arsenide Crystal Growth	M551, M552, M553, and M555 shall be performed on Mission SL-1/SL-2. M554 may be performed on either SL-1/Sl-2 or SL-3.	390 390 390 390 390 390
	M516	Crew Activities and Maintenance Study	This experiment is assigned to all three missions. The fine manipulation maintenance tasks shall be performed on Mission SL-4.	110
	S009	Nuclear Emulsion	One nuclear emulsion detector package shall be exposed and retrieved on Mission SL-1/SL-2.	220
	S015	Zero Gravity Single Human Cells	This experiment is assigned to Mission SL-1/SL-2 (the experiment hardware is integrated in CSM 116).	230
	S019	Ultraviolet Stellar Astronomy	One hundred fifty data exposures on 36 starfields shall be obtained on Mission SL-1/SL-2. Another 150 data exposures on 36 starfields shall be obtained on either SL-3 or SL-4.	290
	S020	X-Ray/Ultraviolet Solar Photography	Ten data exposures on the quiet sun shall be obtained on each of two missions; ten data exposures on the active sun shall be obtained on each of the same two missions. The experiment shall be performed on any two of the three missions.	130

Table 3.2-1. Skylab Experiment Assignments (Continued)

Experiment Group	Experiment		Assignment Instructions	FSP
	Number	Title		
Corollary (Individual Experiments)	S063	Ultraviolet Airglow Horizon Photography	A total of 600 data exposures shall be obtained on any one mission, or on any two missions, or on three missions.	120
	S073	Gegenschein/Zodiacal Light	Thirty-six photometer data scans shall be performed on each of Missions SL-1/SL-2, SL-3, and SL-4.	270
	S149	Particle Collection	Four sets of detector cassettes shall be deployed, exposed, and retrieved. One set shall be exposed during the unmanned portion of Mission SL-3, and one set shall be exposed on the manned portion of SL-3. A third set shall be exposed on the unmanned portion of SL-4. The fourth set may be exposed on either Mission SL-2 or the manned portion of SL-4.	140
	S183	Ultraviolet Panorama	Thirty-five data exposures shall be obtained on Mission SL-1/SL-2; another 35 data exposures shall be obtained on either SL-3 or SL-4.	250
	T002	Manual Navigation Sightings (B)	This experiment shall be performed by one or more crewmen on one, two, or three missions, at the convenience of the crew and on a noninterference basis with the other experiments.	100

Table 3.2-1. Skylab Experiment Assignments (Continued)

Experiment Group	Experiment		Assignment Instructions	FSP
	Number	Title		
Corollary (Individual Experiments)	T003	In-Flight Aerosol Analysis	This experiment shall be performed on Missions SL-1/SL-2, SL-3, and SL-4.	400
	T013	Crew Vehicle Disturbance	This experiment shall be performed in the OWS on any single mission.	210
	T020	Foot Controlled Maneuver Unit	Each of two crewmen shall perform a set of five experiment runs (three unsuited and two suited). The experiment shall be performed by two crewmen on any one mission, or by one crewman on one mission and by another crewman on a subsequent mission. At least one of the crewmen who perform T020 shall also perform one set of experiment runs on M509.	200
	T025	Coronagraph Contamination Measurement	A total of 150 data frames shall be exposed on Mission SL-1/SL-2.	180
	T027	ATM Contamination Measurement	One sample array shall be deployed, exposed, and retrieved on Mission SL-1/SL-2. The program of photometer data scans shall be performed on each of Missions SL-1/SL-2, SL-3, and SL-4.	380

MEDICAL DTO'S

3.2 EXPERIMENT DETAILED TEST OBJECTIVES

3.2.1 Medical Experiments

3.2.1.1 General

A series of medical experiments will be carried out on Skylab mission SL-3 to determine man's ability to live and work in space for extended periods.

The data will be used to determine the effects on the crew resulting from a space flight of up to 56 days duration and to determine if a subsequent mission of greater than 56 days duration is feasible and advisable.

3.2.1.2 Medical DTO's

The specific objectives of the medical experiment DTO's are to determine and evaluate man's physiological responses and aptitudes in space under zero gravity conditions and his post mission adaptation to the terrestrial environment.

The inflight medical experiments assigned to the Skylab SL-3 mission are:

M071	Mineral Balance
M073	Bioassay of Body Fluids
M074	Specimen Mass Measurement
M092	Lower Body Negative Pressure
M093	Vectorcardiogram
M131	Human Vestibular Function
M133	Sleep Monitoring
M151	Time and Motion Study
M171	Metabolic Activity
M172	Body Mass Measurement

The DTO's are presented in alphanumeric order on the following pages.

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Experiment M071 — MINERAL BALANCE

Obtain data on metabolic constituents.

Purpose and Background

The purpose is to determine the effects of space flight on the muscle and skeletal body systems by quantitative assessment of the gains and losses of pertinent biochemical (metabolic) constituents.

Continuous losses of calcium and nitrogen (such as those which occur in ground-based simulation studies) during long duration missions might result in impairment of skeletal and muscle integrity and the formation of renal calculi. Identification of the rates of actual deterioration will allow specific countermeasures (such as institution of exercise routines and the manipulation of dietary constituents) to be taken on later flights. Data from this experiment will provide for definition and quantitative assessment of the gains and losses from the body of various biochemical constituents, particularly water, calcium, and nitrogen, during space flight.

Functional Objectives

FO 1)	Measure and record the total diet residue, menu deviations, and fluid intake for each crewman throughout the mission.	(20%)
FO 2)	Collect, identify, measure, and process all urine eliminations of each crewman throughout the mission.	(20%)
FO 3)	Collect, identify, measure, process, and store for return a homogeneous urine sample of at least 45 ml every 24 hours for each crewman, throughout the mission.	(20%)
FO 4)	Collect, identify, measure, process, and store for return all fecal eliminations (and vomitus) of each crewman throughout the mission.	(20%)
FO 5)	Measure and record body mass of each crewman once every 24 hours throughout the mission.	(20%)

Test Conditions

FO 1) Each crewman will consume a nominal menu and record any deviations. If deviations occur, recommended menus for subsequent days (based on ground computer support) will be forwarded to the crew.

The Specimen Mass Measurement Device (SMMD) from Experiment M074 (Specimen Mass Measurement) will be used to establish the mass of unconsumed food with sufficient accuracy to determine the daily food intake within 2 percent per procedures contained in the M074 Experiment Operations Handbook (EOH). The SMMD will be calibrated prior to its first use in support of Experiment M071 and the calibration data will be recorded.

Individual water drinks must be known to within 2 percent. Water added to rehydrate food must be known to within 2 percent.

FO 2) All urine passed in flight must be collected and sampled. Voids shall be accumulated over each 24-hour period and maintained at 10° ±5°C (50° ±9°F). After termination of the 24-hour urine pool collection, a 120 (+10, -0)-ml homogeneous sample (45 ml for M071 and 75 for M073) shall be withdrawn and treated so as to preserve the constituents required. Provisions must be made for identification of samples as to crewmember, date, time, and volume of 24-hour pool. All samples shall be stored for return.

The Orbital Workshop (OWS) Habitability Support System (HSS) will provide for the collection, measurement, and processing of the urinary void per procedures contained in the Multiple Docking Adapter (MDA), Airlock Module (AM), and OWS Operation Handbooks.

Voids should be accumulated in 24-hour cycles for each crewman. Except for unusual circumstances, the 24-hour time period will be regularized by making the closeout time period within 30 minutes of the same hour each day.

FO 3) Volume measurements of the 24-hour urine pool shall be accurate to within 2 percent.

FO 4) All fecal matter will be collected, mass measured within 2 percent, identified (crewman, wet mass, and time) and processed for return per procedures contained in the MDA, AM, and OWS Operation Handbooks.

Two types of dye markers pills will be ingested at 6 day intervals in alternating sequence.

Any vomitus passed will be collected, mass measured within 2 percent, identified (crewman, wet mass, and time) and processed for return per procedures contained in the M074 EOH and the MDA, AM, and OWS operation Handbooks.

FO 5) Body mass of each crewman will be measured within 1 percent and recorded once every 24 hours after first urine voiding following the sleep period. This function will be accomplished using the Body Mass Measurement Device (BMMD) from Experiment M172 (Body Mass Measurement) per procedures contained in the M172 EOH. The BMMD will be calibrated prior to its first use in support of M071 and the calibration data will be recorded.

FO 1)
FO 4)
FO 5) No SMMD or BMMD calibration will take place during spacecraft linear or angular maneuvers. If it is determined that the spacecraft accelerated during an SMMD or BMMD calibration operation, that operation must be repeated.

FO 1) FO 2) FO 3) FO 4) The CM must support this experiment during ascent and recovery phases of the mission as well as during orbital operations. Measurement and preservation procedures will be completed in the OWS or recovery ship as required.

FO 1) FO 2) FO 3) FO 4) FO 5) The Greenwich Mean Time (GMT) of operation for Experiment M092 (Inflight Lower Body Negative Pressure), Experiment M171 (Metabolic Activity), extravehicular activity (EVA), and general crew activities will be provided together with the respective crewman identification.

Required telemetry measurements will be recorded on the AM recorder for subsequent playback and transmission to the ground.

The astronaut log book containing recorded experiment data will be returned at the end of the mission.

Records of general crew activity, temperature, relative humidity profile throughout the OA, crew radiation exposure data, and OA partial pressure will be obtained.

Success Criteria

FO 1) Astronaut logs and/or voice records sufficient to determine the total diet residue, menu deviations, and fluid intake throughout the mission shall be processed and returned to the Principal Investigator for analysis.

FO 2) All urine passed in flight shall be collected, volume measured, identified (crewman, volume, and time), processed, and the subsequent data returned to the Principal Investigator for analysis.

FO 3) Daily 45-ml homogeneous urinary samples from each crewman, (pooled with 75 ml collected in accordance with the requirements of Experiment M073) identified as to crewman, volume and time and properly preserved, shall be returned to the Principal Investigator for analysis.

FO 4) All feces and vomitus passed in flight shall be collected, mass measured, identified (crewman, wet mass, and time), processed and returned to the Principal Investigator for analysis.

FO 5) Data sufficient to determine the body mass of each crewman once every 24 hours shall be returned to the Principal Investigator for analysis.

Evaluation

FO 1) FO 2) FO 3) FO 4) FO 5) At the Manned Spacecraft Center the Principal Investigator will process and analyze all returned samples and will study supporting data from pre and postflight tests. (Astronaut records, selected telemetry data, M074, M092, M171, and M172 operational data)

Data Requirements

Refer to Appendix A.

Experiment M073

BIOASSAY OF BODY FLUIDS

Study body fluid data from related experiments.

Purpose and Background

The purpose is to evaluate the endocrinological adaptation resulting from extended exposure to space flight environment.

This experiment will identify changes in hormonal and associated fluid and electrolyte parameters. These changes will be reflected in the blood and urine of the crewmen participating in the Skylab flight. Postflight evaluation will indicate the rate(s) of readaptation to the preflight content levels. Preflight data will establish baseline norms for understanding in-flight and postflight changes. Data will be developed by analyzing urine and blood samples and related fluid/electrolyte components. Accurate evaluation of these data will require the control and specific analysis of dietary and fluid ingestion.

Functional Objectives

FO 1) Collect, identify, measure, process, and store for return, a homogeneous urine sample of at least 75 ml every 24 hours for each crewman, throughout the mission.

Test Conditions

FO 1) No flight hardware will be supplied by this experiment.

No in-flight data will be generated directly by this experiment.

All urine passed in flight will be collected, volume measured within 2 percent, identified (crewman, volume and time), processed, and a sample stored and returned. The Orbital Workshop (OWS) Waste Management System (WMS) will provide for the collection, measurement and processing of the urinary void per procedures contained in the Multiple Docking Adapter (MDA), Airlock Module (AM), and OWS Operations Handbooks.

Voids shall be accumulated for each crewmember over each 24-hour period and maintained at 10° $\pm$5°C (50° $\pm$9°F). Within 3 hours after termination of the 24-hour urine pool, a 120 (+10, -0)-ml homogeneous sample (75 ml for M073 and 45 ml for M071) shall be withdrawn for each crewmember and frozen below -19.1°C (-2.4°F).

Voids should be accumulated in 24-hour cycles for each crewman. The 24-hour time period will be regularized by making the closeout time within 30 minutes of the same hour each day.

Sample storage in the Command Module (CM) shall be performed in a manner which will preclude degradation of the constituents of interest. Urine samples shall be stored in a passive freezer which maintains the maximum temperature below -10°C (14°F) at time of recovery.

The CM must support this experiment during ascent and recovery phases of the mission as well as during orbital operations. Measurement and preservation procedures will be completed in the OWS or recovery ship as required.

The Greenwich Mean Time (GMT) of operation for Experiment M092 (Inflight Lower Body Negative Pressure), Experiment M171 (Metabolic Activity), extravehicular activity (EVA), and general crew activities will be provided together with the respective crewman identification.

Required telemetry measurements will be recorded on AM recorder for subsequent transmission to the ground.

The astronaut log book will be returned after the mission and will contain operational data from Experiment M071.

Records of general crew activity temperature and relative humidity profile throughout the OA will be obtained.

Calibration data from Experiments M074 and M172 will be provided.

Success Criteria

FO 1) All urine passed in flight shall be collected, volume measured (crewman, volume and time) and the subsequent data returned to MSC for analysis by the Principal Investigator.

Daily 75-ml homogeneous urinary samples from each crewman (pooled with the 45-ml collected in accordance with the requirements of Experiment M071), identified (crewman, volume, and time) and properly preserved, shall be returned to the Manned Spacecraft Center (MSC) for analysis by the Principal Investigator.

Data on food consumption, fluid intake, and crewmember weight shall be obtained postflight by the Principal Investigator from the M071 Experiment Log.

Evaluation

FO 1) The Principal Investigator will study data returned from supporting experiments, from analyses of the returned urine and from pre and postflight tests in order to evaluate endocrinological adaptation. (Telemetry data, M071, M074, M172, M092, and M171 experiments and operational data, other data)

Data Requirements

Refer to Appendix A.

Experiment M074 SPECIMEN MASS MEASUREMENT

Measure specimen mass in zero gravity.

Purpose and Background

The purpose is to measure the mass of various objects in the absence of gravity.

A set of known small masses will be used to calibrate the Specimen Mass Measurement Device (SMMD) on earth (preflight). Identical masses will be used in the orbital environment to verify the calibration in the absence of gravity. The objectives of this experiment are to: (a) demonstrate mass measurement without gravity, (b) validate theoretical characteristics of the device, and (c) support biomedical experiments requiring mass determination.

Functional Objectives

FO 1) Perform SMMD calibration validations using preflight calibrated masses weighing from 50 grams to 900 grams.

Test Conditions

FO 1) The calibration measurements will be taken on each of the two SMMD's (early, middle, and late in the mission).

Calibration data (timer display, SMMD temperature, comments on SMMD operation, Greenwich Mean Time, specimen identification, and SMMD unit identification) will be logged, transmitted by voice to the ground, and the log book returned in the Command Module.

Calibration validation will be accomplished per procedures contained in the M074 Experiment Operations Handbook.

The total calibration validation procedure will consist of the following:

a) Temperature measurement readout
b) Calibration measurement consisting of 0, 50, 150, 400, 500, 750, 850, 900, and 0 grams
c) Temperature measurement readout

Each mass will be measured five times.

Calibration data will be transmitted by voice to the ground and shall be made available to the Principal Investigator within 48 hours after each calibration.

SMMD operations will be performed only when the ambient temperature is between 65°F and 80°F.

SMMD measurements will not be made during planned maneuvers. Any measurements made during inadvertent shocks or accelerations shall be repeated.

Success Criteria

FO 1) A SMMD calibration on each of two units using preflight calibrated masses weighing from 50 grams to 900 grams shall be performed three times during the mission.

Evaluation

FO 1) The Principal Investigator will analyze all returned flight data, perform calculations, and prepare calibration curves. The Principal Investigator will transmit plotted curves as required to the Principal Investigators of the M071 and M073 experiments. (Astronaut records)

Data Requirements

Refer to Appendix A.

Experiment M092

INFLIGHT LOWER BODY NEGATIVE PRESSURE

Obtain cardiovascular data in a zero-gravity environment.

Purpose and Background

The purpose is to detect and measure the degradation in cardiovascular function resulting from space flight.

Crewmen of Projects Mercury and Gemini, as well as subjects of recumbency and immersion studies, exhibited a reduced orthostatic tolerance when exposed to the stress of passive tilt table studies during the postflight, postrecumbency or postimmersion period. Characteristic features of this orthostatic response are cardioacceleration, lower extremity pooling of blood, and decreased pulse pressure. Severe orthostatism invariably results in syncope (loss of consciousness). Additionally, loss of body water (evidenced by weight loss), decrease in red blood cell mass, decrease in red blood cell survival time, and increase in red blood cell fragility have been demonstrated postflight in Gemini flight crews. Therefore, it is significant to future manned mission safety to detect and measure space flight cardiovascular deconditioning (degradations in cardiovascular function which may impair manned performance during space flight or after return to earth's environment) and establish the time course of these changes.

Functional Objectives

FO 1) Perform lower body negative pressure (LBNP) experiment using an LBNP device.

Test Conditions

FO 1) The experiment will be performed using each of the three astronauts as subjects per procedures contained in the M092 Experiment Operations Handbook. One astronaut will be an observer for each run.

Each subject will participate in the LBNP tests at approximately the same time each day, every third day during the mission.

It is highly desirable that at least 2 hours and mandatory that at least 1 hour intervene between eating and the performance of this experiment.

If schedule constraints do not allow a 2 hour interval, the food ingested between 1 and 2 hours prior to the experiment should be low in carbohydrate content.

It is desirable that M092 be followed immediately by M093 (Vectorcardiogram) or, when applicable, by M171 (Metabolic Activity) in order to reduce requirements for subject instrumentation.

Although sequential performance of M092, M093 or M171 is desirable, M092 must in all instances be the first experiment in the sequence.

These tests will not be preceded by vigorous exercise, nor should they be performed while unduly fatigued.

These tests must not be conducted within 2 hours after Experiment M171.

Air motion in the vicinity of the experiment shall be controlled from 15 ft/min to 100 ft/min.

Air velocity will be ascertained using the velometer from experiment M487 (Habitability/Crew Quarters).

The experiment operational procedure will consist of three phases:

a) 5-minute control phase

b) 15-minute negative pressure phase

c) 5-minute recovery phase

Vectorcardiogram, body temperature, and leg plethysmograph recordings will be made continuously throughout the procedure.

Blood pressure will be measured every 30 seconds.

The subject crewman will remain immobile during the 25 minutes that recordings are being made.

There will be a minimum of 17 in-flight sessions for each crewman.

This experiment shall commence as soon as possible after Orbital Workshop (OWS) activation.

The test will be performed at an OWS ambient temperature of 67° to 78°F at 5 psia.

There must be no maneuvering of the spacecraft that will cause accelerations in excess of 10^{-4}g's during experiment operation.

Portions of this experiment may be covered photographically as required by Experiment M151 (Time and Motion Study).

Comments by subject and observer will be recorded during conduct of the experiment.

Voice observations will be required on the presence or absence of symptoms and/or physical signs resulting from the experiment.

Required telemetry measurements and voice data for each LBNP session will be transmitted on a real time basis when ground coverage permits; otherwise the data will be recorded for subsequent playback and transmission. Dumps of recorded data will be initiated at least once per day.

Operational data from Experiments M093, M171, and M172 will be provided.

Preflight and postflight data on M092 will be required for evaluation and correlation.

Success Criteria

FO 1) Each crewman shall participate in a minimum of 17 LBNP tests using the LBNP device.

Evaluation

FO 1) The Principle Investigator will analyze the data and issue a series of technical reports on the experiment. The reports will be issued at 1, 3, 4, and 8 months after the flight. (Telemetry data, astronaut records, photographs, other data)

Data Requirements

Refer to Appendix A.

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Experiment M093 — VECTORCARDIOGRAM

Obtain electrocardiograph data in a zero-g environment.

Purpose and Background

The purpose is to measure electrocardiographic potentials in a zero-g environment.

The stresses of space flight produce changes in the cardiac function of the astronaut which are reflected in electrical potential variations on the surface of the body. This experiment is designed to measure these electrocardiographic potentials of each astronaut during the weightless period and the preflight and postflight periods by methods that will allow precise quantitative measurement of the changes that occur.

Vectorcardiograms (VCG's) taken on each astronaut at regular intervals during space flight will be compared with VCG's taken prior to flight and postflight. Changes in the VCG patterns will be correlated with anatomical and functional changes in the heart using computer techniques for data reduction and analysis.

Functional Objectives

FO 1) Obtain VCG's on each astronaut every third day during the mission.

Test Conditions

FO 1) VCG's will be taken on each astronaut commencing as soon as possible after Orbital Workshop (OWS) activation every third day during the mission per procedures contained in the M093 Experiment Operations Handbook.

VCG data from eight in-flight performances of Experiment M171 (Metabolic Activity) by each crewman (if acquired) will be substituted for eight in-flight performances of M093. The M171 protocol will govern these performances.

Three channels of data will be obtained from seven voltages recorded simultaneously from eight electrodes (one electrode is a ground) placed on the astronauts' body. Heart rate data is derived from any one of these channels.

The tests will be performed at an OWS ambient temperature of 67° to 78°F at 5 psia.

The experiment will not be performed less than one half hour after vigorous exercise or performance of M131 (Human Vestibular Function).

It is desirable that at least 2 hours intervene between eating and performance of the experiment.

It is desirable that this experiment be performed immediately after completing M092 (Inflight Lower Body Negative Pressure).

VCG's for each experiment session will be taken as follows:

a) Rest - baseline data	5 minutes
b) Exercise period	2 minutes
c) Post exercise control data	10 minutes

A bicycle ergometer from Experiment M171 will be used by the subject for the exercise period required for the vectorcardiogram.

Portions of this experiment may be covered photographically as required by Experiment M151 (Time and Motion Study).

Required telemetry measurements and voice data for each experiment session will be transmitted on a real time basis when ground coverage permits, otherwise the data will be recorded for subsequent playback and transmission.

Greenwich Mean Time will be required with the instrumentation data and with the recorded voice comments.

Operational data from Experiments M092 and M171 will be provided.

Preflight and postflight data on M093 will be required for evaluation and correlation.

Success Criteria

FO 1) Vectorcardiograms shall be obtained on each astronaut every third day during the mission.

Evalaution

FO 1) The Principal Investigator will analyze the data and issue reports. (Telemetry data, astronaut records, photographs, other data)

Data Requirements

Refer to Appendix A.

Experiment M131

HUMAN VESTIBULAR FUNCTION

Obtain data on semicircular canal stimulation and spatial localication.

Purpose and Background

The purpose is to determine the effects of prolonged absence of gravity on an astronaut's susceptibility to Coriolis force and on his judgment of spatial localization.

Evaluation of related hypotheses includes the following significant factors:

If there is no measured acute change in motion sensitivity in any of the crew, then the results would not be consistent with transient zero-g aircraft studies. In this case, these types of studies may be de-emphasized for future usefulness, but a greater need for future studies on orbiting and rotating spacecraft would be indicated.

If increased susceptibility is accompanied by decreased canal threshold, then an etiological (intralabrinthine) mechanism may be defined which would indicate the need for artificial gravity in terms of otolithic modulating activity.

If there is increased susceptibility but no change in canal thresholds, then the importance of functional interaction of canals and otoliths with other physiological systems (cardiovascular, etc.) in the production of behavior decrement or malaise would be demonstrated.

If there is no change in susceptibility but a definite change in canal thresholds, then insufficient time for the effect to manifest itself in whole body response or the role of compensatory mechanisms to act would be indicated.

Functional Objectives

FO 1) Perform Motion Sensitivity (MS) tests using the Rotating Litter Chair (RLC) in the rotating mode to determine susceptibility to Coriolis forces as a function of time in weightlessness. In order to supplement these data, measure semicircular canal response thresholds by conducting Oculogyral Illusion (OGI) threshold tests. (60%)*

FO 2) Perform spatial localization tests using the Otolith Test Goggles (OTG), the rod and sphere device, and the RLC in the static mode. (40%)*

Test Conditions

FO 1) The OGI and MS test will be performed on two crewmen six times during the mission per procedures contained in the M131 Experiment Operations Handbook (EOH).

The combined OGI and MS tests will be conducted no closer than every other day and will be equally time spaced where possible.

During the first experiment session involving rotation and with one subject only, photograph the RLC setup procedures, the subject entering the chair, the attachment and adjustment of the OTG, the initial portion of the OGI test and TBD trial runs to determine OGI threshold.

It is highly desirable to perform the OGI test immediately prior to the MS test.

Both crewmen will perform as experiment subjects within a 16-hour period.

During the MS tests, responses of each of the two subject crewmen will be sequence photographed for the first, third, and sixth experimental sessions. The camera will be started when the subject initiates the first head movement sequence and will be stopped when the Malaise IIa level is reached. Approximately 60 minutes of film time will be required to cover all MS tests.

FO 2) The spatial localization tests will be performed on all crewmen once early in the mission, once at midmission and once late in the mission per procedures contained in the M131 EOH.

A select portion of the spatial localization measurement procedures will be filmed with only one subject and during only one session (preferably the second). The total film time required will be approximately 20 minutes.

All three crewmen will perform as experiment subjects within a 16-hour period.

FO 1)
FO 2) The Orbital Workshop (OWS) ambient temperatures for the experiment should lie within a range of 67-78°F at 5.0 psia (70-80°F at 14.7 psia).

Air motion control shall be from 15 ft/min. to 100 ft/min.

The spacecraft will not be maneuvered during experiment operations.

Experiment procedures shall be interrupted during spacecraft accelerations greater than 0.0003 g's or 0.001 degrees/sec^2 about the spacecraft X-axis and 0.002 degrees/sec^2 about the spacecraft Y and Z-axes.

The OWS lighting will be adequate, while the experiment is in progress, to allow the observer to recognize color changes in the subject's face and to read applicable instrumentation.

Spatial localization (static) tests shall not be performed on the same day as rotating tests.

No dynamic testing shall be done until 1 hour after completion of a meal.

All men should go through the same test on any one day rather than mixing tests.

Experiment data will be recorded on tape and telemetered to ground for analysis.

Greenwich Mean Time (GMT) is required with the instrumentation data and with the recorded voice comments of subject and observer relative to operations and conduct of experiment.

The ground will command data dumps from the Airlock Module (AM) recorder.

The OTG will be returned for postflight calibration and tests.

Success Criteria

FO 1) All OGI and MS test data shall be returned for 12 test performances (six performances for two crewmen).

FO 2) All spatial localization test data shall be returned for nine test performances (three performances for three crewmen).

Evaluation

FO 1)
FO 2) The Principal Investigator will analyze and evaluate the experimental data acquired and issue technical reports as appropriate. (Telemetry data, astronaut records, photographs, other data)

Data Requirements

See Appendix A.

Experiment M133

SLEEP MONITORING

Obtain data on sleep patterns in a space environment.

Purpose and Background

The purpose of this experiment is to objectively evaluate sleep quantity and quality during prolonged space flight.

It has been shown that subjective assessment of ones' sleep quality is frequently inaccurate. A method for objectively evaluating sleep is to determine the electrical activity of the brain and the motions of the eyes during the sleep period. On-board analysis of the electroencephalographic (EEG), electro-oculographic (EOG) activity, and near real time telemetry of analysis results will provide an objective progressive record of sleep throughout the flight.

It has been demonstrated that disrupted patterns of sleep are associated with modified performance capability. Accurate information regarding sleep in the space environment is therefore of practical significance and may find useful application in future mission planning.

Functional Objectives

FO 1) Obtain EEG, EOG, and headmovement data from a subject continuously during an 8-hour sleep period for 21 scheduled sleep periods.

Test Conditions

FO 1) EEG, EOG, and headmovement data will be taken during 21 regularly scheduled 8-hour sleep periods. The flight recording schedule of the sleep periods is presented below:

Day	Recording	Day	Recording	Day	Recording
1		20	X	39	
2		21		40	
3	X	22		41	X
4	X	23	X	42	
5	X	24		43	
6		25		44	X
7		26	X	45	
8	X	27		46	
9		28		47	X
10		29	X	48	
11	X	30		49	
12		31		50	X
13		32	X	51	
14	X	33		52	X
15		34		53	X
16		35	X	54	X
17	X	36		55	
18		37		56	
19		38	X		

Experiment preparation and post operation tasks will be accomplished per procedures contained in the M133 Experiment Operations Handbook (EOH).

Recordings will be made during the regularly scheduled sleep periods and the analyzed data will be telemetered to ground in near real-time.

Astronaut log entries will be made following each monitored sleep period and the log book returned after the mission.

Two reels of magnetic tape containing sleep data will be returned after the mission.

Success Criteria

FO 1) Recordings of EEG, EOG, and headmovement data shall be obtained for twenty-one 8-hour regularly scheduled sleep periods.

Evaluation

FO 1) The Principal Investigator will analyze in detail the recorded on-board data to assess any sleep variations encountered in flight. (Telemetry data, astronaut records, other data)

Data Requirements

Refer to Appendix A.

C.2

Experiment M151 TIME AND MOTION STUDY

Obtain photographs of crew activity.

Purpose and Background

The purpose is to study the adaptability, mobility, fine and gross motor activities of crewmen and effects of other variables on motor activity in work and task performance during a spaceflight of up to 56 days duration.

Skylab film will produce time and motion data directly applicable to the Skylab Program and will be especially valuable for future programs. Specifically, they are pertinent to:

a) Providing an insight into the nature of work performed in space flight, the variables affecting the time and motion patterns required to perform specific tasks, and valuable information for the design of procedures, methods, tasks and equipment for future missions.

b) Providing supplemental pictorial information (in conjunction with planned metabolic activity, extravehicular activity, and other studies) regarding the effectiveness of restraint systems utilized and energy cost of astronaut movements.

c) Determining the training time and level of training which will be required of astronauts to perform certain in-flight tasks, especially portions of approved experiments.

d) Determining the time and resource requirements which may be anticipated for ground-based training (including neutral buoyancy) and zero-g training flights for specific types of astronaut activities.

e) Determining the time requirements for the conduct of specific types of inflight activities and thereby provide an input to mission planning for future flights.

Functional Objectives*

FO 1) Photograph two crewmen during donning of Vectorcardiogram (VCG) sensors, harness and belt; translation to and from, and ingress and egress into and out of confined enclosures; including at least one of the crewmen mounting, applying restraints and operating the ergometer.

FO 2) Photograph crew activity during the deployment and retrieval of large (both size and mass) experiment hardware, including translation, installation, activation, transfer from one location to another, removal, and stowage of the hardware.

FO 3) Photograph crew activity during the deployment and retrieval of medium size experiment hardware, including translation, installation, activation, removal, and stowage of the hardware.

FO 4) Photograph two crewmen during activity pertinent to donning and doffing of the pressure garment assembly.

FO 5) Photograph crew activities associated with the periodic maintenance of experiment hardware which requires the removal and installation of assemblies and the donning of such hardware, when appropriate.

† FO 6) Photograph crewman during activities pertinent to food preparation and measurement of food residue.

*Each of the above functional objectives have equal priority with respect to satisfying the experiment requirements. Since this experiment is dependent upon scheduling requirements of other experiments, a percentage value has not been assigned to each functional objective.

†This FO will not be scheduled on SL-3.

Test Conditions

FO 1) thru FO 5) The crewmen will perform and photograph activities in accordance with procedures contained in the M151 Experiment Operations Handbook.

A sufficient number of performances of selected crew activities (see following Table of Test Conditions) will be photographed to provide data for study of the potential variables which satisfy the functional objectives of M151. If one of the primary test conditions is not performed for any reason, the M151 Principal Investigator will be available for consultation on a real time basis for selection of an alternate or contingency activity source.

During experiment operations, a voice record will be made identifying the experiment, crewmen, cassette, camera settings and Greenwich Mean Time.

Thermal requirements for film storage will be 80°F maximum with short periods allowable at 90°F.

Atmosphere requirements for film storage will be 75 percent relative humidity maximum.

Inflight TV will be obtained if available (real time and kinescopes).

Postflight crew debriefing data will be obtained for evaluation and correlation.

Success Criteria

FO 1) thru FO 5) Actual performance and photography of in-flight performances of crew activity in accordance with Table of Test Conditions.

Evaluation

FO 1) thru FO 5) The pictorial data of crew activity obtained as specified under the test conditions will be evaluated for each functional objective using time and motion techniques and compared to preflight baseline data. (Astronaut records, photographs, other data)

Data Requirements

Refer to Appendix A.

M151
Table of Test Conditions

PHOTOGRAPHED ACTIVITY	ACTIVITY SOURCE			TEST CONDITION	EST. FILMING TIME PER PERFORMANCE (MIN.)
	PRIME	ALTERNATE	CONTINGENCY		
FO 1) Donning of VCG sensors, harness and belt; translation to and from, and ingress and egress of confined enclosures; donning of metabolic apparatus, mounting, applying restraints, and operating ergometer.	M092/M171	1. M092/M093	TBD	Total of 10 performances of M092 of 2 crewmen 5 times each including at least 5 performances of metabolic activity by one of the above crewmen	M092 29.0 M171 15.0
FO 2) Deployment and retrieval of large hardware.	T027 or S073	1. S149 2. S183	TBD	At least one each: Deploy at SOL SAL Deploy at A-SOL SAL Retrieve SOL SAL Retrieve A-SOL SAL	Deploy 43.0 Retrieve 25.0
FO 3) Deployment and retrieval of medium size hardware.	S020	1. T025 2. S019	TBD	1 Deploy (any SAL) 1 Retrieve (any SAL)	Deploy 20.0 Retrieve 40.0
FO 4) Donning and doffing of the pressure garment assembly	Pre-EVA Post-EVA	1. M509 (Pre & Post Suited) 2. T020 (Pre & Post Suited)	TBD	3 performances of 2 crewmen donning and doffing PGA	Don 45.0 Doff 45.0
FO 5) Periodic maintenance of hardware which requires removal and installation of assemblies and donning of such hardware where applicable.	M509	1. T020 2. S190 (Prep.)	TBD	5 performances of at least 1 crewman	18.0
FO 6) Food preparation and food residue mass measurement				Not scheduled	

Experiment M171 — METABOLIC ACTIVITY

Obtain data on man's metabolic effectiveness in zero-gravity.

Purpose and Background

The purpose is to determine if man's metabolic effectiveness in doing mechanical work is progressively altered during exposure to a space environment.

A bicycle ergometer will be evaluated as an exerciser during the mission.

The metabolic rate will be measured in terms of oxygen consumption, minute volume, carbon dioxide production during rest, and calibrated exercise using an ergometer. In addition, body temperature, blood pressure, heart rate, and vectorcardiogram data will be taken. Vital capacity will be measured separately.

The entire set of measurements will be repeated throughout the mission to determine the effects due to mission duration.

In order to evaluate results obtained in flight, ground-based data will be obtained on each crewman. Additional ground-based physiological data will be obtained where practicable in separate studies, including bed rest, water immersion, reduced gravity simulators, and exercise training protocols.

Functional Objectives

FO 1) Perform calibrated exercise (by all three crewmen) on a bicycle ergometer.

Test Conditions

FO 1) Resting metabolic rate and bicycle ergometry will be conducted per procedures contained in the M171 Experiment Operations Handbook.

Bicycle ergometry will be performed eight times by each crewman as a test subject for a 56-day mission for a total of 24 runs.

The subject will perform portions of the experiment by himself and the observer will be required for portions of the experiment.

During the experiment performance the environmental gas temperature shall be within the range of 67° to 78°F at 5 psia.

Air motion should be within a velocity range of 15 feet per minute to 100 feet per minute.

Vectorcardiogram (VCG) data from eight performances of M171 by each crewman (if acquired) will be substituted for eight performances of Experiment M093 (Vectorcardiogram).

Spacecraft pitch, yaw, and roll rates will be limited to 6 degrees per minute during all experiment operations.

Prior to scheduling the experiment there must be:

a) A 2-hour delay if eating is scheduled before performing the experiment

b) A 2-hour delay if severe exercise is performed before M171

The experiment period should be scheduled at approximately the same time of day for each crewman.

Certain portions of this experiment will be filmed as part of Experiment M151 (Time and Motion Study).

Comments by the observer will be recorded simultaneously with the experiment and supporting telemetry measurements for subsequent playback and transmission to the ground.

Time correlation of voice comments will be accomplished by audio annotation in Greenwich Mean Time.

Data dumps via the telemetry system will be commanded from the ground.

Basic energy inputs to the subjects (food and drink) will be required from Experiment M071 (Mineral Balance).

Data from Experiment M172 (Body Mass Measurement) to assess total body water and reserve will be required.

Success Criteria

FO 1) Each crewman shall perform calibrated exercise on the bicycle ergometer and related data acquired eight times during the 56-day mission.

Evaluation

FO 1) The Principal Investigator and Investigation Team will analyze and evaluate experimental data acquired during all experiment periods. (Telemetry data, astronaut records, photographs, other data)

Data Requirements

Refer to Appendix A.

Experiment M172 — BODY MASS MEASUREMENT

Measure body mass in zero gravity.

Purpose and Background

The purpose is to measure body mass in the absence of gravity.

A set of known masses will be used to calibrate the Body Mass Measurement Device (BMMD) on earth (preflight). Identical masses shall be used for calibration in the orbital environment to verify the calibration in the absence of gravity.

The objectives of this experiment are to: (a) demonstrate mass measurement without gravity, (b) validate theoretical characteristics of the device, and (c) support biomedical experiments requiring body mass determination.

Functional Objectives

FO 1) Perform BMMD calibration validations using preflight calibrated masses weighing from 59 to 95.5 kilograms.

Test Conditions

FO 1) Calibration measurements will be taken three times; early, middle, and late in the mission.

Calibration validation will be per procedures contained in the M172 Experiment Operations Handbook.

The BMMD will be calibrated in flight for a range of masses between 59 and 95.5 kilograms identical to those used in preflight calibration.

The measurement of each mass during calibration or operation will be repeated five times and the most discrepant reading discarded.

Calibration data (calibration time, Greenwich Mean Time [GMT], BMMD temperature, and mass identification) will be logged, transmitted by voice to ground, and the log book returned in the Command Module.

Comments will be made on the operation of the BMMD.

Calibration data will be made available to the Principal Investigator within 48 hours after each calibration sequence.

The BMMD will be operated only when the ambient Orbital Workshop temperature is between 65°F and 80°F.

No BMMD measurements will be made during planned maneuvers. Any measurements made during inadvertent shocks or accelerations will be repeated.

Success Criteria

FO 1) A BMMD calibration using preflight calibrated masses weighing from 59 to 95.5 kilograms shall be performed three times during the mission.

Evaluation

FO 1) The Principal Investigator will analyze all returned flight data, perform calculations, and prepare calibration curves.

The Principal Investigator will transmit plotted curves as required to the M071 (Mineral Balance), M073 (Bioassay of Body Fluids), and M171 (Metabolic Activity) Principal Investigators. (Astronaut records)

Data Requirements

Refer to Appendix A.

3.2.2 Apollo Telescope Mount Experiments.

To Be Supplied

Pages 3-41 through 3-96 to be supplied.

3.2.3 Earth Resources Experiment Package

3.2.3.1 General

The Skylab Earth Resources Experiment Package (EREP), composed of five remote sensors, is designed as a spaceborne facility for use by the scientific community as a part of and in support of the already existing broadly based international studies on the techniques and application of earth remote sensing. These programs encompass multispectral sensing at ground level, by low and high altitude aircraft, by unmanned spacecraft, and from Skylab.

Skylab EREP will provide additional and more precise data on spacecraft sensing capabilities, allowing a more thorough evaluation of sensor techniques and returned data correlation and application. The manned Earth Resources (ER) facility also offers unique features not presently possible with automated systems. These are the ability to evaluate test site conditions, to acquire and track uniform small test sites off the ground track and to vary the data acquisition activities as systems conditions warrant.

The EREP experiments/sensors can be operated individually or as a group depending on the scientific requirements and other factors such as weather and vehicle capability. Data will be recorded on tape and film and returned to MSC for initial processing. There are no real time telemetered experiment housekeeping or scientific data.

The selection of EREP investigators and associated test sites is currently underway by the National Aeronautics and Space Administration (NASA) on the basis of on-going or proposed new correlated activities with the goal of maximizing the benefits from the above objectives. Announcement to the scientific community of the availability of this EREP facility has been made by the Office of Space Sciences and Application by the means of the "Opportunities For Participation In Space Flight Investigations" document. Final selection of the EREP investigators and related experiments for Skylab will be made upon completion of an evaluation currently underway of proposals received from the scientific community.

The present locations of active ER test sites are well known and distributed worldwide. It is fully expected that 60 to 80 percent of the final ER sites will be collocated with these existing research areas. Based on this knowledge, and currently planned sensor and experiment DTO's on EREP, the Skylab Orbital Assembly (OA) will provide reasonably flexible Z-LV(E) profiles allowing a limited number of 120-degree and 60-degree passes at any location within the orbit, i.e., sunrise, nighttime, etc. This capability is described in Section 2.3.2.10.

3.2.3.2 EREP DTO's

The five EREP sensor experiments presently assigned to the SL-3 mission are:

- S190 Multispectral Photographic Facility
- S191 Infrared Spectrometer
- S192 Multispectral Scanner
- S193 Microwave Radiometer/Scatterometer and Altimeter
- S194 L-Band Radiometer

Preliminary flight planning guidelines for EREP have been identified and incorporated into the DTO's under Test Conditions. General test conditions relating to all EREP DTO's are contained in the following section. The EREP DTO's are presented in alphanumeric order on later pages of this section.

In order to minimize the total number of EREP DTO's, there will be two categories, i.e., hardware performance verification and applications. The first will cover verification of sensor performance over specific target types and with specific operating modes. The included S190 through S194 DTO's are this type. These DTO's are based on the E-series sensor performance evaluation DTO's contained in Reference 3. Additional EREP DTO's will be developed addressing the utilization of these remote sensors to ER disciplines and to a better understanding of possible applications of these sensor techniques. These DTO's are referred to as scientific investigations or "experiment" DTO's as contrasted to hardware verification DTO's and will be organized to cover total disciplines rather than individual investigative areas. These are being developed in at least the following ER disciplines:

<u>Disciplines</u>	
Geography	Land Use Mapping, Biosphere Measurements
Geology	Geological Mapping
Hydrology	Detection of Rainfall, Overland Snow Cover
Oceanography	Sea States, Chlorophyll Content
Forestry	Vegetation Mapping
Agriculture	Crop Surveys
Atmospheric Science	Severe Storms, Air Mass Properties

At present, only the hardware performance verification DTO's are included since NASA has not currently selected the investigators for DTO's of the application category. Although accepted EREP investigation proposals may alter current planning, it is anticipated that vehicle capability is adequate and that many investigations can be accomplished with parallel studies and sharing of the same data. Final EREP planning and site overpass scheduling can only be done once all EREP proposals have been reviewed and accepted for implementation. For these reasons, the sites and number of passes shown in individual DTO's may have little meaning and often duplicate each other until all EREP DTO's are approved and a ground site versus sensor scheduling matrix can be constructed. (Reference 4 contains a list of preliminary EREP test sites.)

To the extent practicable, EREP experiment DTO's will appear in a common format containing general criteria and constraints applicable to the entire group. Functional Objectives (FO's) will be identified with schedulable sensing of specific test sites where possible and prioritized for incorporation into the Flight Plan in order of importance. Functional objectives may be structured in either an "active" (schedulable entities) form requiring crew participation or other Flight Plan timeline scheduling considerations or a "passive" form not requiring the scheduling of specific mission timeline activity. In either case, provision will be made for the acquisition of suitable data to satisfy the requirements of the objective. Depending on further definition of EREP applications requirements, functional objectives may encompass the acquisition of data through single or multiple sensing of single or multiple test sites.

3.2.3.3 General EREP Test Conditions

The following test conditions are expected to be applicable to all EREP DTO's:

a) Distribution of test sites will be 70 to 80 percent in the United States, with the balance in other countries and over ocean areas.

b) Test Sites will be scheduled on the basis of priority, weather, and proximity of ground tracks of pre-selected EREP passes.

c) Preliminary estimates of test site scheduling will be required 12 hours prior to test site acquisition. Final selection of test site(s) will be made and passed to the astronauts from one to three hours prior to test site overflight via a Pre-Advisory Data (PAD) message. General format and content of PAD's are contained in the mission Flight Plan.

d) The time of each EREP data taking period will depend on test site characteristics and availability. The number of performances will also depend on the quantity of film and tape available.

e) The OA drift rate will not exceed 0.05 degrees/second in any axis.

f) The OA attitude will be the Z-LV(E) attitude and maintained within a pointing accuracy of 2 degrees in all three axes.

g) Voice annotation on the AM tape recorder shall be made for each data pass of the experiment noting such items as test site acquired, meteorological descriptions, unusual occurrences, and Greenwich Mean Time (GMT) at start and finish of each data pass.

h) Experiment scientific and housekeeping measurements will be recorded on the EREP tape recorder.

i) The EREP scientific equipment operations will be conducted in accordance with procecures contained in Volume II of the Skylab Experiment Operations Handbook.

j) EREP/ETC experiment data taking will normally require three crewmen.

k) Free liquid discharges into the OWS waste tank and controllable OA venting must be completed 15 minutes prior to experiment operation and avoided during experiment performance for S190, S191, and S192.

l) The Best Estimate of Trajectory will be determined in order to provide real time scheduling of EREP passes.

m) Aperture doors and experiment optics (including their windows) covers must be closed except during the data taking periods of S190, S191, and S192.

3.2.3.4 Sensor Combinations Matrix

The following matrix of Roman numeral coded groups versus EREP sensors identify the unique combinations of the sensors required for all ER investigations received to date.

The group codes will be incorporated into future EREP DTO's through association with each functional objective. This coding method has been indicated in DTO's S190 through S194.

EREP Sensor Combinations Matrix

GROUP	EREP SENSORS				
	190	191	192	193	194
I	X	X	X	X	
II	X	X		X	X
III	X	X	X		
IV	X	X		X	
V	X			X	X
VI	X	X			
VII	X		X		
VIII	X			X	
IX	X				X
X		X	X		
XI		X			
XII			X		
XIII				X	
XIV					X

Experiment S190 (E-6/E-10)

MULTISPECTRAL PHOTOGRAPHIC FACILITY

Obtain multispectral photographic data.

Purpose and Background

The purposes are to gather Multispectral Photographic Facility data to evaluate and calibrate the performance of the multispectral photographic sensors and to evaluate the usefulness of a window and viewfinder for crew observations.

The objectives are to determine the long and short term spectroradiometric accuracy of the hardware and the resolution and metric capabilities of the sensors. Transmission of the photographs will be measured and correlated with sensitometric data on the film to establish the absolute exposure. Both pre-flight and post-flight sensitometry will be applied to the film so that conversion between exposure and film transmission is determined.

Due to dynamic effects, a test site of fixed radiance properties should be photographed periodically; the full moon provides such a test site. The moon variation in radiance is a function of the geometry of the sun, moon, and earth and is not affected by atmospheric effects. S191 (Infrared Spectrometer) and S192 (Multispectral Scanner) data should be taken at the same time S190 is used to photograph test sites. These data will be used to evaluate the relative accuracies of the sensors. Both long term and short term variations of the sensors can be determined.

The short term variations in spectroradiometric measurements of S190 will be determined by taking data over the earth test sites. Data taken over the earth test sites will be reduced using photogrammetric methods to evaluate any distortion effects caused by the S190 window. Spatial resolution will be determined using natural and man-made earth test sites.

The objective of the visual observations of test sites is to evaluate the utilization of windows and viewfinders located near the experiment control areas.

Functional Objectives

		Group*
FO 1)	Obtain Multispectral Photographic Facility performance evaluation data of the following test sites:** a) 031, Houston, MDTS b) 035, Houston Intercontinental Airport c) 037, Sam Houston State Park d) 038, Big Thicket, Texas e) 056, Mississippi Delta f) 076, Padre Island, Texas g) TBD, Test Sites	(III)
FO 2)	Obtain Multispectral Photographic Facility performance evaluation data using the full moon (Test Site 176) as the test site.	(III)

FO 3) Obtain visual observations (two crewmen) through the S190 MDA window and through the Viewfinder Tracking System (VTS) of the following test sites. The Sensor Test Sites are TBD.

* The unique combination of Earth Resources Experiment Package (EREP) sensors required for each FO is identified by a Roman numeral under the Group column. Refer to the Sensor Combinations Matrix in Section 3.2.3.4.

**Order of precedence of test sites is indicated in the sequential listing of test sites under each FO.

Test Conditions

FO 1) Clear skies or less than 20-percent cloud cover will be required.

A forward overlap of 60 percent on the S190 photography will be obtained.

Photography in the summer hemisphere will be performed when the sun elevation angle is $\geq$ 30 degrees. Photography in the winter hemisphere will be performed when the sun elevation angle is $\geq$ 20 degrees.

Underflight data TBD will be acquired at the time of the Skylab overflight.

FO 2) This FO will be accomplished in the solar inertial attitude.

This FO will be accomplished when the moon is full.

The S190 interval rate and aperture settings are TBD.

FO 1)
FO 2) S191 data will be obtained simultaneously with S190 data.

S192 data will be obtained simultaneously with S190 data.

To minimize radiation damage, the film will be returned to the film vault immediately after completion of a photographic pass and, whenever possible, prior to crossing the South Atlantic Anomaly.

After completion of all photography on the mission, the film will be advanced into the takeup cassettes and stowed in the Command Module as late in the mission as possible (preferably within a day of undocking).

Voice recordings pertinent to experiment operations will be transmitted in delayed time. Voice data will include:

a) Test site acquired
b) Meteorological description of earth test sites
c) Greenwich Mean Time at start and finish of data pass
d) Comments regarding EREP update PAD's

Required telemetry measurements will be recorded on the AM tape recorder for subsequent playback and transmission to the ground.

Prelaunch data denoting ground calibration of the S190 lens and window, and ground calibration of the VTS will be required.

FO 3) S190 Photographic Assembly will be in the stowed position. One crewman will observe from the MDA window, and one from the VTS.

FO 1)
FO 2)
FO 3) Experiment scientific and housekeeping measurement data will be recorded on the EREP tape recorder.

Other test conditions applicable to all FO's of this experiment are contained in Section 3.2.3.3.

Success Criteria

FO 1) Multispectral photography (60 percent forward overlap) of Test Sites FO 1-a through -g shall be acquired and returned for processing.

FO 2) Multispectral photography of the full moon shall be acquired and returned for processing.

FO 3) Visual observations of the test sites shall be made through the MDA window and the VTS. Crewmen comments on the usefulness of the window and VTS for acquiring and observing target test sites shall be recorded, logged, and returned.

Evaluation

FO 1) Densitometer measurements will be made with the film and these data will be correlated to sensitometric data on the film to establish the absolute exposure of image points.

Data taken over earth test sites will be photogrammetrically reduced to evaluate the dynamic distortion effects. Spatial resolution will be determined from multispectral photography over these test sites using natural and man-made targets. (Astronaut records, S190 film, ground truth data, aircraft data, pre-launch data, BET, EREP update PADS, OA ephemeris data, and K382-702)

FO 2) Analysis of the timing history and ground calibration of the lens and window will be used to evaluate the radiance of the lunar surface. The measured/calculated results will be compared to independent measurements to determine the spectroradiometric accuracy. Comparisons can be made on data from several missions to provide long term accuracy information. (Astronaut records, S190 film and tapes, pre-launch data, BET, EREP update PADS, OA ephemeris data, and K382-702)

Radiance levels established from the multispectral photography data will be compared with radiance levels measured by S191 and S192. Error ranges for the S190, S191, and S192 sensors will be determined and compared. (Astronaut records, S190 film and tapes, S191 tapes, S192 tapes, ground truth data, aircraft data, pre-launch data, BET, EREP update PADS, OA ephemeris data, and K382-702)

FO 1)
FO 2) Short term variations in the spectroradiometric measurements of S190 will be determined by analyzing the multispectral photographic data of the earth test sites and the moon. Comparisons will be made with S191 and S192 sensor data. (Astronaut records, S190 film and tapes, S191 tapes, S192 tapes, ground truth data, aircraft data, pre-launch data, BET, EREP update PADS, OA ephemeris data, and K382-702)

FO 3) Records and crewmen debriefing will be used to determine the utilization and value of having a viewing port and/or telescope near experiment displays and controls. (Astronaut records, pre-launch data, BET, OA ephemeris data, and K382-702)

<u>Data Requirements</u>

Refer to Appendix A.

Experiment S191 (E-8) INFRARED SPECTROMETER

Obtain infrared spectral data.

Purpose and Background

The purpose is to gather infrared (IR) spectral data of sources of known radiance and sources of constant radiance to evaluate the performance of the IR Spectrometer.

Quantitative calibration of the S191 sensor will be obtained prior to launch; however, the calibration can change. Each of the test sites listed below under FO 1 and FO 2 represents a portion of the total objective of monitoring the change from the pre-launch calibration. Any change recorded will be used in adjusting the data values.

The data collected from the spectrometer will be compared with data gathered simultaneously on the ground and from aircraft underflights to allow evaluation of the sensor capability, sensitivity, and spectral resolution. In addition, the extent to which the effects of the atmosphere can be removed from the data will be quantitatively tested.

Functional Objectives

		Group*
FO 1)	Obtain IR Spectrometer performance evaluation data of selected internal calibration sources (See Test Conditions).	(XI)
FO 2)	Obtain IR Spectrometer performance evaluation data of the following test sites:**	(XI/VI)

a) 176, Moon
b) 177, Deep Space
c) High Uniform Cloud Decks
d) 063, White Sands, New Mexico
e) 055, Gulf Coast
f) 097, Midwest U. S.
g) 032, Houston, Texas
h) 088, Los Angeles, California

FO 3)	Obtain IR spectral data of any gaseous cloud surrounding the Skylab Orbital Assembly (OA).	(XI)

* The unique combination of Earth Resources Experiment Package (EREP) sensors required for each FO is identified by a Roman numeral under the Group column. Refer to the Sensor Combinations Matrix in Section 3.2.3.4. (FO 2-a, -b, -c require combination XI, FO 2-d, -e, -f, -g, -h require combination VI)

**Order of precedence of test sites is indicated in the sequential listing of test sites under each FO.

Test Conditions

FO 1) The following internal targets sequence will be conducted five times during the mission to obtain data from internal targets (calibration sources):

a) Crewman will perform S191 Automatic Calibration Sequence* per procedures contained in Volume II of the Skylab Experiment Operations Handbook (EOH). (Estimated performance time will be 3 minutes.)

b) Crewman will obtain 60 seconds of data with the aperture door blackbody in the S191 Spectrometer field of view (FOV).

c) Crewman will repeat steps (a) and (b) twice and finish with step (a). (Estimated performance time will be 15 minutes.)

The five performances of the internal targets sequence will be distributed over the beginning, middle, and end of the mission.

The internal targets sequence may be conducted in either the solar inertial or earth pointing attitude (Z-LV[E]).

The temperatures of the internal targets (step a above) will be selected by the crewman on the EREP Control and Display (C&D) panel in accordance with the EREP update PAD.

The temperature and current readouts on the EREP C&D Panel will be monitored and recorded by the crewman per procedures contained in the S191 EOH.

FO 2) Three data gathering passes will be conducted of Test Site 176. The crewman will acquire and track an area TBD within Test Site 176.

Five data gathering passes will be conducted of Test Site 177 for a duration of at least 60 seconds each.

Three data scans will be performed of high uniform cloud decks in either the solar inertial or Z-LV(E) attitude.

Data gathering passes for Test Sites 176 and 177 will be performed in the solar inertial attitude.

Two data gathering passes will be conducted over each of Test Sites 063, 055, and 097. At least one pass of each site will be performed with ground truth and aircraft data acquired simultaneously with the Skylab overflight.

Two data gathering passes will be conducted over each of Test Sites 032 and 088 on days of heavy smog conditions. At least one pass of each site will be performed with ground truth and aircraft data acquired simultaneously with the Skylab overflight.

Test Site 032 overpasses will be conducted on clear days with 90 percent relative humidity.

Test Sites 063, 055, 097, 032, and 088 will be tracked and data acquired for 3 to 30 seconds.

S190 (Multispectral Photographic Facility) photographic data support will be acquired simultaneously with S191 data acquisition of Test Sites 063, 055, 097, 032, and 088 for each daylight pass.

Voice recordings pertinent to experiment operations will be transmitted in delayed time. Voice data will include:

a) Test site acquired
b) Meteorological description of earth test sites
c) Greenwich Mean Time (GMT) at start and finish of data pass
d) Comments regarding EREP update PAD's

Underflight data including black and white, aerial color, and IR color film will be collected over the specific instrumented earth test sites at the time S190 and S191 data are acquired by the Skylab overflight.

FO 3) Perform two data scans of a gaseous cloud formation during the sunlight portion of the orbit. The spectrometer FOV will not contain the earth, moon, sun, or bright stars.

The above data scans will be conducted during different times of the mission TBD.

One data scan of a gaseous cloud formation will be conducted during the dark portion of the orbit. The spectrometer FOV will not contain the earth, moon, sun, or bright stars.

Data scans of gaseous cloud formations may be conducted in either the solar inertial or Z-LV(E) attitude.

At least 30 minutes cooldown for the spectrometer detector will be required prior to S191 data taking.

FO 1)
FO 2)
FO 3)

Experiment scientific and housekeeping measurement data will be recorded on the EREP tape recorder.

Required telemetry measurements will be recorded on the AM tape recorder for subsequent playback and transmission to the ground.

Other test conditions applicable to all FO's of this experiment are contained in Section 3.2.3.3.

*This sequence will be performed at GMT specified by the EREP update PAD per procedures contained in the EOH. The AUTO CAL pushbutton switch on the VTS (Viewfinder Tracking System) Control Panel will be used to automatically select the following internal targets: ambient thermal calibration blackbody, heated thermal calibration blackbody, and short wavelength calibration lamp.

Success Criteria

FO 1) A minimum of three performances of the internal targets sequence shall be required at different times during the mission.

FO 2) A minimum of one data scan of Test Site 176 shall be required.

A minimum of five data scans of Test Site 177 for at least 60-seconds duration shall be required.

A minimum of one data scan of high uniform cloud decks shall be required.

A minimum of two data gathering passes of Test Sites 063, 055, 097, 032, and 088 shall be required. A minimum of one pass of each test site shall be acquired with ground truth spectra and aircraft underflight data obtain simultaneously with the Skylab overflight.

FO 3) A minimum of one data scan of a gaseous cloud formation shall be required during the sunlight portion of the orbit excluding the earth, moon, sun, and bright stars from the spectrometer FOV.

Evaluation

FO 1)
FO 2)
FO 3) The spectrometer output will be digitally sampled and recorded on magnetic tape. The tape(s) will be returned to MSC for data reduction. Inflight calibration spectra (recorded before and after each S191 data gathering pass) will allow the spectral voltage to be converted into radiances at known wavelengths.

Data Requirements

Refer to Appendix A.

Experiment S192 (E-4) MULTISPECTRAL SCANNER

Obtain multispectral scanner data.

Purpose and Background

The purpose is to gather high resolution line-scan imagery data in the 0.4 to 12.5 micron region to evaluate the sensor performance.

The data from this experiment will be used to evaluate the scanner system response utilizing homogeneous sites of known radiometric difference, particularly where the sites present a step function input to the S192 scanner. The effect of different digital sampling rates on the system response will be analyzed for the same conditions. Nonhomogeneous periodic sites of variable spatial frequency will also be scanned to evaluate system response.

The use of data from high-level, completely cloud covered, fields of view will be investigated to establish scanner response with respect to scan angle and for use as a secondary calibration standard. The moon will be used as a test site and the reflectance data investigated for use as a calibration source.

The scanner imagery will be compared and evaluated with photography obtained from the S190 (Multispectral Photographic Facility) and S191 (Infrared Spectrometer) cameras to determine the relative accuracy of the sensor. The effect of atmospheric attenuation on the radiance measured by the scanner at 235 n mi will be investigated by using S191 in conjunction with S192.

This experiment will enable an assessment to be made of the value of an operational system using multispectral scanners at orbital altitudes and will identify system characteristics for such scanners.

Functional Objectives

		Group*
FO 1)	Obtain Multispectral Scanner performance evaluation data of the following test sites:** a) TBD, Water-sand interface b) TBD, Water-snow interface c) TBD, Ice-snow interface	(III)
FO 2)	Obtain Multispectral Scanner performance evaluation data of the following test sites:** a) 052, Imperial Valley, California b) 022, Phoenix, Arizona	(III)
FO 3)	Obtain Multispectral Scanner performance evaluation data of any test site or area during 100 percent cloud cover conditions (See Test Conditions).	(III)
FO 4)	Obtain Multispectral Scanner performance evaluation data of Test Site 176 (moon).	(III)

FO 5) Obtain Multispectral Scanner performance evaluation data of the following test sites:** (III)

a) TBD, Detroit, Michigan
b) 088, Los Angeles, California
c) 033, Galveston Bay
d) 034, Houston Ship Channel
e) TBD, Oil Slick Areas
f) 179, Hudson River, New York
g) 178, Delaware Estuary
h) 089, Lake Erie

FO 6) Obtain Multispectral Scanner performance evaluation data of the following test sites:** (III)

a) 014, Upper Chesapeake Bay
b) 090, Gulf Stream (Eastern U.S. Coast)
c) 041, Straits of Florida - Key West
d) 095, Bermuda Land/Sea Interface
e) 056, Mississippi Delta

* The unique combination of Earth Resources Experiment Package (EREP) sensors required for each FO is identified by a Roman numeral under the Group column. Refer to the Sensor Combinations Matrix in Section 3.2.3.4.

**Order of precedence of test sites is indicated in the sequential listing of test sites under each FO.

Test Conditions

FO 1) Three data gathering passes will be conducted over Test Site FO 1-a and three over FO 1-b or FO 1-c.

Each data scan of Test Site FO 1-a will be scheduled to begin over water at least 400 n mi from the sand interface. The total data taking duration will be at least two minutes.

Each data scan of Test Sites FO 1-b or FO 1-c will be scheduled to begin over water or ice respectively at least TBD n mi from the snow interface. The total data taking duration will be at least TBD minutes.

FO 2) Two data gathering passes will be conducted over Test Site 052 and at least one pass will be conducted over Test Site 022.

Each data scan of Test Sites 052 or 022 will be at least one minute in duration.

FO 3) Three data scans will be performed of any test site or area during 100 percent cloud cover conditions. One scan will be conducted at the beginning, middle, and end of the mission.

Each data scan will be at least 20 seconds in duration.

Cloud cover (100 percent) must be of uniform height and at an altitude of approximately 30,000 feet.

S191 and Viewfinder Tracking System (VTS) support will be required with the S191 field-of-view (FOV) pointed at nadir per procedures contained in Volume II of the Skylab Experiment Operations Handbook.

FO 4) Two data scans of Test Site 176 will be performed. One scan will be conducted at the beginning and end of the mission.

The Orbital Assembly (OA) moon-sun angle will be 30 degrees or less with the OA -Z axis pointed toward the moon center.

S190 photographic data support will be required simultaneously with S192 data acquisition.

Data gathering passes of the moon will be performed in either the solar inertial or solar inertial off-set attitude.

Each data scan will be TBD seconds in duration.

FO 5) Four data gathering passes will be conducted over any of Test Sites FO 5-a through -h and the data taking period will be at least 1 minute.

FO 6) One data gathering pass will be conducted over each of Test Sites 014, 041, 095, and 056.

Five data gathering passes will be conducted over Test Site 090.

The duration of each data gathering period for all test sites of this FO will be at least 1 minute.

FO 1)
FO 2)
FO 5)
FO 6)

Cloud cover conditions of $\leq$20 percent will be required for all data gathering periods.

S190 photographic data support will be required simultaneously with S192 data acquisition for all daylight passes.

TBD dark side (nighttime) data gathering passes will be conducted over selected Test Sites TBD of FO's 1, 2, 5, and 6.

S191 and VTS support will be required for all data gathering passes of these FO's.

S191 data will be acquired for at least 10 seconds over each test stie.

The VTS acquisition and tracking procedures will be performed per procedures contained in Volume II of the EOH.

FO 1)
FO 2)
FO 3)
FO 5)
FO 6)

Data gathering will be performed at a sun elevation angle of $\geq$30 degrees in the summer hemisphere and $\geq$ 20 degrees in the winter hemisphere.

Underflight data including data from the 24-band multispectral scanner will be acquired at the time of the Skylab overflight.

Ground truth data including measurements of test site radiance and temperature, land maps, measurements of nitrogen dioxide (NO_2) and aerosol content in the vertical column over the test site, measurements of cloud top height, percent cloud cover, and type of clouds will be required at the time of the Skylab overflight.

Radiosonde data including measurements of temperature, water content, and particulate matter density from cloud top altitude to 100,000 feet will be required at the time of the Skylab overflight.

FO 1)
FO 2)
FO 3)
FO 4)
FO 5)
FO 6)

The S192 detector assembly will be aligned prior to the first data taking pass.

At least 20 minutes cooldown and warmup (performed simultaneously) for the scanner assembly will be required prior to the S192 data taking.

Voice recordings pertinent to experiment operations will be transmitted in delayed time. Voice data will include:

a) Test site acquired
b) Meteorological description of earth test sites
c) Greenwich Mean Time at start and finish of data pass
d) Comments regarding EREP update PAD's

Experiment scientific and housekeeping measurement data will be recorded on the EREP tape recorder.

Required telemetry measurements will be recorded on the AM tape recorder for subsequent playback and transmission to the ground.

Other test conditions applicable to all FO's of this experiment are contained in Section 3.2.3.3.

Success Criteria

FO 1) A minimum of two data passes of Test Site FO 1-a shall be required in conjunction with S190 and S191.

A minimum of two data passes of Test Sites FO 1-b or -c shall be required in conjunction with S190 and S191.

FO 2) A minimum of one data pass each of Test Sites 052 and 022 shall be required in conjunction with S190 and S191.

FO 3) A minimum of three data passes of any test site or area with 100 percent cloud cover shall be required in conjunction with S191.

FO 4) A minimum of two data scans of Test Site 176 shall be required in conjunction with S190.

FO 5) A minimum of three data passes of any Test Sites FO 5-a through -h shall be required in conjunction with S190 and S191.

FO 6) A minimum of one data pass each of Test Sites 014, 041, 095, and 056 shall be required in conjunction with S190 and S191.

A minimum of three data passes of Test Site 090 shall be required in conjunction with S190 and S191.

Evaluation

FO 1)
FO 2)
FO 3)
FO 4) S192 performance evaluation will include an evaluation and determination of the multispectral scanner frequency response, signal-to-noise ratio, radiometric calibration scheme, response with scan angle, and an evaluation of sampling and enhancement techniques. The post-flight analysis also will include an evaluation of atmospheric correction techniques. (S190, S191, and S192 tapes, astronaut records, S190 and S191 film, ground truth and underflight data [FO 1, FO 2, FO 3], BET, EREP update PADs, OA ephemeris data, and K382-702)

FO 5)
FO 6) The data from the test sites of these FO's will be analyzed utilizing both multiband line-scan imagery and computer processing programs TBD. These results will be compared with ground truth measurements to determine the performance characteristics of the S192 scanner. (S190, S191, and S192 tapes, astronaut records, S190 and S191 film, ground truth and underflight data, BET, EREP update PADs, OA ephemeris data, and K382-702)

Data Requirements

Refer to Appendix A.

Experiment S193 (E-1/E-2)

MICROWAVE RADIOMETER/SCATTEROMETER AND ALTIMETER

Obtain radar altimeter and scatterometric and radiometric microwave data.

Purpose and Background

The purpose is to gather correlated scatterometric, radiometric, and altimetric data over sea areas and certain land sites to verify the functional operation and system characteristics of the S193 sensors at orbital altitude.

Altimeter Experiments (FO 1, FO 2, FO 3). The Skylab Radar Altimeter is a pulse radar system which operates in five modes (See Test Conditions) over the ocean areas of the earth's surface. The main purpose of this instrument is to obtain scientific and engineering data on signals backscattered from the ocean surface. These data will permit a better understanding of the ocean backscatter process which is necessary to design very accurate radar altimeter instruments required in the future. This instrument also measures altitude data which may be used to relate mean sea level measurements to the geoid. The radar altimeter will obtain data from which the following information can be derived:

a) Signal correlation properties as a function of time, space, and frequency

b) Signal characteristics pertaining to pulse compression

c) Sea state effects on transient pulse characteristics

d) Sea surface radar cross-section measurements both at nadir and as a function of angle off-nadir

e) Ocean return characteristics for a coherently coded pulse

Radiometer/Scatterometer Sensor Evaluation (FO 4). The sensors for this Functional Objective (FO) are a microwave radiometer and scatterometer. Both active and passive sensors are combined to meet the two fundamental objectives:

a) System design/performance

b) Correlation data for prediction purposes

The Radiometer is a passive sensor which measures the brightness temperature from a cell on the earth's surface as a function of incidence angle from the surface normal in the microwave region (13.8-14 GHz). The mean value of the earth thermal noise signal is accurately determined by long period observation. The measured quantity is compared to the measured mean noise value from two known temperature sources to yield an accurate, proportional measurement of the earth cell's emission temperature.

The Scatterometer measures the backscattering coefficient (sigma-zero) of the earth at 13.9 GHz as a function of incidence angle ranging from zero to 48 degrees. This scattering coefficient is related to the roughness and dielectric properties of the scattering surface. Sufficient integration times for both antenna noise and for the scattered return signal (which looks like thermal noise) plus the receiver noise are taken in order to obtain an accurate measurement of the average return power from which sigma-zero is calculated. The Radiometer and Scatterometer may operate in various scanning and polarization modes (See Test Conditions) jointly or separately. Collections of paired values of sigma-zero and total apparent blackbody temperature for each surface cell will permit the separation of emissivity effects and reflectivity effects. These data will be correlated postflight with sea state and wind conditions.

Radiometer Sensor Evaluation (FO 5). The Radiometer will be operated as a single instrument in this FO with two combined objectives. The system design and performance will be evaluated and the feasibility of making surface emissivity measurements from orbital altitude with the 13.9 GHz Radiometer will be determined.

Functional Objectives

		Group*
FO 1)	Obtain Altimeter Experiment data of the following test sites**	(VIII)

a) 149, Sensor Test Site 1
b) 150, " " " 2
c) 151, " " " 3
d) 152, " " " 4
e) 153, " " " 5
f) 154, " " " 6
g) 155, " " " 7
h) 156, " " " 8
i) 157, " " " 9
j) 158, " " " 10

FO 2)	Perform Altimeter Experiment in conjunction with Pulse Shape Experiment (Mode I). Test Sites 419, 150, 151, 152, 155, 157, and 158 will be used.***	(VIII)
FO 3)	Obtain Cross-Section Experiment (Mode II) Altimeter data of the following test sites**	(VIII)

a) 108, Central Gulf of Mexico
b) 159, El Paso Area
c) 070, Great Salt Lake, Utah

FO 4)	Obtain Radiometer/Scatterometer Sensor Evaluation data on the following test sites**	(VIII)

a) 108, Central Gulf of Mexico
b) 159, El Paso Area
c) 070, Great Salt Lake, Utah

FO 5)	Obtain Radiometer performance evaluation data of the following test sites**	(VIII)

a) 063, White Sands, N.M. (Desert)
b) 070, Great Salt Lake, Utah
c) 106, Trinity Bay
d) 033, Galveston Bay
e) 105, Matagorda Bay

* The unique combination of Earth Resources Experiment Package (EREP) sensors required for each FO is identified by a Roman numeral under the Group column. Refer to the Sensor Combinations Matrix in Section 3.2.3.4.

** Order of precedence of test sites is indicated in the sequential listing of test sites under each FO.

***Data required for this FO will be obtained during Mode I operations of FO 1 for the indicated test sites.

Test Conditions

FO 1) The altimeter instrument will be operated in the following five basic modes (Mode IV deleted):

a) Pulse Shape Experiment (Mode I) - This mode will measure the return pulse shape with the antenna pointing at nadir and off-nadir. Individual return pulses will be sampled and recorded for different sets of system parameters.

b) Cross-Section Experiment (Mode II) - This mode will measure the radar backscatter coefficient with the antenna pointing at nadir and off-nadir.

c) Time Correlation Experiment (Mode III) - Mode III will measure the range gated correlation between pairs of pulses with variable time spacing. Individual return pulses (pairs) will be sampled and recorded for different sets of system parameters.

d) Pulse Compression Experiment (Mode V) - Mode V will make measurements to compare the ocean return signal characteristics for a 10-nanosecond uncoded pulse with the return characteristics for a 120-nanosecond coded pulse compressed to 10 nanoseconds.

e) Nadir Align Experiment (Mode VI) - Mode VI will be used to accomplish on-orbit alignment of the antenna. The antenna will be gimbaled automatically in pitch and roll to the position where the Automatic Gain Control voltage is a maximum. This antenna position will be redesignated as the nadir position (within 0.7 degrees). No return waveform samples will be obtained in this mode.

Four altimeter modes will be manually selected by the astronaut in accordance with the test sites and number of passes as follows:

Test Site	Number of Passes	Modes
149	TBD	I, II, III
150	TBD	I, III, V
151	TBD	I, II
152	TBD	I, II
153	TBD	III, V

Test Site	Number of Passes	Modes
154	TBD	II, V
155	TBD	I, II
156	TBD	II
157	TBD	I, III, V
158	TBD	I, II, III

FO 2) Only Mode I of the altimeter will be used during data gathering periods of this FO.

FO 3) Only Mode II of the altimeter will be used during data gathering periods of this FO.

Ten data gathering passes per site will be conducted over Test Sites 108, 159, and 070.

FO 1)
FO 2)
FO 3) The estimated time to complete each altimeter mode will be 3 minutes and 30 seconds. The minimum recycle requirements for each mode are TBD.

Mode VI will be initiated by the crewman prior to selected data passes TBD.

The altimeter will be calibrated in each mode per procedures contained in Volume II of the Experiment Operations Handbook (EOH).

During the operation of the altimeter, no other portion of the S193 experiment will be operating.

FO 4) The Radiometer and Scatterometer will be operated in the following four scan modes:

a) In-Track Non-Contiguous Mode - This mode is used for joint radiometer/scatterometer operation. The objective of the mode is the measurement of backscatter and brightness temperature from the earth at five incident angles between zero degrees and 48 degrees. The five cells, A, B, C, D, and E will be initially viewed at antenna gimbal angles of 48, 40.1, 29.4, 15.6 and zero degrees respectively. The antenna is then repositioned to 48 degrees and the slew and dwell sequence repeated. The process will be repeated until each cell has five successive scans at five successive smaller gimbal angles. During each dwell period, measurements are taken for each transmit receive polarization pair: vertical/vertical (VV), vertical/horizontal (VH), horizontal/vertical (HV), and horizontal/horizontal (HH). Radiometer measurements are also taken at each receive polarization (H and V).

b) Cross-Track Non-Contiguous Mode - The cross-track non-contiguous mode is identical to the in-track non-contiguous mode with the exception that instead of scanning in the forward (pitch) direction with no roll motion the scan is in the cross-track (roll) direction.

The roll dwell angles are 48, 40.1, 29.4, 15.6, and zero degrees. There are three cross-track non-contiguous scans available; left scan, right scan, and left/right scan.

c) In-Track Contiguous Mode - The antenna scans continuously from about 48 degrees to zero degrees. The scattering cross-section will be measured over 1.6 degrees widths near 48, 40.1, 29.4, 15.6, and zero degrees (gimbal angle) while the antenna scans in a smooth manner. The roll angle (cross-track) is zero degrees. In this mode, only one polarization will be selected by the astronaut. The choices are: VV, VH, HV, or HH.

d) Cross-Track Contiguous Mode - This mode contains three submodes: Radiometer/Scatterometer (with one selected in-phase polarization pair); Radiometer only (with both polarizations); and Scatterometer only (with both in-phase polarizations). This mode provides cross-track continuous scanning with a zero elevation angle (zero degrees pitch) and a non-zero elevation angle (pitch not equal to zero degrees). During the zero elevation angle scan (mapping mode), the antenna will scan continuously from about 29.4 degrees to zero degrees in roll. The scattering cross-section will be measured as the antenna beam sweeps $\pm$11.375 degrees from one center angle (zero, 15.6, and 29.4 degrees). The non-zero elevation angle scan provides a side to side scan as the antenna beam sweeps $\pm$11.375 degrees from a zero degree roll position at one pitch position (15.6, 29.4, and 40.1 degrees). Measurements will be made for every 1.896 degrees of beam center motion. In the scatterometer and radiometer submode the astronaut must select the polarization pair (VV or HH). In other modes, polarization selection will be automatic.

The Radiometer and Scatterometer will be operated in the following scan modes in accordance with the number of data passes as shown:

Scan Mode	Number of Passes*
In-Track Non-Contiguous	8 (6)
Cross-Track Non-Contiguous	8 (6)
In-Track Contiguous	8 (6)
Cross-Track Contiguous	
a) Radiometer/Scatterometer	8 (6)
b) Radiometer Only	8 (6)
c) Scatterometer Only	8 (6)

Note: The number indicated in parenthesis reflects the minimum pass requirements.

During performances TBD, the antenna will be scanning in the in-track non-contiguous mode.

During performances TBD, the antenna will be scanning in the cross-track non-contiguous mode.

During performances TBD, the antenna will be scanning in the in-track contiguous mode.

During performances TBD, the antenna will be scanning in the cross-track contiguous mode.

Polarization and scan angle selections TBD by the crewman will be performed per procedures contained in Volume II of the EOH.

Five data gathering passes will be conducted over Test Site 108 for each S193 scan mode.

Three data gathering passes will be conducted over Test Sites 159 or 070 for each S193 scan mode.

Only one of the above scan modes may be selected at a time (six-position rotary switch).

During the operation of the Radiometer and/or the Scatterometer, the Altimeter will not be operating.

Reflected, emitted microwave data will be obtained of Test Site 108 with low sea state condition (4 to 5 foot waves) and no heavy cloud, rain, or storm conditions.

Dense clouds and rain should be avoided during data collection periods (the weather should be relatively uniform over the data gathering areas).

FO 5) Four data gathering passes per site will be conducted over Test Sites 063 and 070.

Data will be acquired for at least two different cloud cover conditions (from totally clear to 100% overcast) and two different surface-subsurface temperature gradients (during clear weather) for Test Sites 063 and 070.

Four data gathering passes per site will be conducted over Test Sites 106, 033, and 105.

Data will be acquired for at least two different cloud cover conditions (from totally clear to 100% overcast) and two different sea state conditions (from calm to strong breeze) for Test Sites 106, 033, and 105.

Scan angle selections TBD by the crewman will be performed per procedures contained in Volume II of the EOH.

Only the Radiometer will be operated during data gathering passes of this FO. The cross-track contiguous mode will be selected (polarization selection automatic).

Test site surface and subsurface temperature will be the primary criteria for local time selection of each pass.

** TBD dark side (nighttime) data gathering passes will be conducted over selected test sites TBD.

FO 1) thru FO 5) S190 (Multispectral Photographic Facility) photographic data support will be required for all daylight data passes.

Approximately 15 minutes warmup time for each S193 sensor (Radiometer, Scatterometer, and Altimeter) will be required prior to S193 passes utilizing the respective sensor.

Voice recordings pertinent to experiment operations will be transmitted in delayed time. Voice data will include:

a) Test site acquired
b) Meteorological description
c) Greenwich Mean Time at start and finish of data pass
d) Comments regarding EREP update PAD's

Experiment scientific and housekeeping measurement data will be recorded on the EREP tape recorder.

Required telemetry measurements will be recorded on the AM tape recorder for subsequent playback and transmission to the ground.

Underflight data including laser profiles and infrared spectrometer will be required during the Skylab overflight.

Ground truth data for terrain sites (including photography, surface configuration/statistics, dielectric properties and statistics of the properties) and for the ocean sites (including wind velocity, sea statistics, aircraft laser profiles, and air and water temperatures) will be required during the Skylab overflight.

Other test conditions applicable to all FO's of this experiment are contained in Section 3.2.3.3.

* The total number of passes indicated reflect the total requirements for all three missions (SL-1/SL-2, SL-3, and SL-4). Scheduling of passes versus test sites for each mission shall be consistent with the number of available earth pointing attitude (Z-LV[E]) passes and priority TBD of the sites.

**It would be desirable to take data at various times of the day and night for each test site to obtain microwave data at varying surface and subsurface temperatures.

Success Criteria

FO 1) FO 2) S193 data shall be acquired for the designated test sites (FO 1-a through -j) such that a minimum of 50 percent of the specified system operating times shall be achieved. (See Test Conditions for operating times and number of required recycles.)

FO 3) A minimum of two data passes per site for Test Sites 108, 159, and 070 shall be required. Altimeter Mode II shall be used.

FO 4) A minimum of three data passes of Test Site 108 for each S193 scan mode shall be required.

A minimum of three data passes of Test Sites 159 or 070 for each S193 scan mode shall be required.

FO 5) A minimum of four data passes per site for Test Sites 063 and 070 shall be required.

A minimum of four data passes per site for Test Sites 106, 033, and 105 shall be required.

Evaluation

FO 1)
FO 2)
FO 3)
FO 4)
FO 5) S190 photographic data obtained during each of the data evaluation periods will be required for assistance in the preliminary evaluation. A final report will be required of each investigator within TBD days of the availability of data from MSC. (S190 and S193 tapes, astronaut records, S190 film, ground truth, underflight data, BET, EREP update PADs, OA ephemeris data, and K382-702)

FO 1)
FO 2)
FO 3) The altimeter system operating data will be evaluated to estimate or determine the performance capabilities during the mission and the expected performance capability for the next mission will be adjusted accordingly. No data processing schemes are being developed at this time. Experts in the radar altimetry field will evaluate the data either from strip chart or digital printouts for a segment of each data taking mode at the beginning of the mission and near the end of the mission.

FO 4) The consistency and repeatability of data will be checked. The average scattering cross-section, sigma-zero, will be calculated using the scatterometer data and this will be checked with calculated theoretical values. Comparisons with spacecraft altimeter, aircraft data, and/or theoretical data will be made.

Data Requirements

Refer to Appendix A.

Experiment S194 (E-5) | L-BAND RADIOMETER

Obtain passive microwave radiometric data.

Purpose and Background

The purpose is to gather L-Band passive microwave radiometric data to evaluate the performance of the L-Band Radiometer sensor including internal system stability, total system response (simple sites), and total system response over a source having a changing brightness distribution.

The radiometric temperature from known, simple surfaces (sky, water) will be compared with calculated values to analyze the system response. The sky and water provide homogeneous sources to check overall system performance with minimized contributions from antenna pattern effects. By comparing the spatial brightness distribution derived from different frequency of data points, the influence of data point spacing will be determined.

The Florida peninsula offers a highly desirable test site to provide a sharp change in radiometric temperature for the land and water interface.

Functional Objectives

		Group*
FO 1)	Obtain L-Band Radiometer System performance evaluation data of the following test sites:** a) 112, Florida Land/Sea Interface b) 111, Baja Land/Sea Interface c) TBD Test Sites (selected in conjunction with S193 [Microwave Radiometer/Scatterometer and Altimeter] data gathering passes)	(IX/V)
FO 2)	Obtain L-Band Radiometer System performance evaluation data of the cold sky.	(XIV)

* The unique combination of Earth Resources Experiment Package (EREP) sensors required for each FO is identified by a Roman numeral under the Group column. Refer to the Sensor Combinations Matrix in Section 3.2.3.4. (FO 1-a, -b require combination IX, FO 1-c requires combination V)

**Order of precedence of test sites is indicated in the sequential listing of test sites under each FO.

Test Conditions

FO 1) Daytime and clear or less than 20 percent cloud cover conditions will be required for scheduling data passes with S190 (Multispectral Photographic Facility) support.

A series of three standard inflight internal calibrations will be obtained before and after the profile scans of Test Sites 112 or 111 (alternate).

Each data scan Test Site 112 or 111 will be scheduled to begin over water at least 100 n mi from land (or 480 n mi during stability test), pass over the land peninsula and terminate over water at least 100 n mi from land.

Five data gathering passes will be conducted over Test Site 112 under different salinity and water temperature conditions (Test Site 111 will be the alternate).

Prior to each data scan, the radiometer will be operating for at least 10 seconds for integration information.

It is highly desirable that the L-Band radiometer be operated concurrently with the S193 sensor (Radiometer/Scatterometer mode) over open water to perform an equipment compatibility test.

Two data gathering passes will be conducted over Test Site FO 1-c for the equipment compatibility test.

The S194 equipment should be turned on prior to the S193 equipment and remain on for approximately 1 minute for the compatibility test.

The L-Band Radiometer equipment will be turned on for a minimum of 2 minutes over open water to perform a stability test. Clear weather will be required for this test.

One data gathering pass will be conducted over Test Site 112 (Test Site 111 will be the alternate) for the stability test.

The sun elevation angle should be ≥ 30 degrees during Radiometer operation in the summer hemisphere and ≥ 20 degrees during operation on the winter hemisphere.

S190 photographic data support will be required of the land/sea transition for each daylight pass.

Ground truth data including ocean salinity and temperature and other accurate ground truth data for peninsula surface conditions TBD will be required at the time of the Skylab overflight.

FO 2) The cold sky measurement will be performed during the dark portion of the orbit (preferably looking perpendicular to the galactic plane and avoiding the galactic center).

Three data gathering passes will be conducted during the dark portion of the orbit (cold sky measurement).

FO 1)
FO 2) At least 30-minutes warmup time will be required for the Radiometer prior to each S194 data taking pass.

Voice recordings pertinent to experiment operations will be transmitted in delayed time. Voice data will include:

a) Test site acquired
b) Meteorological description of earth test sites
c) Greenwich Mean Time at start and finish of data pass
d) Comments regarding EREP update PAD's

Experiment scientific and housekeeping measurement data will be recorded on the EREP tape recorder.

Required telemetry measurements will be recorded on the AM tape recorder for subsequent playback and transmission to the ground.

Other test conditions applicable to all FO's of this experiment are contained in Section 3.2.3.3.

Success Criteria

FO 1) A minimum of three data passes over Test Site 112 under different salinity and water temperature conditions shall be required (Test Site 111 shall be the alternate).

A minimum of one data pass shall be required over Test Site FO 1-c for the equipment compatibility test.

FO 2) A minimum of two data passes during the dark portion of the orbit (cold sky measurement) shall be required.

Evaluation

FO 1)
FO 2) The data will be converted to brightness temperatures and a plot of temperature versus latitude-longitude obtained. Relative beam-spot size will be plotted as a function of latitude and longitude. Correlation between theory of beam smoothing and specific antenna pattern characteristics will be performed to demonstrate antenna characteristics and system sensitivity. All inflight calibrations will be converted to temperature units for gain stability and baseline stability evaluation. Cold sky measurement will provide a low-end reference point for evaluation of the lower end of the receiver response as well as provide a measure of front-end losses. (S190, S193, and S194 tapes, astronaut records, S190 film, ground truth, underflight data, pre-launch data, BET, EREP update PADs, OA ephemeris data, and K382-702)

Data Requirements

Refer to Appendix A.

3.2.4 Corollary Experiments

3.2.4.1 General

The corollary group of experiment DTO's have been designated as those experiment DTO's which are not medical, ATM, or EREP. These DTO's constitute a group of scientific, engineering, technology and DOD experiments.

3.2.4.2 Corollary DTO's

The objectives of the corollary experiment DTO's are to conduct a broad series of experiments to:

a) Study the effects of space environment on various experimental materials

b) Conduct investigations related to the effects of performing work tasks in space

c) Obtain data on various experimental maneuvering equipment for future EVA requirements

d) Obtain data due to the effects of zero gravity on biological materials

e) Obtain stellar and solar photographic data outside the earth's atmosphere.

The corollary experiments assigned to the SL-3 mission are:

D024	Thermal Control Coatings
M487	Habitability/Crew Quarters
M509	Astronaut Maneuvering Equipment
M512	Materials Processing Facility
M516	Crew Activities/Maintenance Study
M554	Composite Casting
S019	Ultraviolet Stellar Astronomy
S020	X-Ray/Ultraviolet Solar Photography
S063	Ultraviolet Airglow Horizon Photography
S071/ S072	Circadian Rhythm - Pocket Mice/Vinegar Gnat
S149	Particle Collection
S183	Ultraviolet Panorama
T002	Manual Navigation Sightings (B)
T003	In-Flight Aerosol Analysis

T013	Crew Vehicle Disturbances
T020	Foot Controlled Maneuvering Unit
T027/ S073	Contamination Measurement and Gegenschein/Zodiacal Light

The corollary DTO's are presented in alphanumeric order on the following pages.

Experiment D024 | THERMAL CONTROL COATINGS

Obtain thermal radiation data on a variety of coating materials.

Purpose and Background

The purpose is to determine the effects of space environment on selected thermal control coatings and polymeric film, calibrate earth based laboratory test data, and to gain new insight on the mechanisms of degradation.

Four sample panels, two with 36 disks each of various thermal control coatings and two with 32 strips each of polymeric film, will be returned from space orbit to be analyzed. Two sample panels, one of each type, will be returned by SL-2. The remaining two sample panels may be retrieved on either SL-3 or SL-4 to evaluate the ability of these materials to withstand long duration exposure to a space environment. Measured spectral reflectance, transmittance, physical, and electrical data obtained from samples exposed to the space environment will be compared to earth based laboratory test data.

Functional Objectives

FO 1) Retrieve two sunlight exposed D024 experiment panels from the Airlock Module (AM) external structure during an Apollo Telescope Mount (ATM) extravehicular activity (EVA).

Test Conditions

FO 1) The D024 sample panels will be exposed to sunlight the maximum amount of time that the flight schedule will allow.

An EVA astronaut will inspect and retrieve two D024 sample panels (one of each type described above) during an ATM EVA in accordance with procedures contained in the D024 Experiment Operations Handbook.

Crew voice comments will be recorded of the sample panels inspection, retrieval, and stowage in the material return container.

Operational EVA 16-mm photography will document the retrieval of the D024 sample panels.

Time correlated Orbital Assembly position data (accurate to the nearest minute of time and nearest degree of angle) relating three-axis vehicle attitude with respect to sun vector during the duration of D024 specimen exposure to the space environment will be required to support D024 evaluations.

The D024 sample panels will be placed in the material return container which will be sealed during retrieval and checked prior to repressurizing the AM airlock.

The material return container will be stowed in the Command Module for return to earth.

The material return container must be returned to the Principal Investigator unopened within four days of recovery. The sample panels must not be exposed to the atmosphere prior to delivery to the Principal Investigator.

Success Criteria

FO 1) The D024 sample panels shall be exposed to a sunlighted space environment for the maximum time allowed, retrieved, retained in a vacuum state, and returned to the Principal Investigator.

Evaluation

FO 1) The Principal Investigator will use laboratory simulations, over the visible spectrum as well as infrared and ultra-violet radiations, to provide degradation correlation of duplicate thermal control coating materials. The same spectral reflectance measurements facility will be used to measure both the laboratory samples and the space samples. (Astronaut records, experiment samples, other data)

Data Requirements

Refer to Appendix A.

Experiment M487

HABITABILITY/CREW QUARTERS

Obtain data on Orbital Workshop crew quarters habitability.

Purpose and Background

The purpose is to gather data on the habitability features of the Orbital Workshop (OWS) crew quarters which will be useful in the design of future manned spacecraft.

Everyday spacecraft type activities such as sleeping, food preparation, sanitation and waste management, locomotion, recreation, and personal hygiene will be evaluated as they are affected by the local environment which includes architecture, temperature, humidity, pressure, zero gravity, communications, and work load.

Functional Objectives

FO 1)	Obtain objective and subjective data on the OWS environment during the Skylab missions.	(15%)*
FO 2)	Obtain motion picture and objective and subjective data on the OWS internal architecture.	(10%)*
FO 3)	Obtain motion picture and objective and subjective data on the adequacy of OWS mobility aids and restraints.	(10%)*
FO 4)	Obtain motion picture and objective and subjective data on the adequacy of the food and water.	(10%)*
FO 5)	Obtain motion picture and objective and subjective data on garments and personal accouterments.	(10%)*
FO 6)	Obtain motion picture and objective and subjective data on personal hygiene.	(15%)*
FO 7)	Obtain motion picture and objective and subjective data on OWS housekeeping.	(10%)*
FO 8)	Obtain motion picture and objective and subjective data on communications within the OWS.	(10%)*
FO 9)	Obtain subjective data on the adequacy of the OWS off-duty activity provisions.	(10%)*

Test Conditions

FO 1) thru FO 9) At scheduled times and moments of opportunity, the crew will document habitability features of the OWS per procedures contained in the M487 Experiment Operations Handbook (EOH).

The experiment task will augment or coincide with operational activities to be observed, when possible.

Time phased periods of photographic and voice data recordings distributed early, middle, and late in the mission will be required to catalog crewman adaptability as a function of time. Each data recording should include comments on each of the defined areas on interest, covering all aspects, including adequacy, utility, comfort, safety, and suggestions for improvement.

FO 1) Measurements of environmental features will be made with hardware which includes sensors/devices for measuring air movement velocity, distance, sound level, and air or surface temperatures.

These measurements will be recorded by the crew and results related to crew comfort for the following OWS compartments:

a) Sleeping
b) Wardroom
c) Waste Management
d) Experiment
e) Forward

Spacecraft telemetry measurements and other operational hardware will also support this portion of M487 data.

FO 2) Photographs and voice comments on the architectural arrangement will be recorded of crewmen (individually or grouped) performing related activities in each of the following OWS compartments:

a) Sleeping
b) Wardroom
c) Waste Management
d) Experiment
e) Forward

The activities to demonstrate the architectural adequacy of the above areas will include:

a) Ingress
b) Egress
c) At rest
d) In motion
e) Mechanical operation of doors, hatches, curtains, and locker compartments

FO 3) Photographs and voice comments on the adequacy and utility of mobility aids and restraints will be recorded of crewmen performing the following:

a) Sleep restraints in use
b) Using handrails as mobility aids
c) Manipulation of several pieces of hardware
d) Using foot restraints and showing associated degrees of body freedom
e) Using food and eating restraints
f) Degree of access to storage cabinets and areas
g) Using proximity of ceiling to floor as a method of locomotion

FO 4) Photographs and voice comments will be recorded of crewmen performing normal food preparations, open tray eating, normal cleanup, use of water dispensing device(s), use of portable water tank, use of utensils, and meal appearance.

FO 5) Photographs and voice comments will be recorded of crewmen in various garments demonstrating mobility and functional capabilities, donning and doffing, removal, storage, and disposal of garments.

FO 6) Photographs and voice comments on personal hygiene facilities will be recorded of crewmen performing the following activities:

a) Bathing
b) Hand and face washing
c) Drying
d) Brushing teeth
e) Shaving
f) Cutting hair

FO 7) Photographs and voice comments will be recorded for normal housekeeping activities such as refuse disposal, stowing of packages for return, vacuum cleaning operations, feces device cleaning, and urine device cleaning.

Data will include observations on waste (identification, source, generation rate, disposition and handling), cleaning (what and how), replenishing of trash bags, towels, etc., servicing of replacement items, and disinfecting (what, how, and when).

FO 8) Photographs and voice comments will be recorded of crewmen demonstrating the various modes of communication using related OWS equipment.

FO 9) Voice comments will be recorded for physical games requiring crewmen and/or object motion, and exercising with and without exercise devices.

Success Criteria

FO 1) thru FO 9) Photographic and recorded data shall be returned to the Principal Investigator for analysis.

Evaluation

FO 1) thru FO 9) The Principal Investigator will analyze and evaluate the data throughout the Skylab Program. A preliminary report will be made within 15 days after receipt of processed flight data. A final experiment report will be made 6 to 8 months after recovery of the last flight. A report to the engineering community will be available 9 months after the final mission. (Telemetry data, astronaut records, photographs)

Data Requirements

Refer to Appendix A.

Experiment M509

ASTRONAUT MANEUVERING EQUIPMENT

Test and evaluate new maneuvering concepts to enhance future orbital extravehicular activity.

Purpose and Background

The purpose is to demonstrate man's maneuverability while obtaining data and experience on man and Astronaut Maneuvering Unit (AMU) performance in a zero gravity environment. The data and experience gained will be used to improve ground based simulators and project future AMU design requirements and mission capabilities. The flying characteristics of four different AMU control concepts are provided by an Astronaut Maneuvering Research Vehicle (AMRV) with four operating modes. Crewmen pilots will fly various maneuvering tasks inside the Orbital Workshop (OWS) to test and evaluate each operating mode described as follows:

a) Hand Held Maneuvering Unit (HHMU) Mode. This mode will evaluate man's maneuver capability with a very simple, small, lightweight, completely manual, hand held propulsion device.

b) Direct Mode. This mode will be similar to the HHMU in that the astronaut will be completely dependent upon visual cues but differs in that multiple, fixed position thrusters will be used to provide translation and rotation forces about a fixed body axis system.

c) Rate Gyro Mode. This mode will employ the same thruster configuration and performance characteristics as the direct mode but will have proportional rate command and attitude hold.

d) Control Moment Gyro (CMG) Mode. This mode will be similar to the rate gyro mode except that attitude control will be provided through momentum exchange instead of mass expulsion.

Functional Objectives

FO 1)	A crewman will perform various familiarization and mission maneuver tests to evaluate all four operating AMRV modes. Total flying time required is 50 minutes.	(15%)*
FO 2)	The same crewman will repeat some of the familiarization and mission maneuvers (from FO 1) and undertake some exploratory maneuvers to evaluate all four operating modes. Total flying time required is 1 hour 10 minutes.	(25%)*
FO 3)	The same crewman will repeat many of the previous maneuvering tests (from FO 1 to FO 2) to evaluate all four modes while wearing a pressurized suit. Total flying time required is 1 hour 20 minutes.	(40%)*

FO 4) The same crewman will repeat some of the mission maneuvers and complete the exploratory maneuvering tests (from FO 1, FO 2, and FO 3). Total flying time required is 1 hour. (20%)*

Test Conditions

FO 1) The crewman will wear shirtsleeve type clothing.

FO 2)
FO 4) Voice communication will be carried on the OWS intercommunication system by the observer.

FO 3) The crewman will wear a pressurized spacesuit with the Astronaut Life Support Assembly (ALSA) and the Life Support Umbilical (LSU). Special tests without the LSU are planned contingent upon the availability of unused secondary oxygen packages.

Voice communication will be carried on the OWS intercommunication system by the observer and by the pilot via the LSU.

FO 1)
FO 2)
FO 3)
FO 4) Four experiment runs are planned. Two crewmen will perform the experiment operations, one serving as the pilot while the other serves as the observer.

The observer will operate/load the cameras, cue the pilot on the test procedures, and analyze and describe the test progress via voice communications. The observer will be on voice communication at all times.

Propellant gas for experiment operations for the AMRV will be supplied from the self-contained AMRV Propellant Supply Subsystem (PSS).

Detailed maneuver elements and times are TBD for the four operating modes. Experiment operations (excluding maneuvers) will be performed per procedures contained in the M509 Experiment Operations Handbook.

At least 2 days between experiment runs will be required, based on Saturn Workshop (SWS) atmosphere management considerations. The exact elapsed time required between runs will depend on run time, gas used, modes used, and SWS leakage rate.

The waste management compartment exhaust fan will be removed prior to performance of experiment operations.

At least 2 days are required between the performance of M509 and T020 (Foot Controlled Maneuvering Unit). The exact time between experiment performance will depend on atmosphere management considerations.

The T027 extension mechanism shall not be installed in the anti-solar SAL during M509 experiment operations. This constraint is due to the proximity of the extension mechanism to the M509 maneuvering volume when installed in the anti-solar SAL.

During experiment operations, the allowable spacecraft acceleration shall be no greater than 1 x 10^{-3} degrees/sec^2 or 3 x 10^{-4}g along any axis.

During experiment operations, the maximum allowable spacecraft rate about any axis will be 6 degrees per minute.

Air velocity in the OWS forward compartment should not exceed 15 feet per minute during experiment operations.

Comments made by pilot and observer during and immediately after each experiment run will be tape recorded and dumped at scheduled intervals per the Flight Plan.

The start of the first experiment run should be scheduled to maximize real time monitoring of experiment operations. All M509 telemetry will be recorded on the Airlock Module recorder for subsequent dumping to the ground at scheduled intervals per the Flight Plan.

During each experiment run, some data will be flagged for processing at the Mission Control Center, Houston (MCC-H) for post-pass performance analysis.

SWS cabin pressure will be transmitted to the ground during experiment operations for quick look evaluation. This measurement is also required to be recorded for 24-hour availability.

The Principal Investigator or his representative will be present at the MCC-H to assess experiment progress and to consult with the flight control team or crew as required.

Complete photographic coverage of all experiment maneuvers will be obtained.

Experiment M151 (Time and Motion Study) will photograph M509 recharging, donning, and doffing operations. Experiment M516 (Crew Activities/Maintenance) will photograph M509 launch unstowage and mass handling operations.

The astronaut log book will be returned after the mission.

Success Criteria

FO 1) A crewman shall perform various familiarization and mission maneuver tests for 50 minutes.

FO 2) The same crewman shall repeat some of the familiarization and mission maneuvers (from FO 1) and undertake some exploratory maneuvers for 1 hour 10 minutes.

FO 3) The same crewman shall repeat many of the previous maneuvering tests (from FO 1 and FO 2) while wearing a pressurized suit for 1 hour 20 minutes.

FO 4) The same crewman shall repeat some of the mission maneuvers and complete the exploratory maneuvering tests (from FO 1, FO 2, and FO 3) for 1 hour.

Evaluation

FO 1)
FO 2)
FO 3)
FO 4)

Mission Control Center Personnel will make a near real time evaluation of each experiment run to assess proper hardware functioning (experiment and spacecraft support), cabin atmosphere and consumables management, and Flight Plan updates.

The Principal Investigator will be responsible for the analysis and evaluation of photographic, telemetry, and voice commentary data for each AMRV control mode. (Telemetry data, astronaut records, photographs)

Data Requirements

Refer to Appendix A.

Experiment M512 — MATERIALS PROCESSING FACILITY

Provide facility for performing tasks in a space environment to study molten metal and flammability phenomena.

Purpose and Background

The purpose is to provide a basic apparatus and a common spacecraft interface for a group of space experiments in materials science and technology, and to test and demonstrate a system approximating the "facility approach". The Materials Processing Facility (MPF) will provide the basic structure and support facilities to operate the following experiments:

M479 - Zero Gravity Flammability

M551 - Metals Melting

M552 - Exothermic Brazing

M553 - Sphere Forming

M554 - Composite Casting

M555 - Gallium Arsenide Crystal Growth

Each of these experiments will be operated in the MPF vacuum chamber utilizing the power distribution and control features of the facility.

Functional Objectives

FO 1) Obtain objective and subjective data on the performance and operation of the MPF. (TBD%)

† FO 2) Discharge the MPF battery and close the battery case vent valve. (TBD%)

† This functional objective must have been scheduled and completed on SL-1/SL-2.

Test Conditions

FO 1) The Experiment M512 MPF will support the performance of Experiments M551, M553, M552, M555, M554, and M479, (in that order) per procedures contained in the M479/M512 Series Experiment Operations Handbook (EOH).

During the performance of the above experiment, objective and subjective data will be voice recorded and pertinent observation entered in the experiment log book concerning the performance and operation of the M512 facility.

Photographic film from Experiments M551, M553, and M479 will be required for evaluation of the MPF.

Operational photography, TV, or photography from Experiment M516 (Crew Activities/Maintenance Study), if available, are highly desirable.

FO 2) Discharge of the M512 battery and closure of the battery case vent valve will be accomplished per procedures contained in the M479/M512 Series EOH.

These tasks will be performed only after completion of Experiments M551, M552, and M553.

Though not mandatory, it is highly desirable that these tasks be performed prior to start of Experiments M555, M554, and M479. However, it is mandatory that battery discharge be accomplished prior to completion of SL-1/SL-2.

Times for discharge initiate, complete, and vent valve closure should be voice recorded or logged in the M512 Log Book.

Success Criteria

FO 1) The MPF shall adequately support the performance of the required experiments. Objective and subjective data on the performance of the MPF shall be returned to the Principal Investigator (PI) for analysis.

FO 2) The battery shall be discharged and the battery case vent valve shall be closed.

Evaluation

FO 1)
FO 2) The PI will evaluate the MPF design and construction for adaption to future space manufacturing techniques. Together with data obtained from the M512 Series experiments, the facility approach to space manufacturing will be evaluated for ability to support manufacture of new or better metals or metal working processes. (Astronaut records, photographs, other)

Data Requirements

Refer to Appendix A.

Experiment M554 — COMPOSITE CASTING

Fabricate three castings in space by undirectional solidification of eutectic composite.

Purpose and Background

The purpose of this experiment is to fabricate a Cu Al_2-Al or other alloy lamellar eutectic composite in the absence of thermal convection and hence to obtain a more perfect structure.

This experiment will contribute to the demonstration and evaluation of the merits of molten metal phenomena for manufacturing in a space environment and to the definition of applications of this science to future space programs and industry.

Functional Objectives

† FO 1) Fabricate three composite castings, and collect data and samples for return to earth.

†This functional objective if scheduled and completed on SL-1/SL-2 will not be repeated on this mission.

Test Conditions

FO 1) The operation of this experiment will be performed in accordance with procedures contained in the M479/M512 Series Experiment Operations Handbook (EOH).

The composite casting experiment will be performed without interruption in the M512 Materials Processing Facility (MPF) by one crewman.

The composite specimens will be removed from the vacuum chamber and the castings stowed in the CM.

One vacuum chamber cycle will be required for the specimen array of this experiment.

The work chamber will be evacuated to space vacuum (no less than 10^{-5} torr) for experiment operation.

This experiment will be completed in the vacuum chamber of the MPF prior to the performance of Experiment M479 (Zero Gravity Flammability).

Astronaut comments during the performance of this experiment will be voice recorded and pertinent observations entered in the experiment log book.

Accelerations are to be avoided if possible. Inhibit of the Control Moment Gyro desaturation maneuver will not be required. However, postflight telemetry data of Thruster Attitude Control Subsystem (TACS) firings and accelerations will be required.

Success Criteria

FO 1) The performance of the composite casting operation and the collection of the composite specimens shall be accomplished. The specimens shall be returned to the Principal Investigator.

Evaluation

FO 1) The casting samples will be studied and evaluated by the Principal Investigator both independently and by comparison to samples obtained in a unity earth gravity environment. In addition, the data will be compared to subjective data recorded in the astronaut logs and voice records. (Telemetry, astronaut records, experiment samples)

Data Requirements

Refer to Appendix A.

Experiment S019 ULTRAVIOLET STELLAR ASTRONOMY

Obtain ultraviolet photographic exposures of selected areas.

Purpose and Background

The purpose is to obtain moderate dispersion stellar spectra extending down to 1400 Å with sufficient spectral resolution to permit the study of ultraviolet (UV) line spectra and of spectral energy distribution of early type stars and to obtain low dispersion UV spectra in a number of Milky Way starfields and nearby galaxies. The data obtained from this experiment should be of sufficient accuracy to permit detailed physical analysis of individual stars and nebulae. The experiment observations will also provide a survey of a significant fraction of the Milky Way in the UV wavelengths.

Functional Objectives

FO 1) thru FO 12) Obtain selective UV photographs of as many designated starfields as possible on a single darkside pass. (8.3%)*

Test Conditions

FO 1) thru FO 12) Candidate starfields will be listed along with pointing coordinates and recognition maps in the Experiment Log Book. The potential starfields to be photographed will be updated by computer based upon exact orbital conditions of the Orbital Workshop (OWS). The updated starfields, pointing coordinates (mirror tilt and rotation angles, etc.) will be supplied to the crew 24 hours prior to the experiment session.

The spectrograph (consisting of a film canister, optical canister, and mirror system) will be assembled into a unit and mounted in the anti-solar Scientific Airlock (SAL) and the mirror oriented toward the target starfield per procedures contained in the S019 Experiment Operations Handbook.

One hundred fifty photographs of 36 starfields are required for this experiment on this mission. It is expected that approximately 12 exposures can be made during each night side pass; therefore, approximately 12 night side passes may satisfy the experiment objectives. However, the exact number of starfields to be photographed within the 150 frame limit and the number of exposures per starfield are dependent upon the brightness of selected starfields and cannot with any certainty be scheduled prior to real time.

To maximize the scientific return of this experiment, it is highly desirable that within the constraint of the 150 exposures, the astronaut be allowed as much flexibility in his choice of stafields and exposure times as possible.

It is highly desirable to have two separate observing periods with an interval of at least 5 days.

The duration of any given exposure will be within 10 percent of its programmed duration.

Programmed exposure times are 30, 90, and 270 seconds. The starfield brightness will determine which combinations of exposure times are used. In some cases only two exposures may be required, in other cases three may be required, and when the stability of the OWS permits (i.e., where the OWS has a rate of 1/2 arc second/second or less and the direction is within 45 degrees of the direction of dispersion) a fourth exposure without the use of the spectral widening mechanism may be desirable.

Pre-exposed attitude knowledge of the Orbital Assembly (OA) to within 2.5 degrees (in the stellar inertial reference system) will be required in order to allow the operator to locate designated target starfields.

It is highly desirable that the experiment be performed during the dark side passes with durations exceeding 32 minutes, when the moon is less than half illuminated and when the OA is in an inertially stable mode, e.g., Solar Inertial Attitude (X-IOP/Z). The mirror should be erected just before sunset and retracted just before sunrise.

For each exposure the operator will voice record: a) the exposure number, b) target field identification, c) time of initiation correlatable to Greenwich Mean Time (GMT) to within 1 minute, d) length of exposure, and e) comments on the quality of image tracking conditions and any other noteworthy conditions relative to the experiment.

To minimize exposure time to radiation, the film canister must be demounted and stowed in the film vault between observing periods separated by more than 12 hours. It is permissible to have the remainder of the experiment in the airlock during this period if the cover is placed on the optical canister and the assembly is vented to space. A total exposure duration to the ambient radiation environment that will exist when out of the film vault shall not exceed 96 hours for the film canister.

If it is necessary to remove the experiment from the airlock for more than 12 hours, all experiment equipment (mirror system, optical canister, and film canister) must be evacuated to 1 torr or less. Evacuation is to begin within 30 minutes of experiment disassembly.

During all mission phases other than the experiment operation periods, the film canister will be maintained at a temperature of 90°F or lower.

Ambient temperature conditions are tolerable for the duration of experiment operation periods.

The UV optical components in the interior of the experiment hardware will be protected by storing in an evacuated condition. Exposure to cabin atmosphere should be limited to a short time interval during installation into the SAL and again at removal.

The fog level on experiment film shall not exceed 0.36 density units during the life of film.

The film canister stowed in its Flight Stowage Container will be transferred to the Command Module prior to SL-2 separation at such a time as to be compatible with the constraint that the film canister shall not be out of the OWS film vault for more than 96 hours. All other experiment hardware will remain stowed as for launch.

The film canister containing exposed film shall be shielded from exposure to natural environments during recovery. As soon as possible upon recovery, the film canister is to be transferred to a temperature controlled storage area where temperature is to be maintained at no greater than 80°F. During transferral from the recovery vessel to the film processing laboratory, the film canister shall be contained and protected in a ground support handling container.

S019 must time share the anti-solar SAL with Experiment S063 (Ultraviolet Airglow Horizon Photography), S149 (Particle Collection), S183 (Ultraviolet Panorama), and T027/S073 (Contamination Measurement and Gegenschein/Zodiacal Light).

T013 (Crew/Vehicle Disturbances), T020 (Foot Controlled Maneuvering Unit) and M509 (Astronaut Maneuvering Equipment) must not operate while S019 equipment is installed in the SAL.

During experiment operation the following lighting conditions will be required:

a) All interior lights in the spacecraft which could impinge on or scatter light into the spectrograph will be extinguished during exposure periods.

b) Red operating lights with no significant intensity at wavelengths shorter than 5500 Å are acceptable without restriction.

c) All ports or windows from any remaining lighted portions of the OA will be covered to prevent light ($\lambda <$ 5500 Å) from scattering into the spectrograph

d) All exterior vehicle running lights will be turned off.

Thruster Attitude Control Subsystem (TACS) firings will be minimized when the articulated mirror system is extended. There will be no TACS firings during an exposure period.

Moisture must not be allowed to condense on the S019 mirror system.

Waste disposal must not occur during or within 30 minutes prior to scheduled experiment operating periods.

Outgassing which leads to redeposition on optical surfaces will be avoided as much as possible.

The quality of the spectra (i.e., the wavelength resolution) produced by this experiment depend critically on the spacecraft rates and spacecraft stabilization. Uniform rates (i.e., relatively constant over a period of 1 minute) are acceptable and of no concern up to magnitudes of 1 arc sec/sec. Rates between 1 and 10 arc sec/sec are acceptable; uniform rates in excess of 10 arc sec/sec are unacceptable.

High frequency (approximately 1 hertz and greater) deviations (harmonic oscillations or random noise) are acceptable so long as the 1 sigma amplitude of angular displacement does not exceed 20 arc seconds.

Excursions resulting from random transitory events, such as crew motion are acceptable without limitation or magnitude so long as the interval between such events exceeds 2 minutes. More frequent excursions of this nature are acceptable only if the 1 sigma amplitude of the excursion is 20 arc seconds or less.

Crew motions are to be kept to a minimum during S019 exposures. Schedules of crew activities involving violent activity (e.g., recreational activity such as handball, operation of mass measurement devices, etc.) are to be avoided during S019 operation periods.

It will be necessary to inhibit momentum dump maneuvers during the period when this experiment is operating since this experiment cannot operate while the spacecraft is in motion.

<u>Success Criteria</u>

FO 1) thru FO 12) A minimum of 115 (77% of the 150) UV photographs of <u>TBD</u> starfields shall be obtained and returned along with the required support data.

Evaluation

FO 1) thru FO 12) Film processing will be performed at the Manned Spacecraft Center by the Principal Investigator or his representative. Data reduction using the original flight film will be performed by means of a photometric film analysis facility at the home laboratory of the Principal Investigator, Lindheimer Astronomical Research Center, Northwestern University. All flight film handling and duplication will be performed by the Principal Investigator or his representative. Results of data analysis and evaluation will be reported by the Principal Investigator in a series of reports, with an initial draft of the final report to be available within six months following receipt of complete flight data by the Principal Investigator. (Astronaut records, photographs, trajectory data, other data)

Data Requirements

Refer to Appendix A.

Experiment S020 — X-RAY/ULTRAVIOLET SOLAR PHOTOGRAPHY

Photograph the quiet and active sun.

Purpose and Background

The purpose is to obtain spectral data of the sun to aid in prediction of solar flares and the quality of radio communications.

This experiment offers the possibility of obtaining more information on the solar spectrum, in the 10 to 200 Å region, than has been obtained with earth-based or rocket-borne spectrographic equipment. The spectral data associated with solar flares is of interest in solar flare prediction and the effects of solar flares on the quality of radio communications. The ability to accurately predict solar flares will be useful in the planning of manned space flights.

The data from this experiment will also be of use to those in the engineering and scientific community with interests in the fields of astrophysics and plasma physics, as well as the development of methods of thermonuclear power production.

Functional Objectives

FO 1) Obtain photographic data of the "quiet" sun in the wavelength region from 10 to 200 Å. (50%)*

FO 2) Obtain photographic data of the "active" sun in the wavelength region from 10 to 200 Å. (50%)*

Test Conditions

FO 1) Obtain ten preplanned exposures of "quiet" sun per procedures contained in the S020 Experiment Operations Handbook (EOH) as follows:

a) 2 exposures of 60 minutes each†
b) 2 exposures of 30 minutes each
c) 2 exposures of 15 minutes each
d) 2 exposures of 8 minutes each
e) 2 exposures of 5 minutes each

†Each 60-minute exposure may be broken down into two 30-minute exposure periods. It is mandatory that each 30-minute exposure be obtained on successive orbits.

It is desirable that one set of each exposure sequence be performed during the early stages of the mission and that the other set be performed near the end of the mission.

Pointing of the experiment line-of-sight to the center of the solar disk must be maintained within 0.25 degrees during the exposure period.

FO 2) Photography of the active sun is to be scheduled for performance during periods when solar flare activity has been predicted. The S020 assigned operator is to be on "Flare Watch" during this period. It is not mandatory that the operator be on station during this entire period. He may be engaged in other activities but must be able to return and operate S020 within TBD seconds after a flare alarm occurs.

During the "Flare Watch" period the experiment operator will periodically TBD monitor experiment pointing.

Pointing of the experiment line-of-sight to the center of likely flare activity must be maintained within 0.25 degrees.

Ten exposures will be allocated to a flare watch with approximately three exposures per flare. Exposure period will vary from approximately 1 minute during flare rise period to several minutes during flare decay period.

A minimum of 48 hours of crew time in increments of 8 hours minimum is to be assigned to flare watch activity. A period of high probability of solar flare activity cannot be predicted with a high degree of accuracy prior to 1 to 2 days before the occurrence. It is desirable that the 48 hours of flare watch be scheduled with flexibility and the possibility of trading airlock time with other experiments that do not have this near real time requirement.

Upon completion of an exposure sequence for one solar flare, the remaining flare watch periods may be cancelled. If, however, airlock and crew time is available, it would be desirable to attempt to use the remaining film for either quiet sun or solar flares. If no solar flare has occurred during the majority of alloted flare watch time, it would be desirable to use the remaining flare watch time to secure additional photographs of the quiet sun.

X-ray monitor display of Apollo Telescope Mount (ATM) Experiment S054 (X-Ray Spectrographic Telescope) will be in operation during flare watch periods.

It is desirable that ATM Experiments S082A (Coronal Extreme Ultraviolet Spectroheliograph) and S082B (Chromospheric Extreme Ultraviolet Spectrograph) be in operation whenever exposures are made of the "active" sun.

Based on the assumption that experiment pointing will be performed by maneuvering the Orbital Workshop (OWS), an alignment operation to align the S020 principal axis to the sun line will be required. This operation will consist of biasing the ATM sun sensor in increments of 0.1 degrees until the S020 operator observes the area of likely flare activity centered in the S020 Boresighting Port optical display. A bias angle of 1.75 degrees away from Z solar inertial is presently the maximum allowable in order that Experiments S020, S082A, and S082B may be conducted concurrently.

FO 1) FO 2) The experiment will be mounted in the solar Scientific Airlock (SAL) and pointed toward the sun per procedures contained in the S020 EOH.

The SAL outer hatch is to be closed for each dark side pass and opened at orbital sunrise.

Experiment S020 uses the solar SAL and must not be scheduled concurrently with S063 (Ultraviolet Airglow Horizon Photography), and T027/S073 (Contamination Measurement and Gegenschein/Zodiacal Light).

T013 (Crew/Vehicle Disturbances), T020 (Foot Controlled Maneuvering Unit) and M509 (Astronaut Maneuvering Equipment) must not operate when S020 equipment is installed in the SAL.

The experiment will be performed when the Orbital Assembly (OA) is in the solar inertial attitude (X-IOP/Z) solar inertial mode. Small angular bias correction may be required to point S020 at the sun since the experiment is hard-mounted to the SAL.

All contamination events (e.g., urine dump, water dump) will be inhibited whenever the SAL outer door is open and an exposure is in progress.

Experiment operation will be limited to the period from five minutes after OA sunrise to five minutes before OA sunset.

The fog level on experiment film shall not exceed 0.2 density units during the life of the film.

Film temperature must be maintained between 35° and 75°F, except that during preflight and reentry the maximum allowable temperature will be 80°F. Maximum cumulative soak time at TBS°F may not exceed 2 days.

Film canister interiors will not be exposed to an oxygen-rich atmosphere for more than 30 minutes.

The film magazines will be stowed in the film magazine stowage container (FMSC) which in turn will be stowed in the OWS film vault during experiment non-operational periods. One film magazine will be used at a time in the Spectrograph Assembly during experiment operation. The remaining magazine will remain in the container in the vault.

The FMSC will be evacuated for 3 minutes prior to returning it to the OWS film vault in between experiment performances. After the final performance, the FMSC will be evacuated to 1 torr.

Required telemetry measurements will be recorded for subsequent playback and transmission to the ground

C.3

The following will be recorded by the astronaut using both the voice recorder and the S020 portion of the crew log book.

a) Vacuum Valve positions: closed, vented, open

b) Film advance (index position)

c) The angular offset bias in pitch and yaw required to point the experiment at the solar disk. It is also required that the crewman at the ATM control panel voice record the angular offset bias input to the attitude control system.

d) Any other comments pertinent to S020 experiment setup, operation and restowage

Success Criteria

FO 1) Film magazine(s) containing at least one exposure from each of the five preplanned exposure sequences shall be returned to the Principal Investigator.

FO 2) TBD exposures of one flare shall be returned to the Principal Investigator.

Evaluation

FO 1) Information on the solar spectrum in the wavelength region from 10 to 200 Å will be reviewed by the Principal Investigator. Although the total evaluation plan will be controlled by the Principal Investigator, the quality of the photographs will be noted, the data will be compared to that obtained by present earth-based and rocket-borne photography, and a datum will be established for a "quiet" sun.

FO 2) Photographic data of the "active" sun will be analyzed by the Principal Investigator, and will include a comparison with the datum obtained in FO 1. The potential effects of solar flares on radio communications will be reviewed.

FO 1)
FO 2) The data from both the "quiet" sun and the "active" sun will be reviewed to determine if the ability to predict solar flares may be enhanced. (Telemetry data, astronaut records, photographs)

Data Requirements

Refer to Appendix A.

Experiment S063

ULTRAVIOLET AIRGLOW HORIZON PHOTOGRAPHY

Photograph airglow and ozone layer.

Purpose and Background

The purpose is to photograph in visible and ultraviolet (UV) light the earth's ozone layer and the twilight airglow. These photos, made on a global scale, will be valuable in the studies of visible and UV mechanisms, and knowledge may also be gained pertaining to upper atmospheric movements which seem to be associated with airglow variations.

Functional Objectives

† FO 1) Photograph the earth's ozone atmosphere at UV wavelengths and photograph the earth and its atmosphere at visible wavelengths. (40%)*

† FO 2) Photograph the earth's twilight airglow at visible and UV wavelengths. (Red arcs, aurora, and noctilucent clouds will be photographed during twilight airglow photography sessions when possible.) (60%)*

†Those functional objectives or parts thereof scheduled and completed on SL-1/SL-2 will not be repeated on this mission.

Test Conditions

FO 1) Experiment Assembly I (consisting in part of two cameras, one for taking UV photographs and the other for taking regular color photographs) will be used. The UV camera will be mounted at the anti-solar Scientific Airlock (SAL). The color camera will be mounted in the wardroom window of the Orbital Workshop (OWS) and will automatically take photographs simultaneously with the UV camera.

Three hundred exposures (150 UV and 150 color) are required to satisfy this portion of the experiment. It is estimated that 15 exposures per earth pointing attitude (Z-LV[E]) pass can be made; therefore, approximately ten Z-LV(E) passes will be required. These passes may be the same as Earth Resources Experiment Package Z-LV(E) passes if the crew is available.

Tracking will be accomplished by an astronaut who will keep the optical sight on the UV camera pointed at some feature on or near the earth's surface per procedures contained in the S063 Experiment Operations Handbook (EOH).

Photographs will be made:

a) Over the United States to provide values for comparison with ground based observations

b) Over a variety of terrain, e.g., sea, desert, green forests or fields, cities, snow, cloud layers etc. to provide a check on the efficiency of the three-color filter principle.

c) Over the entire globe at different seasons and different latitudes to view the ozone concentration as distributed over the earth, expecially in areas where no ground stations are available.

The optical sighting device will be kept pointed to within 0.5 degrees on a chosen tracking feature.

Image motion control (IMC) will be maintained by the experimenter through the duration of the exposure. Required tracking rates are functions of orbital position and target altitude. Approximate average rates are 1 degree/sec for the ozone photography.

The 150 UV photographs will be obtained according to the following schedule:

Quantity(1)	Sun Angle	Nominal Exposure Time		Filter (Angstroms)
15(2)	60°-40°	20 sec.	long	2800
15(2)	60°-40°	20 sec.		3200
30(3)	40°-15°	8 sec.	med.	2800
30(3)	40°-15°	8 sec.		3200
30(4)	15°- 0°	2 sec.	short	2800
30(4)	15°- 0°	2 sec.		3200

Notes: (1) Orbital circumstances may not permit scheduling to obtain the desired number of exposures for each group of sun angles listed. While the best pictures will be made with the angle between the sun and the local vertical at a minimum, the experiment objectives can be met with longer exposures and larger angles provided that at least 10 sets (20 exposures) are made for sun angles between 0° and 15°.

(2) After each exposure, the camera/sight carriage must be reset to the start position. Exposures are to be made alternately through the two UV filters.

(3) After each exposure, the camera/sight carriage must be reset to the start position. Exposures are to be made alternately through the two UV filters.

(4) These exposures are to be made in pairs. On a given target, two exposures should be made in rapid succession, one through each UV filter.

FO 1) The 150 color exposures (one taken simultaneously with each UV exposure) will have a duration of 1/250 second.

Experiment Assembly I of S063 must time share the anti-solar SAL with Experiments S019 (Ultraviolet Stellar Astronomy), S149 (Particle Collection), S183 (Ultraviolet Panorama), and T027/S073 (Contamination Measurement and Gegenschein/Zodiacal Light).

FO 2) Experiment Assembly II, used for obtaining twilight airglow photographs, will be attached to the solar SAL.

The airglow, together with the earth limb and background starfield, will be photographed from the spacecraft night position in the solar direction.

Two periods of observing time per orbit are available; during spacecraft evening twilight and the other half during spacecraft dawn.

Three hundred exposures are required to satisfy this portion of the experiment and will generally be divided into three groups: 130 exposures of airglow in the visible spectrum, 130 exposures of the airglow in the UV spectrum, and 40 exposures of targets of opportunity consisting of red arcs, aurora, and noctilucent clouds.

The 260 scheduled twilight airglow exposures will be obtained according to the following schedule:

Quantity		Nominal Exposure Time (sec)	Filter (Angstroms)
30	visible	30	6300
30		60	6300
20		120	6300
20		40	5577
20		80	5577
10		120	5577
30	UV	30	3900
30		60	3900
20		120	3900
20		30	2600
20		60	2600
10		120	2600

The 40 targets of opportunity exposures will be obtained according to the following schedule. When these targets occur during a working period, they should be photographed as soon as possible, except that an on-going exposure should not be interrupted.

Quantity	Nominal Exposure Time(1)	Remarks
15 (red arcs)(2)	5-20 sec.	---
15 (aurora)(3)	1/10 to 20 sec.	6300 Å, 5577 Å, 3900 Å filters
10 (noctilucent(4) clouds)	1/100 to 1 sec.	(Visible camera color film f/1.2)

Notes: (1) Due to the nature of the photographs, exposure times will be variable and will require the judgement of the astronaut observer in every situation.

(2) The spacecraft geomagnetic latitude should be within 10 degrees of the geomagnetic equator.

(3) The spacecraft geomagnetic latitude should be within 40 degrees of the north or south geomagnetic poles.

(4) The best observation times will occur during twilight airglow photography sessions at high latitude when the 80 to 100-km altitude region is sunlit but the spacecraft is dark.

FO 2) Twilight airglow photography must be performed when the spacecraft is in the solar pointed mode and is located at solar depression angles between 26.5 degrees and 37.5 degrees.

The length of the photography sessions are a direct function of the β angle and increase as the β angle increases. It is desirable to schedule the photography sessions at β angles between 35 and 62 degrees.

The exposure sequence at evening twilight will generally be short, medium, long, i.e., of duration 30, 60, and 120 seconds. At spacecraft dawn, the sequence will be reversed, i.e., 120, 60, and 30 seconds.

With working times greater than five consecutive minutes, it is desirable to obtain a series of alternate 6300 Å and 5577 Å exposures with exposure times increasing from twilight and decreasing toward dawn. If less than five consecutive minutes are available, only the red or green filter will be used during an orbit. The same procedures will prevail when the UV camera is in operation; however, alternating the UV filters in one orbit is not necessary.

Exposures with any of the four filters can be made whenever the portion of the twilight horizon that is being photographed is not in either the northern or southern auroral zone.

The internal lights that may cause light to enter the camera will be extinguished during exposure periods. All external lights will be turned off during film exposure.

The camera will be kept pointed at a chosen airglow layer within 0.5 degree.

IMC will be maintained by the experimenter through the duration of exposure. Required tracking rates are functions of orbital position and target altitude. Approximate average rates are 0.06 degrees/sec.

The experiments may be performed during Control Moment Gyro (CMG) desaturation periods.

Experiment Assembly II of S063 must time share the solar SAL with Experiments S020 (X-Ray/Ultraviolet Solar Photography), and T027/S073 (Contamination Measurement and Gegenschein/Zodiacal Light).

FO 1) FO 2) Detailed photographic operations will be conducted in accordance with procedures contained in the S063 EOH.

The maximum pitch, yaw, or roll rates during the exposure period will not exceed 0.1 degree/sec.

No manual overboard dumping or Reaction Control System operation will be permitted during experiment performance.

T013 (Crew/Vehicle Disturbances), T020 (Foot Controlled Maneuvering Unit), and M509 (Astronaut Maneuvering Equipment) must not operate when S063 equipment is installed in the SAL.

The thermal sensitivity of the cameras and film requires that the environmental temperatures will be maintained as follows:

Item	Stored and/or Transported	Operated
Experiment Assembly	0-100°F	65-90°F
Film cassettes	85°F Maximum	65-90°F

The increase in film negative density due to all radiation sources other than timed exposures shall not be greater than 0.3 density units above the density due to base fog.

The film cassettes will require protection from radiation during reentry by stowage in the Command Module (CM). During launch and the manned phase, the cassettes will be stowed in the radiation shielded OWS film vault. If experiment operation times are separated by more than 4 hours, the film and camera will be stowed in the OWS film vault.

Flight crew operations will be scheduled so that no crewman is exposed to UV radiation from the SAL windows for more than 27 minutes in any 24-hour period.

Experiment log book entries will be made at the end of each session and are to include orbit number, location of experiment, beginning film exposure number, last exposure number, and condition of equipment at end of last session.

Voice annotation by the astronaut will be made for each exposure taken and must include camera identification, filter code, series number, camera orientation, exposure initiation in Greenwich Mean Time (GMT) within 1.0 second, exposure number, and exposure duration.

Prior to each photography session a voice recording of beginning exposure number, filter identification, initial camera bracket setting, GMT, and identification of any targets of opportunity will be made.

Voice tapes of astronaut annotations during experiment operations are to be dumped after each photography session.

Success Criteria

FO 1) A minimum of 46 UV photographs and 46 simultaneously acquired color photographs shall be obtained and returned along with the required support data.

The minimum required photographs shall be apportioned as follows:

3 sets (6 exposures) of long exposures
10 sets (20 exposures) of medium exposures
10 sets (20 exposures) of short exposures
46 color exposures, one for each of above

FO 2) A minimum of 80 exposures shall be obtained and returned along with the required support data.

The minimum required photographs shall consist of 20 pictures through each of the four filters with at least three exposures at each of the three exposure times (short, medium, and long).

In addition, three exposures each of targets of opportunity, if at all possible, is highly desirable.

Evaluation

FO 1)
FO 2) The exposed film cassettes will be forwarded to the Manned Spacecraft Center for processing. Final processing of flight data will be made by the experimenters after receipt of processed flight film, computer-compatible tape, ephemeris data, astronaut records, and other data. Results of the data analysis and evaluation will be reported by the Principal Investigator in a series of reports, with an initial draft of the final report to be available within six months following receipt of the above mentioned data. (Telemetry data, astronaut records, photographs, trajectory data)

Data Requirements

Refer to Appendix A.

Experiment S071/S072 — CIRCADIAN RHYTHM - POCKET MICE/VINEGAR GNAT

Obtain circadian rhythm data on pocket mice and vinegar gnats.

Purpose and Background

The purpose is to determine the persistence of the circadian rhythms of body temperature and activity in pocket mice. Additionally, the purpose is to determine the persistence of circadian rhythms and the effect of the phenomenon of temperature compensation in the vinegar gnat.

A statistical analysis of all data (ground and flight) acquired will be performed to determine any variance between the circadian rhythms observed in the flight group while in orbit with respect to the circadian rhythms observed during the baseline run and those observed in the ground control groups. The analysis will be performed by the experimenter at his facilities using computer methods developed for this purpose. A significant digression of either the precision or lengths of the "free running" circadian periods measured in space from those periods measured on earth would constitute evidence of dependency of circadian organization upon geophysical "cues". Conversely, continuance in space of the precise "free running" circadian periods measured on the ground would significantly reduce arguments in favor of dependency of circadian organization upon geophysical "cues".

Functional Objectives

FO 1) Obtain data to determine the persistence of circadian rhythms in pocket mice. (50%)

FO 2) Obtain data to determine the persistence of circadian rhythms and the effect of temperature compensation in the vinegar gnat. (50%)

Test Conditions

FO 1) Six pocket mice, in individual cages that provide living space and food for each mouse, will be placed in orbit in an internal environmental control system that provides a constant atmosphere to the mice.

Mice cage temperature will be held constant within 0.5°C in a temperature range of 20($\pm$2)°C.

The cage pressure will be held constant within $\pm$2% in a pressure range of 700($\pm$60) mm Hg

The air composition will be maintained at a near normal atmosphere.

No crew operations are required except for removing power from the experiment upon completion of the experiment. The only other operations would be as a backup to ground commands. All experiment operations will be nominally controlled from the ground.

The circadian rhythms of each mouse will be continuously monitored from launch for a minimum period of 28 days.

FO 2) After orbital insertion, a "Vinegar Gnat Initiate" ground command will be issued to commence a sequence of events that start the development of vinegar gnat pupae in four separate units, each housing 180 pupae.

The pupae ambient temperature in two of the pupae housing units will be raised to approximately 15°C and in the other two units to approximately 20°C.

After the temperature has stabilized (within 12 hours) the pupae in each of the units, two at each temperature, will be exposed to a simulus light. Confirmation of stimulus light operation will be required.

The date and time of day of the initiate command, 15°C and 20°C temperature stabilizations, and first stimulus light operations within 5 minutes will be recorded.

The S072 control electronics will monitor the ambient temperature for the pupae of each housing unit and relay these data to the S071 Circadian Data System (CDS) every 10 minutes to be stored in memory. (Each 10-minute data frame consists of both S071 and S072 instrumentation.)

The stored S072 data will be relayed to the ground receiving stations together with the S071 data upon ground command.

FO 1)
FO 2) Data dumps will be periodically scheduled during the operation of S071 and S072.

The astronaut log book will be returned after the mission.

Success Criteria

FO 1) Circadian data shall be returned to the Principal Investigator to perform circadian rhythm studies on pocket mice.

FO 2) Circadian data shall be returned to the Principal Investigator to perform circadian rhythm studies on the vinegar gnat.

Evaluation

FO 1) A statistical analysis of all S071 data acquired will be performed by the Principal Investigator to determine any variation in the circadian rhythms of body temperature, and activity of the pocket mice in orbit with respect to those observed in the control groups. (Telemetry data, astronaut records, other data)

FO 2) A statistical analysis of all S072 data acquired will be performed by the Principal Investigator to determine any variation in the circadian rhythms of the pupae in orbit with respect to the rhythms observed in the control groups. (Telemetry data, astronaut records, other data)

Data Requirements

Refer to Appendix A.

Experiment S149 PARTICLE COLLECTION

Determine distribution, composition, and morphology of micrometeorites in near-earth space.

Purpose and Background

The purpose is to determine the mass distribution of micrometeorites in near-earth space by studying the impact phenomena that are produced on suitably prepared and exposed surfaces and to determine the composition and morphology of micrometeorites from an examination of micrometeorite deposits in the impact craters.

Micrometeorite impact data shall be acquired through the use of two types of impact surface detectors. The largest portion of the impact surface detection area consists of highly polished surfaces that have been pre-scanned with optical microscopes. The remaining area consists of thin film. The principle of the multiple film detector system is to allow examination of the layered film as a unit to facilitate identification of film penetration events. The coincidence of holes in the layered films plus the characteristics of the impact event on the underlying witness plate will determine cosmic origin.

Functional Objectives

† FO 1) Deploy, expose, retrieve, and return to earth on set of micrometeorite impact detection cassettes. (N/A)

† FO 2) Prepare one set (4) of micrometeorite impact detection cassettes for deployment and exposure during the unmanned storage period of SL-3. (The cassettes will be retrieved and returned to earth during the manned portion of SL-3) (N/A)

FO 3) Expose during the unmanned storage period of SL-3, retrieve, and return to earth the one set (4) of micrometeorite impact detection cassettes that were prepared for deployment during SL-2 (by FO 2 above). (40)*

FO 4) Deploy, expose, retrieve, and return to earth one set (4) of micrometeorite impact detection cassettes. (25)*

FO 5) Prepare one set (4) of micrometeorite impact detection cassettes for deployment and exposure during the unmanned storage period of SL-4. (The cassettes will be retrieved and returned to earth during the manned portion of SL-4). (35)*

†Those functional objectives have been scheduled for completion on SL-1/SL-2 and will not be repeated on this mission.

Test Conditions

FO 1) Not applicable (N/A) for mission SL-3.

FO 2) N/A for mission SL-3.

FO 3) Ground control will open the cassettes for exposure during the unmanned storage period of SL-3 no sooner than 6 hours after the separation of the Command and Service Module (CSM) for SL-2.

With the exception of any ground commanded or other pre-known venting that may occur during the unmanned storage period, the cassettes will remain open throughout this period.

Required telemetry measurements will be recorded for subsequent playback and transmission to the ground.

Ground control will close the cassettes at least 6 hours before docking of the CSM for the manned period SL-3. The cassettes will remain closed until retrieved and replaced with the cassettes to be exposed during the manned portion of SL-3.

The exposed impact surfaces will be retrieved per procedures contained in the S149 Experiment Operation Handbook (EOH) and stored in the Orbital Workshop (OWS) prior to CSM separation when they will be transferred to the Command Module (CM).

FO 4) The experiment hardware will be positioned by deployment of the Experiment T027 (Contamination Measurement) extension device out of the Scientific Airlock (SAL) on the anti-solar side of the OWS per procedures contained in the S149 EOH.

The Micrometeorite Impact Detection System (impact surfaces) will be exposed to near-earth space for a period of 240 hours during the manned portion of SL-3.

Exact exposure schedules within the various exposure periods will depend on vehicle attitudes and maneuvers and high contamination periods.

S149 uses the anti-solar SAL and must not be scheduled concurrently with S019 (Ultraviolet Stellar Astronomy), S063 (Ultraviolet Airglow Horizon Photography), S183 (Ultraviolet Panorama), and T027/S073 (Contamination Measurement and Gegenschein/Zodiacal Light).

S149 uses T027/S073 equipment and therefore cannot be scheduled concurrently. In addition, this equipment protrudes into the operational volume required by T020 (Foot Controlled Maneuvering Unit), M509 (Astronaut Maneuvering Equipment) and T013 (Crew/Vehicle Distrubances).

The C and D Panel No. 2 for the Tape Recorder select precludes operation of Experiments M092 (Inflight Lower Body Negative Pressure), M093 (Vectorcardiogram), M131 (Human

Vestibular Function), M171 (Metabolic Activity), M509, T027/S073, S183, and T013 with S149.

Recorded voice annotations or log entries will be made to describe unscheduled or anomalous conditons (e.g., contamination) that could affect the experiment. Time spans and quantities will also be recorded when possible.

The experiment will be scheduled during solar inertial attitude (Z-IOP/Z) mode only. Vehicle attitude deviations from the nominal solar inertial mode will be recorded whenever the vehicle attitude varies more than 15 degrees about any axis from the nominal attitude.

Recorded voice annotations will be made to document the experiment preparation, checkout, operation, and post-operation tasks at the beginning and end of the exposure period.

The experiment must not be scheduled during periods of high contamination. Elimination of extraneous contamination will be accomplished by closing the detector cassettes per procedures contained in the S149 EOH.

Required telemetry measurements will be recorded for subsequent playback and transmission to the ground.

The exposed impact surfaces will be retrieved per procedures contained in the S149 EOH and stored in the OWS prior to CSM separation when they will be transferred to the CM.

FO 5) The experiment hardware will be positioned utilizing the T027 (Contamination Measurement) extension device in the anti-solar SAL prior to CSM separation.

Ground control will cycle the cassettes for opening prior to astronaut departure. In the event of malfunction, the experiment is to be activated by the astronaut.

Recorded voice annotations will be made to document the experiment preparation and checkout.

Success Criteria

FO 1) N/A

FO 2) N/A

FO 3) Impact surfaces shall be exposed for a minimum of 75% of the orbital storage period of SL-3 and returned to earth. These surfaces along with the required experiment and support data shall be delivered and be of acceptable quality to the Principal Investigator.

FO 4) Impact surfaces shall be exposed for a minimum of 8 hours during the manned portion of SL-3 and returned to earth. These surfaces along with the required experiment and support data shall be delivered and be of acceptable quality to the Principal Investigator.

FO 5) The impact surfaces shall be prepared for deployment and exposure during the unmanned storage period of SL-4, (if the ground controlled deployment mechanism malfunctions the success criteria will include deployment of the impact surfaces).

Evaluation

FO 1) N/A

FO 2) N/A

FO 3)
FO 4) Exposed surfaces contained in cassettes and supporting data will be provided directly to the Principal Investigator or his representative for analysis. Results of data analysis and evaluation will be reported in a series of reports, with the final experiment report to be available within 15 months following receipt of the final set of cassettes and complete flight data. (Telemetry data, astronaut records, trajectory data, other data)

Data Requirements

Refer to Appendix A.

Experiment S183 ULTRAVIOLET PANORAMA

Obtain color index of stellar objects.

Purpose and Background

The purpose is to obtain the color index of stellar objects in two bands, each 600 angstroms wide, which are centered around the 1800 and 3100-angstrom wavelengths.

The stellar objects to be studied are individual hot stars which are distributed in different regions of the sky in relation to the Milky Way and collective groups of stars such as clusters, galaxy nuclei and the stellar clouds in the Milky Way. The data obtained from this experiment will be used in the broad sense to determine galactic structure and galactic evolution. Specifically, the ultraviolet (UV) data of S183 will be combined with previously gathered X-ray, visible infrared, and radio spectral data to accomplish this objective. Correlation will also be made with the data of Experiment S019 (Ultraviolet Stellar Astronomy) so that comparisons of the spectra and color indices of certain starfields can be accomplished.

Functional Objectives

FO 1) thru FO 12) Obtain selective UV photographs of as many designated starfields as practical on a single darkside pass for each functional objective. (8.3%)*

Test Conditions

FO 1) thru FO 12) Candidate starfields will be listed along with pointing coordinates and recognition maps in the Experiment Log Book. The potential starfields to be photographed will be updated by computer based upon exact orbital conditions of the workshop. The updated starfields, pointing coordinates (mirror tilt and rotation angles), etc. will be supplied to the crew 24 hours prior to the experiment session.

The experiment will be operated through the anti-solar Scientific Airlock (SAL) using the S183 Spectrograph Assembly (S183 SA) and the S019 Mirror System (S019 MS) in accordance with procedures contained in the S183 Experiment Operations Handbook (EOH).

Two crewmen are required to handle the S183 SA during experiment preparation tasks and post operation tasks.

Thirty-five photographs of approximately 12 starfields are required for this experiment on this mission. It is estimated that three UV photographs can be taken during one orbital night side pass; therefore, approximately 12 night passes may be required to meet the experiment objectives.

UV photographs of the starfields will be made on 35 of 36 photographic plates contained in a film carrousel (one unexposed plate will be used for control purposes). Simultaneous 16-mm Data Acquisition Camera (DAC) photographs of the starfields will be made.

The duration of each exposure will be determined by the starfield brightness and will vary from 20 seconds to 1260 seconds. The S183 SA will be controlled by internal logic after an operating sequence is started.

The experiment will be performed during dark side passes when the Orbital Assembly (OA) is in an inertially stable mode Solar Inertial Attitude (X-IOP/Z). The mirror should be erected just before sunset and retracted just before sunrise.

In order to be able to correlate experiment data between S183 and S019 (photograph identical starfields with similar degradation to film and mirror system) it is highly desirable that at least one sequence of three photos for S183 be obtained on an orbit successive to an orbit where S019 is scheduled to obtain starfield photos. If successive orbits are not possible, then the closest orbit possible will be satisfactory provided the time span is no greater than 24 hours.

The experiment line-of-sight shall be aligned to within 30 arc minutes of each of the selected starfields utilizing the S019 mirror system.

S183 will share the anti-solar SAL with Experiments S019, S063 (Ultraviolet Airglow Horizon Photography), S149 (Particle Collection), and T027/S073 (Contamination Measurement and Gegenschein/Zodiacal Light).

T013 (Crew/Vehicle Disturbances), T020 (Foot Controlled Maneuvering Unit) and M509 (Astronaut Maneuvering Equipment) must not operate while S019/S183 equipment is installed in the SAL.

Time correlation to within 1.0 second Greenwich Mean Time (GMT) will be required with the "Shutter Open" timing signal.

If a Control Moment Gyro desaturation maneuver is performed, the exposure sequence must be stopped and a new exposure sequence started when the maneuver is completed. It is, therefore, desirable to inhibit such maneuvers during exposures.

Crew motions are to be kept to a minimum during S183 exposures. Schedules of crew activities involving violent activity (e.g., recreational activity such as handball, operation of mass measurement devices, etc.) are to be avoided during S183 operation periods.

Moisture must not be allowed to condense on the S019 MS.

Any waste dumps or TACS firing which would either affect S183 viewing or contaminate the S183 and S019 optics must be inhibited when the S019 MS is deployed.

Any external lights of less than 6000 Å which might reflect into the experiment must be off during the operation of the experiment. All ports or windows which might reflect light of less than 6000 Å into the experiment must be covered.

The film carrousel cannot be exposed to more than TBD rads and the 16-mm films to more than TBD rads during the entire length of the mission.

Orbital Workshop internal light level of less than 0.5 foot-candles is required during experiment sighting periods.

The film storage container containing the film carrousel will be evacuated immediately following the film carrousel usage and before restowing in order to achieve a vacuum of 10 torr. The S183 SA will be evacuated following the experiment performance and before restowing in order to achieve a vacuum of 10 torr.

If it is necessary to remove the S019 MS from the airlock for more than 12 hours, it must be evacuated to 1 torr or less. Evacuation is to begin within 30 minutes of experiment disassembly.

It is not necessary to remove the experiment from the SAL during the day portion of the orbit. However, the experiment will be demounted and stowed per procedures contained in the S183 EOH between observing periods separated by more than 12 hours to minimize exposure time to radiation. Ambient radiation levels that will be experienced by the film carrousel while installed at the SAL experiment location are acceptable for a total duration of exposure not to exceed 4 days.

The film carrousel will be maintained at a temperature not to exceed 80°F during Orbital Workshop (OWS) and Command Module (CM) stowage and all phases of the mission, except during experiment operation. Ambient spacecraft temperatures during operation of the experiment are acceptable. The thermal requirements of the 16-mm film are TBD.

The fog level on experiment film shall not exceed 0.36 density units during the life of the film.

For each exposure that operator will voice record: a) the exposure number, b) target field identification, c) time of initiation correlatable to GMT to within 1 minute, d) length of exposure, e) DAC setting, and f) comments on the quality of image tracking conditions and any other noteworthy conditions relative to the experiment.

The film carrousel in its film magazine storage container and 16-mm film magazine are to be transferred to the CM prior to reentry.

It is necessary for the crewman operating the experiment to know when the dark portion of the orbit starts to within 1.0 minute.

Required telemetry measurements will be recorded for subsequent playback and transmission to the ground.

Success Criteria

FO 1) thru FO 12) Obtain 27 photographs of nine starfields using spectrograph assembly. These photographs along with photographs obtained with the DAC and the required support data shall be returned to the Principal Investigator.

Evaluation

FO 1) thru FO 12) Film processing and film analysis are to be performed by the Principal Investigator. (Telemetry data, astronaut records, photographs, trajectory data, other data)

Data Requirements

Refer to Appendix A.

Experiment T002 — MANUAL NAVIGATION SIGHTINGS (B)

Obtain data on manual midcourse and orbit navigation.

Purpose and Background

The purpose is to investigate the effects of the spacecraft environment (long mission time and confinement) on a navigator's ability to obtain space navigation measurements through a spacecraft window using hand-held instruments. A second purpose is to demonstrate the operational feasibility of a manual navigation system consisting of a hand-held sextant (SXT) and stadimeter.

Experimental measurements of the angle between star pairs and between stars and the earth horizon were made using hand-held sextants in Gemini Experiments. This experiment will extend the Gemini results to include measurements of the star/lunar limb angle with a hand-held sextant and spacecraft altitude with a hand-held stadimeter.

Midcourse type navigation measurements using a hand-held SXT will be made during the dark portion of the orbit using star/lunar limb target combinations. Measurements of the angle between selected star pairs will also be made.

Orbital type navigation measurements using a hand-held SXT and hand-held stadimeter will be made using a star and the earth horizon as targets. The measurements will include series of sextant and stadimeter sightings selected to provide complete navigation information for orbit determination.

Functional Objectives

† FO 1)	Perform six SXT sighting periods on a pair of known stars for midcourse type navigation.	(25%)*
† FO 2)	Perform 12 SXT sighting periods on a known star and the lunar limb for midcourse type navigation.	(17%)*
† FO 3)	Perform six SXT sighting periods on two portions of the lunar limb for midcourse type navigation.	(8%)*
† FO 4)	Perform five stadimeter sighting periods on the earth horizon for orbit type navigation.	(10%)*
† FO 5)	Perform two SXT sighting periods on the earth horizon and a known star for orbit type navigation.	(10%)*
† FO 6)	Perform three SXT/stadimeter sighting periods consisting of SXT measurements on the earth horizon and two known stars and stadimeter measurements on the earth horizon for orbit type navigation.	(30%)*

† Those functional objectives or parts thereof scheduled and completed on SL-1/SL-2 will not be repeated on this mission.

Test Conditions

FO 1)
FO 2)
FO 3)

Midcourse type navigation SXT sighting periods will be distributed equally in time throughout the mission (preferred) or one-half of the sighting periods to the first half of the mission and one-half to the last half of the mission.

FO 1)
FO 2)
FO 3)
FO 5)
FO 6)

A SXT sighting period will consist of a minimum of 10 SXT angle measurements within one night pass.

The Orbital Workshop (OWS) must be on the night side of the orbit for SXT sightings.

FO 1)
FO 2)
FO 3)
FO 6)

A SXT reference calibration consisting of five night SXT angle measurements of a single known star will be performed for each SXT sighting period.

FO 1)
FO 2)
FO 3)
FO 4)
FO 5)
FO 6)

All midcourse and orbit type measurements will be performed at the wardroom window in accordance with procedures contained in the T002 Experiment Operations Handbook.

Experiments T002 and S063 (Ultraviolet Airglow-Horizon Photography) use the wardroom window and will not be scheduled concurrently.

External lights that affect viewing from the wardroom window will be off and the wardroom interior lights will be dimmed to allow viewing of starfields during the experiment performance.

Waste dumps will not be performed during experiment performance.

Voice recordings pertinent to experiment operations will be dumped to the ground during normal dumps to allow near real time evaluation of the data. Voice data will include:

a) Zero bias measurements of the SXT

   (1) Greenwich Mean Time (GMT)
   (2) Target used
   (3) Window line of sight location
   (4) Temperature
   (5) SXT readout
   (6) Comments

b) SXT angle measurement (Mid-course and Orbit)

   (1) GMT at start and end of session
   (2) Temperature at start and end of session
   (3) Targets
   (4) Window line of sight location
   (5) Voice "mark" for each image alignment
   (6) Sextant readout
   (7) Diopter setting
   (8) Filter used
   (9) Reticle brightness
   (10) Comments

c) Stadimeter angle measurements

(1) GMT
(2) Characteristics of horizon used
(3) Voice "mark" for each image alignment
(4) Stadimeter readout
(5) Stadimeter stopwatch and astronaut chronograph reading
(6) Reticle brightness
(7) Filter used
(8) Comments

Required telemetry measurements will be recorded on the AM recorder during sighting periods for subsequent transmission to the ground.

Best Estimate of Trajectory of geodetic latitude, longitude, and altitude will be required of each sighting to allow near real time evaluation of experiment data.

Ephemeris data will be required of each sighting to allow near real time evaluation of experiment data.

FO 2) Four SXT sighting periods will be performed with a 1.0 filter setting, four with no filter, and four with a 1.6 filter setting; if the moon is too dim with the 1.6 filter, six sightings with no filter and six sightings with the 1.0 filter will be made.

FO 2)
FO 3) The lunar limb must be visible through the wardroom window.

FO 4) Perform as many stadimeter measurements of the earth horizon as convenient during each sighting period.

FO 5) Perform as many night SXT measurements of the earth horizon and a known star as convenient.

A SXT calibration consisting of five night SXT angle measurements of a single known star will be performed for each sighting period.

FO 5)
FO 6) The night earth horizon must be moonlit and visible from the wardroom window.

The OWS must be in the earth's shadow.

FO 6) The following sequence of sightings during each of the three sighting periods will be performed:

a) Perform a minimum of three daylight stadimeter sightings at approximately 15-minute intervals of the earth horizon upon entering the day portion of the orbit

b) Perform a SXT sighting using the first known star and the night earth horizon

c) Perform a SXT sighting using the second known star and the night earth horizon

d) Perform a SXT sighting using the first known star and the night earth horizon

e) Perform a SXT sighting using the second known star and the night earth horizon

For each of the two stars, perform two SXT sightings with a 1.0 filter setting, two with no filter, and two with a 1.6 filter setting; if the earth's horizon is too dim with the 1.6 filter, then three sightings with no filter and three sightings with the 1.0 filter will be made.

Success Criteria

†† FO 1) Data for six midcourse type navigation SXT sighting periods on a pair of known stars shall be obtained.

†† FO 2) Data for 12 midcourse type navigation SXT sighting periods on a known star and the lunar limb shall be obtained.

†† FO 3) Data for six midcourse type navigation SXT sighting periods utilizing sightings on two portions of the lunar limb shall be obtained.

†† FO 4) Data for five orbit type navigation stadimeter sighting periods utilizing the earth's horizon shall be obtained.

†† FO 5) Data for two orbit type navigation SXT sighting periods utilizing the earth's horizon and a known star shall be obtained.

†† FO 6) Data for three orbit type navigation SXT/stadimeter sighting periods utilizing various combinations of the earth's horizon and known stars shall be obtained.

FO 1)
FO 2)
FO 3)
FO 4)
FO 5)
FO 6) SXT/stadimeter voice data shall be acquired and made available to the Principal Investigator for analysis and evaluation.

††Quantitative values of these success criteria reflect total Skylab Program criteria for this experiment; portions thereof successfully completed on the SL-1/SL-2 mission shall be included in the overall accountability.

Evaluation

FO 1)
FO 2)
FO 3) The midcourse type navigation data will be analyzed by Ames Research Center, using standard statistical methods and results compared with preflight and postflight measurement data. (Telemetry data, astronaut records, trajectory data)

FO 4) FO 5) FO 6) The orbital type navigation data will be analyzed by the Air Force. The results will be compared with spacecraft orbit parameters obtained by Manned Space Flight Network during the mission. (Telemetry data, astronaut records, trajectory data)

Data Requirements

Refer to Appendix A.

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Experiment T003 — IN-FLIGHT AEROSOL ANALYSIS

Obtain particulate matter generation data.

Purpose and Background

The purpose is to measure the aerosol particulate matter concentration and size distribution in the spacecraft as a function of time and location, and to collect and return to earth the aerosol particles and the logged data for postflight analysis.

Investigations regarding various optical methods of counting and sizing small aerosol particles having unknown indices of refraction have been conducted with the conclusion that the geometry used in the Aerosol Analyzer (AA) can identify particles primarily by size alone.

Functional Objectives

FO 1) Operate the AA to obtain readings at Crew Station CS-11 (crew quarters near the ceiling), CS-10, CS-1B, CS-11 (crew quarters near air diffuser), CS-15, CS-16, and CS-12. (60%)*

FO 2) Operate the AA to obtain readings at CS-10, CS-1B, and CS-11 (crew quarters near air diffuser). (15%)*

FO 3) Operate the AA to obtain readings at CS-15, CS-16, and CS-12. (15%)*

FO 4) Operate the AA, at the crew's discretion, to obtain up to 20 readings, at any time interval or location to investigate suspect particle generation sources. (10%)*

Test Conditions

FO 1) As soon as practical after Orbital Workshop (OWS) activation, but not later than 5 days, the experiment will be performed at CS-11 (crew quarters near the ceiling); CS-10 (center of Airlock Module [AM]/OWS hatch); CS-1B (Command Module [CM] center couch); CS-11 (crew quarters near air diffuser); CS-15 (wardroom); CS-16 (head); and CS-12 (forward compartment).

Upon completion, the AA will be returned to the storage location and subsequent readings at CS-11 (crew quarters near the ceiling) will be taken every 8(±2) hours thereafter.

FO 2) Every 10 days (after initial measurements) AA readings will be taken at CS-10 (center of AM/OWS hatch), CS-1B (CM center couch) and CS-11 (crew quarters near the air diffuser) immediately after the regularly scheduled 8(±2)-hour readings at CS-11 (crew quarters near the ceiling).

FO 3) Every 10 days (after initial measurements), AA readings will be taken at CS-15 (wardroom) before food preparation, and after meals, at CS-16 (immediately before use of the sanitary facility and after weighing of the wet fecal sample bag [Experiment M071 Mineral Balance] utilizing the Experiment M074 Specimen Mass Measurement Device), and at CS-12 immediately after change and/or suit donning as occurrence of events permits.

FO 4) At the astronaut's discretion, up to 20 readings will be made during the flight at times and positions the astronaut feels may be a source of particulate generation.

FO 1)
FO 2)
FO 3)
FO 4)

All experiment operations will be conducted in accordance with procedures contained in the T003 Experiment Operations Handbook (EOH).

The AA will be hand held during all experiment runs with the air inlet pointing perpendicular to spacecraft longitudinal axis, and away from the couch pad in the CM.

Entries will be made on the experiment log cards noting the time at start of the INITIATE CYCLE, AA channel number, accumulated counts, and activity in progress for each reading.

Comments relative to the operation and conduct of the experiment are to be made by the crew as appropriate.

Upon completion of the experiment, the Filter Impactor Unit will be removed, placed in its container, and transferred to the CM for return to earth. The Experiment Log cards will also be returned to earth after the mission.

Success Criteria

FO 1) AA readings shall be obtained at CS-11 (crew quarters near the ceiling and near the air diffuser), CS-10, CS-1B, CS-12 CS-15, and CS-16 as soon as practical after the OWS crew activation, but not later than 5 days, and at CS-11 (crew quarters near the ceiling) at 8($\pm$2)- hour intervals thereafter.

FO 2) AA readings shall be obtained at CS-10, CS-1B and CS-11 (crew quarters near air diffuser) as soon as possible after OWS activation and every 10 days thereafter.

FO 3) AA readings shall be obtained as soon as possible after OWS activation and every 10 days thereafter at CS-15 before food preparation and after meals, CS-16 (immediately before use of the sanitary facility and after weighing of the fecal sample bag), and CS-12 immediately after change and/or suit donning.

FO 4) Where determined by the crew that a special AA survey requirement exists, AA readings shall be obtained at suspect particle generation sources.

Evaluation

The data obtained from the AA readings taken at the selected stations and time intervals throughout the mission will be used to assess the generation of particulate matter by personnel and equipment; the adequacy of air distribution, circulation, and filtration; the effects of zero-g environment on aerosol buildup and distribution; and aid in the establishment of indices for habitability and allowable aerosol levels in spacecraft atmospheres.

Postflight inspection of the Experiment Log cards and analysis of the particles collected by the Filter Impactor Unit will give confirmatory information and may permit further identification of the spacecraft particulate contaminants by material and shape. (Astronaut records, other data)

Data Requirements

Refer to Appendix A.

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Experiment T013

CREW VEHICLE DISTURBANCES

Obtain data on crew motion disturbance characteristics and the Attitude and Pointing Control System.

Purpose and Background

The purpose is to obtain data on crew motion disturbance characteristics and performance of the Attitude and Pointing Control System (APCS).

The objectives of this experiment are to determine discrete and statistical (stochastic) crew motion disturbance characteristics and their effects on the in-flight performance on the first Control Moment Gyro (CMG) and experiment isolation systems flown on a manned spacecraft. Specifically, partial and total body motion of an astronaut subject will be measured by actual body instrumentation Limb Motion Sensor (LIMS) and by motion picture photography. The applied forces and moments produced by the astronaut will be measured by the force measuring platforms of the Force Measuring System (FMS). Vehicle motions will be sensed by real time ATM measurements and performance data will be obtained. All data will be telemetered to the earth and used to check the validity of information obtained from mathematical models and ground simulations.

Definition of zero-gravity crew motion disturbance characteristics is essential for defining allowable crew motions during the performance of experiments requiring very low acceleration levels or extreme pointing accuracies. Verification of analytical models of crew motion disturbances will permit their use in sizing, design, and simulation of control systems for future manned space missions.

Functional Objectives

† FO 1) Perform various body movements in the Orbital Workshop (OWS) using a LIMS and the FMS.

†This functional objective if scheduled and completed on SL-1/SL-2 will not be repeated on this mission.

Test Conditions

FO 1) One astronaut will conduct experiment operations with the second astronaut monitoring. The remaining astronaut will remain motionless and will not take part in the experiment performance.

An astronaut wearing the LIMS device will perform various stationary motions per procedures contained in the T013 Experiment Operations Handbook while attached to the Force Measuring Unit (FMU) platform of the FMS in the OWS.

The astronaut will also perform translation movements between the two FMU platforms of the FMS.

The second astronaut in support of the experiment operation will start the two motion picture cameras. Film and telemetry data time correlation will be accomplished by the "Time Correlation Sequence" crew procedure.

Vehicle motions due to astronaut movement will be sensed by real time ATM measurements.

Both cameras will be adjusted and then pointed toward the experiment performance area by the second astronaut.

All experiment tasks will be performed once during the mission.

The anti-solar Scientific Airlock (SAL) must not be in use during experiment operations.

All equipment that may interfere with experiment performance must be cleared from the surrounding area during experiment performance.

All physical activity of the crew, including vehicle housekeeping functions will be constrained for approximately 30 minutes during experiment data collecting.

During the experiment performance, the APCS must be in active status with the Orbital Assembly (OA) in the Solar Inertial mode and automatic CMG desaturation maneuvers inhibited.

Real time telemetry transmission of APCS data is required during a portion of the performance of T013.

Subject, task identification, and sequences which have been voice annotated by the subjects and observer, and comments on task performances will be recorded in the astronaut log book.

Success Criteria

FO 1) An astronaut shall perform various body movements, tionary motions and translations for approximately 30 minutes using the LIMS and FMS in the OWS. Related film and voice data shall be obtained.

Evaluation

FO 1) The Principal Investigator will conduct analyses with the returned data by comparing with data obtained from ground simulations and theoretical analyses. (Telemetry data, astronaut records, photographs)

Data Requirements

Refer to Appendix A.

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Experiment T020

FOOT CONTROLLED MANEUVERING UNIT

Test a space locomotion device.

Purpose and Background

The purpose is to test and evaluate a research space locomotion device to provide confidence and valuable design information for future experimental hardware.

This experiment is a two-element exploratory program to provide design and operational experience with a test-bed unit which offers a combination of simplification, reliability, and performance capabilities not provided with other design approaches. The first element of this program is the ground-based zero-gravity simulation facilities which are used to carry out experiment definition, crew training, and engineering evaluation. The second element is the in-flight evaluation carried out in the Skylab Orbital Workshop. In carrying out this coordinated two-phase effort, it is expected that a much greater amount of information will be generated than would be derived from singular independent approaches. The in-flight portion will yield the most accurate zero-gravity evaluation, but is limited by the usable volume within the Orbital Workshop (OWS), the relatively short time available for testing, the small number of test variables and test subjects, and the high costs involved. The ground-based evaluation serves to overcome these shortcomings, but is hampered to an unknown degree by simulation artifacts imposed by the earth gravity environment. By providing a commonality of experiment maneuvering tasks for the two elements, the uncertainties regarding the simulation validity can be reduced, thereby increasing the value of the ground-based facilities as a source of information for possible continued maneuvering systems research and development.

Functional Objectives

FO 1)	Perform various maneuvers (Mode I) while flying the Foot Controlled Maneuvering Unit (FCMU) in shirtsleeves.	(60%)*
FO 2)	Perform various maneuvers (Mode II) while flying the FCMU suited.	(40%)*

Test Conditions

FO 1) Mode I maneuvers will be performed by a crewman in experiment runs 1, 2, and 3.

The Mode I maneuvers will be performed per procedures contained in the T020 Experiment Operations Handbook (EOH).

The crewman will perform in the shirtsleeve mode using the backpack propulsion gas supply.

The time for runs 1, 2, and 3 is 15 minutes each for a total of 45 minutes in Session I. Approximately 30 minutes (10 minutes each) is actual flying time.

FO 2) Mode II maneuvers will be performed by the same crewman in experiment runs 4 and 5.

The Mode II maneuvers will be performed per procedures contained in the T020 EOH.

The crewman will perform in the pressure-suited mode using the backpack gas supply and the Pressure Control Unit (PCU) and umbilical.

The times for runs 4 and 5 are 15 minutes each for a total of 30 minutes for Session II. Approximately 20 minutes (10 minutes each) is actual flying time.

FO 1)
FO 2) The Propellant Supply Subsystem (PSS) and the battery provided with the M509 (Astronaut Maneuvering Equipment) Automatically Stabilized Maneuvering Unit (ASMU) are required for this experiment.

All of the maneuvering activities of the experiment will be photographed.

Data Acquisition Cameras (DAC's) will be operated at frame speeds of 6 and 2 frames per second.

Four short DAC sequences of about 60 seconds each will be taken at 24 frames per second to show operation of foot controls under conditions of minimum input.

Approximately 10 still photographs will be required showing the general experiment setup.

Subjective comments and a record of experiment runs will be noted in the astronaut log books for return to earth.

Comments made by the subject and observer during each debriefing session scheduled during the experiment will be tape recorded for subsequent playback and transmission.

Required telemetry measurements will be recorded on the Airlock Module recorder for subsequent playback and transmission.

The maximum allowable spacecraft rate about any axis during an experiment run will be 6 degrees/minute.

The maximum allowable spacecraft acceleration is 1.5×10^{-3}g's along any axis and 1×10^{-3} degrees/sec.^{2}.

A near uniform atmospheric airflow is required across the OWS floor during the performance of the experiment. The OWS diffusers will be adjusted to limit the atmospheric flow velocity to an average of 20 feet per minute over the performance area.

Experiment sessions must be scheduled at least 2 days apart to prevent over-pressurization of the workshop which would result in loss of atmosphere gas through the workshop relief valve.

Experiments using the Scientific Airlock shall not be in place during T020 operations.

The time the crewman will perform in each mode of operations is summarized by experiment run in the following table:

Experiment Run Time

Session	Run	Time (Min.)
1	1	15
	2	15
	3	15
2	4	15
	5	15
	Total	75 minutes

NOTE: Run times do not include experiment setup or stowage items.

Success Criteria

FO 1) The crewman shall perform Session/Mode I (shirtsleeve) maneuvers for at least 30 minutes (flying time). Related telemetry, photographic, and voice data shall also be obtained.

FO 2) The same crewman shall perform Session/Mode II (suited) maneuvers for at least 20 minutes (flying time). Related telemetry, photographic, and voice data shall also be obtained.

Evaluation

FO 1)
FO 2) The Principal Investigator will analyze the flight data using the preflight OWS photographic data to determine whether the operation of the FCMU in-flight has significantly changed the crewman's performance when correlated with pre and postflight ground simulations. A postflight evaluation of the simulations will be obtained from the crew. (Telemetry data, astronaut records, photographs)

Data Requirements

Refer to Appendix A.

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Experiment T027/S073 Photometer System

CONTAMINATION MEASUREMENT and GEGENSCHEIN/ZODIACAL LIGHT

Measure surface brightness and polarization of nightglow and spacecraft corona.

Purpose and Background

The purpose is to measure the sky brightness background caused by solar illumination of the particulate contaminants found about the Orbital Assembly (OA), to measure the surface brightness and polarization of the skyglow over as large a portion of the celestial sphere as possible at several wavelengths in the visible spectrum, and to repeat the latter measurement at the terminator and with sunlight on the spacecraft to determine the extent and nature of the spacecraft corona.

The overlap in objectives of Experiments T027 (Contamination Measurement) and S073 (Gegenschein/Zodiacal Light) led to the design of a photometer system which would permit utilization of the same hardware by both experiments. Each time the photometer is used, it measures all of the light in its field-of-view (FOV). Scattered light from contaminant material around the OA must be separated from the total measurement to analyze the skyglow, which is primarily zodiacal light and starlight. Similarly, quantitative study of contamination is not possible without knowing the characteristics of the skyglow. Due to this similarity and the fact that both S073 and T027 require knowledge of contamination and of starlight and zodiacal light, this DTO combines all the objectives of Experiment S073 with that portion of Experiment T027 which employs the Photometer System. A separate DTO covers that portion of Experiment T027 which employs the Sample Array System and which has the objective to determine the change in optical properties of various transmissive windows, mirrors, and diffraction gratings due to the deposition of contaminants found about the OA.

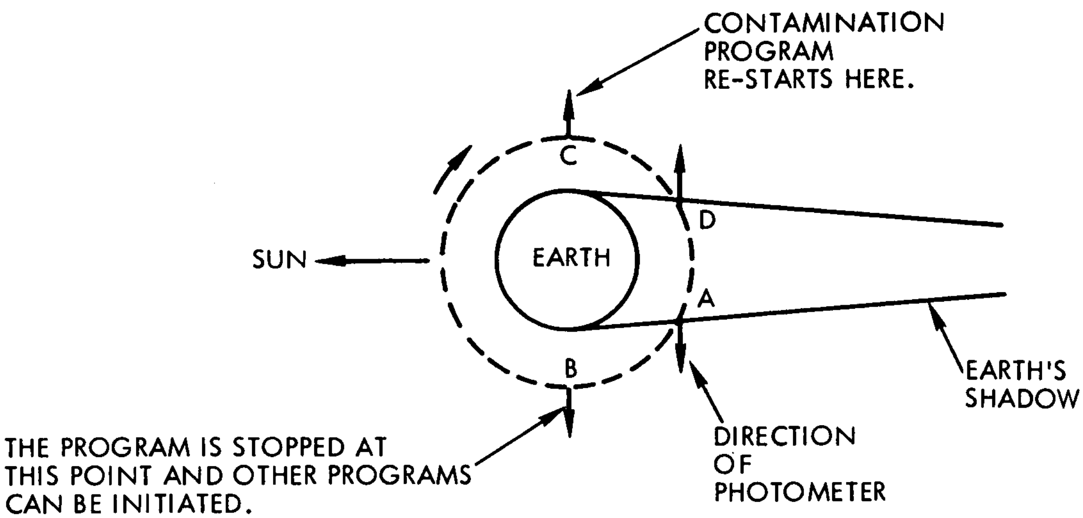
The Photometer System will measure three parameters which fully characterize the radiation from the skyglow and from the OA corona; i.e., brightness of the total and of the polarized components, and orientation of the plane of polarization. Measurements pertaining to the skyglow (zodiacal light, gegenschein, starlight, F-region airglow) are best performed on the dark side. Measurements on the sunlit side and at the terminator will be used to characterize the contaminant cloud and to provide information on the skyglow.

The principal method of collecting photometric data which will satisfy experiment objectives is to scan the areas under study (e.g., ecliptic plane, anti-solar direction, and other regions of the celestial sphere) with the photoelectric polarimeter in the T027/S073 Photometer System using specific observing programs. These specific observing programs are described below according to the particular mode of programmer operation.

Mode 1. Fixed Position

a. $\perp$ to sun line (contamination)

This program is performed with the photometer pointed in a direction 90° from the direction to the sun. This direction is maintained from program start in the earth's shadow (A, below) to a position in sunlight (B). At that time other programs can be performed to position C, where the photometer is again pointed 90° from the sun and 180° from its position between A and B. At position D in the earth's shadow, the program is terminated. All 10 filters are used and are continuously cycled between points A and B and points C and D.



This program will be performed from the dark side (anti-solar) scientific airlock (SAL) and from the solar SAL.

A change in brightness and, especially, in polarization as the spacecraft leaves the earth's shadow, is a direct measure of the effect of the level of contamination (i.e., of the optical environment of the spacecraft). This program is capable of providing near real-time information on contamination; therefore, it should be performed close to the beginning of the mission (i.e., before starting the ATM experiments).

This same program will be used at different distances (rod extension lengths) from the spacecraft to determine the distribution of contaminant material around the OA.

At any time this program is used it can provide information on the zodiacal light at +90° elongation (angular distance from the sun). Comparison of observations in the ecliptic and at the ecliptic poles then gives a measure of the flattening of zodiacal dust toward the ecliptic.

b. Gegenschein

This program is performed with the photometer pointed in the anti-solar direction. It starts at position C (see previous figure) and continues through D and A to B, where the program is stopped. The program is intended as a monitor of short-term (minutes) changes in brightness and of possible changes associated with observing aspect with respect to the earth's shadow.

c. Contamination

This program is performed from the anti-solar SAL. A preselected region which includes part of the OA is observed before, during, and after an overboard venting (i.e., the program starts prior to leaving the earth's shadow and continues for some time on the sunlit side). The camera system is an essential part of this program.

d. Ecliptic poles

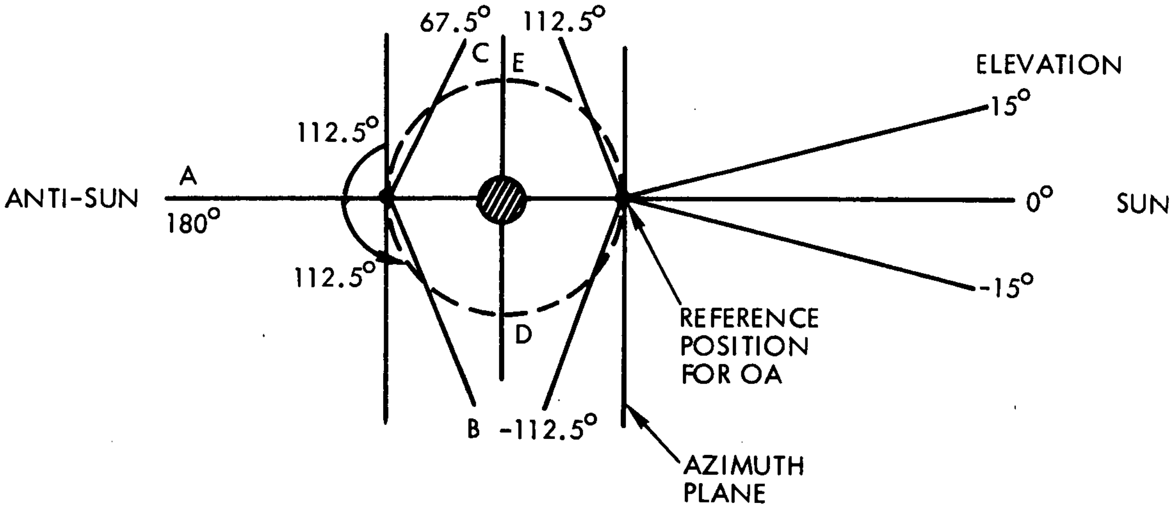
This program is performed from the anti-solar SAL and from the earth's shadow only. All 10 filters are used. The short-duration dark periods resulting from the high inclination orbit are well-suited for this program. The north and south ecliptic poles could be observed during successive orbits.

e. Celestial poles

This program is performed from the anti-solar SAL. All 10 filters are used, as in (d) above, but the program has to run for a longer period at the celestial poles. It is not restricted to observation only from the earth's shadow. This program is particularly important for relating the OA observations to observations being obtained simultaneously from the ground support station. The observing times will be required near new moon, and they must be coordinated with the ground station.

Mode 2. Vertical Circle (A vertical circle is a scan in elevation at fixed azimuth)

a. Scan in ecliptic



(1) Anti-solar SAL. The photometer scans in elevation from B to A (anti-solar point). It then rotates 180° in azimuth with the shutter open and scans from A to C (see previous figure). Limited space resulted in a packaging design that would not permit continuous scans through 0° elevation. The program is performed in darkness outside the earth's shadow (e.g., between points D and E of the orbit) to provide information on contamination backscattering and on the existence of a gegenschein parallax.

(2) Solar SAL. In this program the photometer scans in elevation from 112.5° to within 15 or 20° of the sun. As in (1) above, the mount rotates 180° in azimuth, after which it scans in elevation from -15 or -20° to -112.5° (refer to the last figure). This is performed in the earth's shadow and is repeated during the daylight portion of the same orbit.

b. Other scans

In this program the photometer scans in elevation from 112.5° to 15° at the azimuth corresponding to the plane of the ecliptic. At that point, it rotates 90° in azimuth (at northern ecliptic latitudes), and the photometer returns from 15 to 112.5° elevation. This operation is repeated for each of the 10 filters.

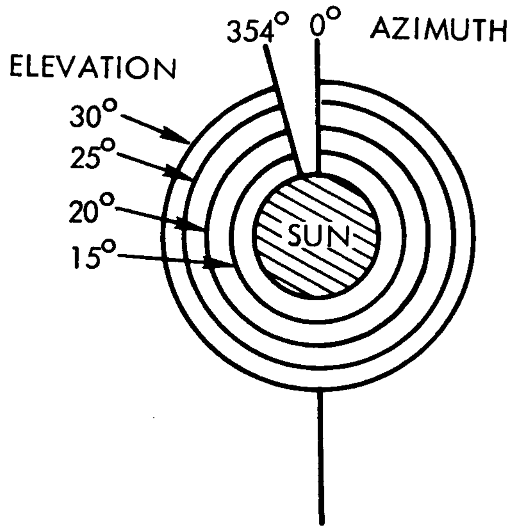
Mode 3. <u>Almucantar</u> (An almucantar is a scan in azimuth at fixed elevation)

a. Scan ⊥ to ecliptic at 90° elongation

This program from the anti-solar SAL is performed from both inside and outside the earth's shadow. The elevation is pre-set to 90° and the photometer scans in azimuth through its entire range; i.e., 0 to 354°, 354 to 0°, etc.

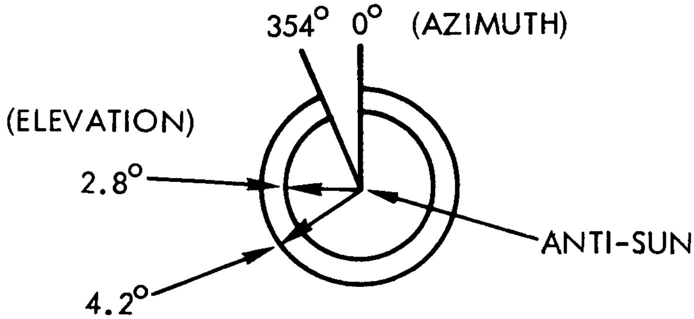
b. Contamination

This program is performed from the solar SAL at octal equivalents of elevations 15, 20, 25, and 30° (decimal). The photometer scans clockwise (CW), i.e., increases in azimuth, with one filter, returns CCW with the next filter, etc., through the 10 filters - all at the same elevation (see below). The elevation is then manually changed to its next position, and the previous set of measurements is repeated. It should be possible to complete the program during the sunlit portion of one orbit. It requires the presence of an astronaut for perhaps 1 minute every 15 minutes to manually change the elevation.



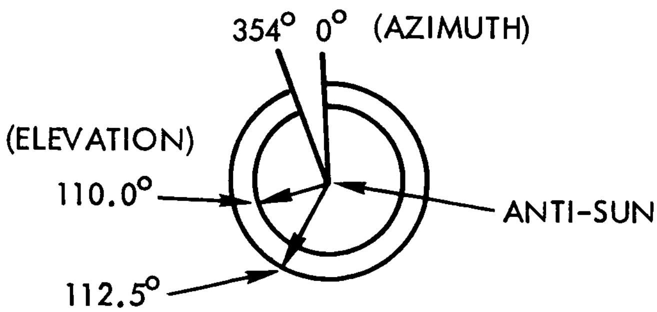
c. Gegenschein

This program is similar to the previous program in that it scans through the entire range of azimuth at each of two elevations; 2.8 and 4.2° - using all 10 filters. This program is performed in order to examine the wavelength dependence of the gegenschein before changes in brightness are possible.



d. Contamination

This program is performed outside the earth's shadow from the anti-solar SAL. It is similar to the previous program in that it scans through the entire range of azimuth at each of two elevations: in this case, 112.5° and 110° - using all 10 filters. The purpose of this program is to examine the wavelength dependence of the OA corona before any change in brightness occurs. The program requires the presence of an astronaut to monitor intensity and perhaps to change photomultiplier gain, since high light levels will be seen as the instrument sweeps across the OA. This program is performed each time with the mast fully extended and with the mast extended two rod lengths.



Mode 4. Sky Mapping

a. Gegenschein

This program is performed from the anti-solar SAL, and it involves concentric scans about the anti-solar direction. The photometer scans over the entire range of 354° in azimuth from 2.8 to 28.0° elevation in steps of 2.8°. A map is required for each of the 10 filters, therefore, it will be necessary to use the orbital counter; i.e., the program can be performed in its entirety during a sleep period. It is not essential that the measurements be performed only from within the earth's shadow.

b. Inner Zodiacal Light/Contamination

This program is performed from the solar SAL, and it involves concentric scans about the sun. It is similar to the Mode 4(a) gegenschein routine except that azimuth scans are performed from 15 to approximately 70° elevation (again, in steps of 2.8°). As with the previous routine, it will be necessary to use the orbital counter to obtain the required number of maps (one map per filter). It is primarily designed to provide information on contamination and on the main cone of the zodiacal light, including high and low galactic latitude regions. This program is equivalent to a program used successfully in observations obtained at the Haleakala Observatory, and it is essential that those observations be related to the observations being obtained from the OA.

Mode 5. All-Sky Mapping

a. From the anti-solar SAL. This program is similar to that of Mode 4(a), except that the elevation steps are 5.6° and the scans cover the entire celestial sphere (0 to 354° in azimuth and elevation scans from 2.8 to 112.5°). This program requires the use of the orbital counter.

b. From the solar SAL. This program is similar to Mode 5(a) except that it maps the entire sunward sky between 15 and 112.5° elevation (at all azimuths). This program also requires the use of the orbital counter.

Other routines

Mode 0 — Mode 0 is identical to Mode 1 except that the instrument is capped and the photometer looks at a standard calibration source in place of the sky. It is necessary to perform Mode 0 one time (10 filters, 2 minutes) prior to the start of every Mode 1 program. One calibration sequence is automatically performed at the conclusion of each sequence of Modes 2 through 5.

Mode 0.

a. System monitor

This program is performed from both SAL's at any elevation and azimuth. The photometer is capped, and the sequence counter is used to cycle through the 10 filters continuously throughout an entire orbit. This program provides essential information on system precision and on typical effects of the changing thermal environment.

Functional Objectives

FO 1)	Perform 7 photometer data scans from the solar SAL.	(20%)*
FO 2)	Perform 8 photometer data scans from the anti-solar SAL.	(15%)*
FO 3)	Perform 5 photometer data scans from the anti-solar SAL.	(15%)*
FO 4)	Perform 4 photometer data scans from the solar SAL.	(10%)*
FO 5)	Perform 7 photometer data scans from the anti-solar SAL.	(15%)*
FO 6)	Perform 4 photometer data scans from the solar SAL.	(10%)*
FO 7)	Perform 10 photometer data scans from the anti-solar SAL.	(15%)*

Test Conditions

Test conditions are presented on the following pages.

F01) Each of the following seven photometer data scans will be performed in the order shown early in the mission from the solar SAL.

Sequence	Program		Rods	FOV	CMG Inhibit	Total Observation Time (min)	Remarks
1	Contamination	1(a)	2, 7	TBD	Yes	40	Highly desirable to perform before ATM
2	System Monitor	0(a)	7	TBD	No	94	Highly desirable to perform before ATM
							(Desirable to perform 1 and 2 on consecutive orbits.)
3	Ecliptic Scan	2(a)	7	TBD	Yes	17	
4	Contamination	3(b)	7	TBD	Yes	68	Requires astronaut for 1 minute each 15 minutes to change elevation. (This sequence is composed of four 15-minute scans.)
5	Vertical Circle	2(b)	7	TBD	Yes	60	
6	All Sky Map	5(b)	7	TBD	No	290	Requires use of orbital counter
7	Contamination	1(a)	2, 7	TBD	Yes	40	

F02) Each of the following eight photometer data scans will be performed in the order shown early in the mission (as soon as possible after F01) from the anti-solar SAL.

Sequence	Program		Rods	FOV	CMG Inhibit	Total Observation Time (min)	Remarks
1	Contamination	1(a)	2, 7	TBD	Yes	40	
2	Vertical Circle	2(b)	2	TBD	Yes	60	
3	Ecliptic Scan	2(a)	2	TBD	Yes	19	
4	System Monitor	0(a)	2	TBD	No	94	
5	Celestial Pole, N	1(e)	2	TBD	TBD	30	Perform within 1 week of new moon. Coordinate with ground observations.
6	Gegenschein	1(b)	2	TBD	Yes	48	Perform within 1 week of new moon. Coordinate with ground observations.
7	Scan ⊥ to Ecliptic	3(a)	2	TBD	TBD	17	
8	All-Sky Map	5(a)	2	TBD	No	320	Requires use of orbital counter.

F03) Each of the following five photometer data scans will be performed in the order shown early in the mission (no later than 5 days into the mission and after F01 and F02) from the anti-solar SAL.

Sequence	Program		Rods	FOV	CMG Inhibit	Total Observation Time (min)	Remarks
1	Ecliptic Pole, N	1(d)	2	TBD	TBD	15	
2	Ecliptic Pole, S	1(d)	2	TBD	TBD	15	
3	Celestial Pole, S	1(e)	2	TBD	TBD	30	Perform within 1 week of new moon. Coordinate with ground observations.
4	Gegenschein	3(c)	2	TBD	Yes	34	
5	Gegenschein	4(a)	2	TBD	No	160	Requires the use of the orbital counter. Can be performed during a sleep period.

F04) Each of the following four photometer data scans will be performed in the order shown during mid-mission (8-10 days after F03) from the solar SAL.

Sequence	Program		Rods	FOV	CMG Inhibit	Total Observation Time (min)	Remarks
1	System Monitor	0(a)	7	TBD	No	94	
2	Ecliptic Scan	2(a)	7	TBD	Yes	17	
3	Vertical Circle	2(b)	7	TBD	Yes	60	
4	Inner Zodiacal Light/Contamination	4(b)	7	TBD	No	320	Coordinate with ground observations. Requires the use of the orbital counter.

F05) Each of the following seven photometer data scans will be performed in the order shown during mid-mission (after F04) from the anti-solar SAL.

Sequence	Program		Rods	FOV	CMG Inhibit	Total Observation Time (min)	Remarks
1	Gegenschein	1(b)	2	TBD	Yes	48	Perform within 1 week of new moon. Coordinate with ground observations.
2	Celestial Pole, N	1(e)	2	TBD	TBD	30	Perform within 1 week of new moon. Coordinate with ground observations.
3	Ecliptic Scan	2(a)	2	TBD	Yes	19	
4	Scan ⊥ to Ecliptic	3(a)	2	TBD	TBD	17	
5	Vertical Circle	2(b)	2	TBD	Yes	60	
6	Celestial Pole, S	1(e)	2	TBD	TBD	30	Perform within 1 week of new moon. Coordinate with ground observations.
7	Gegenschein	4(a)	2	TBD	No	160	Requires the use of the orbital counter. Can be performed during a sleep period.

F06) Each of the following four photometer data scans will be performed in the order shown late in the mission (after F05) from the solar SAL.

Sequence	Program		Rods	FOV	CMG Inhibit	Total Observation Time (min)	Remarks
1	Contamination	1(a)	2, 7	TBD	Yes	40	
2	System Monitor	0(a)	7	TBD	No	94	
3	Ecliptic Scan	2(a)	7	TBD	Yes	19	
4	Contamination	3(b)	7	TBD	No	68	Requires astronaut 1 minute each 15 minutes to change elevation. (This sequence is composed of four 15-minute scans.)

F07) Each of the following ten photometer data scans will be performed in the order shown late in the mission (after F06) from the anti-solar SAL.

Sequence	Program		Rods	FOV	CMG Inhibit	Total Observation Time (min)	Remarks
1	Gegenschein	1(b)	2	TBD	Yes	48	Perform within 1 week on new moon. Coordinate with ground observations.
2	Celestial Pole, N	1(e)	2	TBD	TBD	30	Perform within 1 week of new moon. Coordinate with ground observations.
3	Ecliptic Scan	2(a)	2	TBD	Yes	19	
4	Contamination	1(a)	2, 7	TBD	Yes	40	
5	Contamination	3(d)	2, 7	TBD	TBD	68	Requires astronaut to monitor intensity and change gain. (This sequence is composed of two 30-minute scans.)
6	Contamination	1(a)	2, 7	TBD	Yes	40	
7	Scan ⊥ to Ecliptic	3(a)	2	TBD	TBD	17	
8	Celestial Pole, S	1(e)	2	TBD	TBD	30	Perform within 1 week of new moon. Coordinate with ground observations.
9	Gegenschein	3(c)	2	TBD	Yes	34	
10	Contamination	1(c)	2	TBD	No	20	Perform before, during, and after an overboard venting.

FO 1) Approximately 48 hours of observation are required to com-
FO 2) plete experiment objectives. These will be made up of
FO 3) scanning sequences previously described and scheduled at
FO 4) times when the orbital and celestial conditions are ap-
FO 5) propriate for data collection.
FO 6)
FO 7) The experiment will be mounted in the appropriate SAL, the film magazine installed, and the photometer displayed per procedures contained in the T027/S073 Experiment Operations Handbook (EOH).

An astronaut will set up mode sequences, limit values for elevation and azimuth, and other appropriate switches, and initiate the scan sequences. It is not mandatory that an astronaut be present during scan sequences. However, when other duties permit, it will be highly desirable for an astronaut to monitor detector signal levels and programmer functions and make verbal and/or written record relative to experiment operation, particularly any condition which might degrade results, such as changes in the optical environment around the OA.

The T027/S073 Photometer System will use both SAL's. The SAL's will also be used by S020 (Ultraviolet/X-Ray Solar Photography), S183 (Ultraviolet Panorama), S063 (Ultraviolet Airglow Horizon Photography), S149 (Particle Collection), T025 (Coronagraph Contamination Measurements) and S019 (Ultraviolet Stellar Astronomy). No two experiments can be scheduled concurrently at the same SAL.

T027/S073 shares the extension mechanism with S149 and, therefore, cannot be scheduled concurrently.

When mounted at either SAL, the Photometer System will protrude into the operational volume required by T020 (Foot Controlled Maneuvering Unit) and M509 (Astronaut Maneuvering Equipment). At the anti-solar SAL it will protrude into the T013 (Crew/Vehicle Disturbances) operational volume. In addition, M509 and T013 will use the tape recorder used to record Photometer System data. Thus, T027/S073 should not be scheduled concurrently with T020, M509, or T013.

T027/S073 cannot be scheduled concurrently with M092 (Inflight Lower Body Negative Pressure), M093 (Vectorcardiogram) and any operational biomedical measurements due to the requirement for 320-sample per second data channels in the Airlock Module (AM).

T027/S073 should not be scheduled concurrently with maneuvers into and out of the Z-LV(E) earth pointing attitude orientation.

The Photometer System temperature must be above the dew point to avoid fog or frost on the optics and to prevent acceleration of corrosion due to excess moisture on precision surfaces and delicate components.

All exterior OA lights must be turned off and all OA and Command Module windows that would interfere with experiment operation must be covered during data collection.

The film magazine will be placed in the Orbital Workshop (OWS) film vault before and after exposure and returned to earth in the Command Module (CM). The film magazines must be kept below 80°F.

The total radiation dosage for each film magazine must not exceed 2 rads.

Solar inertial or any other known inertial orientation is most desirable. Inertial orientation modes with random rates below 0.05 degree/second will be preferred. Constant rates up to 0.1 degree/second causing secular changes in orientation are acceptable if they do not result in a loss of the designated target. Generally, if the particular scan is fixed or moving in the opposite direction to the spacecraft, the target could be lost. A back and forth or circular scan probably will not result in a target loss. Angular accelerations which result in rates less than 0.05 degree/second are acceptable.

During data collection, the maximum allowable rate error from average scan rates over the total scan range in shaft or trunnion, or during stationary pointing is ±0.025 degrees per second.

Major maneuvers of the OA must not occur during experiment data collection.

After applying power to the Photometer System, a 30-minute warmup time is required prior to data collection.

When operating at the solar SAL, the Photometer System will be extended and retracted while the OA is in earth shadow.

The photometer shall not be pointed within 15 degrees of the moon or the sun.

The boom is to be retracted when scan sequences are separated by more than TBD hours.

When the photometer is installed in the anti-solar SAL, the electrical power is to be left on when not in a data taking mode.

Photographic data will be obtained from the 16-mm Data Acquisition Camera which is in the photometer head of the Photometer System. Photographs will automatically be taken by the Photometer System by single frames during an observation program.

Experiment and spacecraft systems measurements will be recorded for subsequent playback and transmission to the ground.

The astronaut will voice record and time correlate comments relevant to experiment operation.

For postflight data reduction, knowledge of the pointing direction of the photometer will be required to within one-half degree.

In addition, in-flight measurements will be required to determine the pointing direction of both SAL normals to within one-half degree. These measurements need only to be made one time at each SAL but should be completed early in the mission.

Success Criteria

FO 1) TBD of the 7 scans shall be completed for a minimum of time as shown and the data delivered to the Principal Investigator:

Scan	Time
1. Contamination	TBD
2. System Monitor	TBD
3. Ecliptic Scan	TBD
4. Contamination	TBD
5. Vertical Circle	TBD
6. All-Sky Map	TBD
7. Contamination	TBD

FO 2) TBD of the following 8 scans shall be completed for a minimum of time as shown and the data delivered to the Principal Investigator:

Scan	Time
1. Contamination	TBD
2. Vertical Circle	TBD
3. Ecliptical Scan	TBD
4. System Monitor	TBD
5. Celestial Pole, N	TBD
6. Gegenschein	TBD
7. Scan $\perp$ to Ecliptic	TBD
8. All-Sky Map	TBD

FO 3) TBD of the following 5 scans shall be completed for a minimum of time as shown and the data delivered to the Principal Investigator:

Scan	Time
1. Ecliptic Pole, N	TBD
2. Ecliptic Pole, S	TBD
3. Celestial Pole, S	TBD
4. Gegenschein	TBD
5. Gegenschein	TBD

FO 4) <u>TBD</u> of the following 4 scans shall be completed for a minimum of time as shown and the data delivered to the Principal Investigator:

Scan	Time
1. System Monitor	TBD
2. Ecliptic Scan	TBD
3. Vertical Circle	TBD
4. Inner Zodiacal Light/ Contamination	TBD

FO 5) <u>TBD</u> of the following 7 scans shall be completed for a minimum of time as shown and the data delivered to the Principal Investigator:

Scan	Time
1. Gegenschein	TBD
2. Celestial Pole, N	TBD
3. Ecliptic Scan	TBD
4. Scan ⊥ to Ecliptic	TBD
5. Vertical Circle	TBD
6. Celestial Pole, S	TBD
7. Gegenschein	TBD

FO 6) <u>TBD</u> of the following 4 scans shall be completed for a minimum of time as shown and the data delivered to the Principal Investigator:

Scan	Time
1. Contamination	TBD
2. System Monitor	TBD
3. Ecliptic Scan	TBD
4. Contamination	TBD

FO 7) <u>TBD</u> of the following 10 scans shall be completed for a minimum of time as shown and the data delivered to the Principal Investigator:

Scan	Time
1. Gegenschein	TBD
2. Celestial Pole, N	TBD
3. Ecliptic Scan	TBD
4. Contamination	TBD
5. Contamination	TBD
6. Contamination	TBD
7. Scan ⊥ to Ecliptic	TBD
8. Celestial Pole, S	TBD
9. Gegenschein	TBD
10. Contamination	TBD

Evaluation

FO 1) FO 2) FO 3) FO 4) FO 5) FO 6) FO 7)

After recovery, the magazine containing exposed film will be delivered to the Photographic Division at the Manned Spacecraft Center (MSC) for processing in accordance with procedures determined by the Principal Investigator and Photographic Division representatives.

Postflight experiment related data processing will consist of calibration corrections, temperature shift calculations, units conversions, data channel cross-referencing, phase related photometer output integrations, celestial pointing computations from smoothed ephemeris data and averaged or combined attitude reference data sources and computation, and automatic plotting of expected camera frame views data.

All data will be analyzed by the Principal Investigators' evaluation team and a final report will be issued within TBD days. (Telemetry Data, Astronaut Records, Trajectory Data, Photographs)

Data Requirements

Refer to Appendix A.

3.3 SUBSYSTEM/OPERATIONAL DTO'S

3.3.1 General

Subsystem and Operational DTO's contained herein have been approved by Level II CCB action prior to incorporation into the MRD. The subsystem DTO's are based on new and/or modified hardware which has not flown before. The operational DTO's are representative of tasks undertaken in flight to evaluate operational techniques for planned or contingency use later in the mission, or on subsequent Skylab missions.

3.3.2 Subsystem/Operational DTO's

The Subsystem/Operational DTO's are numbered in accordance with the following system with decimal numbers running chronologically from 0.1 to 0.n.

1.0	CSM	Guidance and Navigation
2.0	CSM	Attitude Control
3.0	CSM	Propulsion
4.0	CSM	Environmental Control
5.0	CSM	Electrical Power
6.0	CSM	Communications/Radar/Instrumentation
7.0	CSM	Thermal/Structures/Mechanical
8.0	CSM	Sequencing
9.0	CSM	Controls and Displays
11.0	SWS	Guidance and Navigation
12.0	SWS	Attitude Control
13.0	SWS	Propulsion
14.0	SWS	Environmental Control
15.0	SWS	Electrical Power
16.0	SWS	Communications/Radar/Instrumentation
17.0	SWS	Thermal/Structures/Mechanical
18.0	SWS	Sequencing
19.0	SWS	Controls and Displays
20.0		Operational/Systems

Table 3.3-1. SL-3 Subsystem/Operational DTO's

DTO Number	Title	Point of Contact
20.10	Environmental Microbiology	J. Ferguson/DC7

20.10 ENVIRONMENTAL MICROBIOLOGY

Obtain inflight microbiology samples.

Purpose and Background

The purpose is to obtain inflight microbiology samples to support maintenance of the overall Saturn Workshop (SWS) habitability.

Data derived from this effort will assist in the assessment of the overall habitability of the SWS. These data are required in the development of cleaning procedures and equipment such as air filters and waste management facilities for maintaining a suitable environment, for the development of preventive measures and for providing treatment for potential crew illness on return visits.

Functional Objectives

FO 1) Obtain inflight microbiological samples from the SWS hardware.

FO 2) Obtain inflight microbiological samples from the crew.

FO 3) Obtain inflight microbiological samples of the SWS atmosphere.

Test Conditions

FO 1) Fifteen inflight microbiological hardware samples will be obtained 16 days prior to the end of the mission and again at the close of the mission.

The microbiological hardware samples will be obtained shortly after high crew activity periods on the days specified.

Each hardware sample will be obtained by swab at sites TBD.

FO 2) Four body samples from each crewman will be obtained 16 days prior to the end of the mission.

The microbiological crew sample will be obtained by swab shortly after crew sleep periods.

FO 3) Two inflight microbiological SWS atmosphere samples will be obtained at the close of the mission at sites TBD, one each in the Orbital Workshop (OWS) and the Multiple Docking Adapter (MDA). Each sample will require three separate volumes of TBD, TBD, and TBD cubic feet.

FO 1)
FO 2) The microbiology sample swabs will be placed into Stuart's Media Tubes, the handles broken and the caps replaced on the tubes for return.

FO 1)
FO 2)
FO 3) The inflight microbiology samples will be stored in the food chiller and placed in the Command Module (CM) Resupply and Return System of the Inflight Medical Support System (IMSS).

Success Criteria

FO 1) Fifteen microbiology samples from SWS hardware shall be obtained in transport media 16 days prior to the end of the mission and again at the close of the mission. The transport media vials will be stored in the food chiller until return of the crew. The vials will be transported to earth via the CM Resupply and Return System of the IMSS.

FO 2) Four body samples from each crewman shall be obtained in transport media 16 days prior to the end of the mission, stored in the food chiller, and returned to earth via the CM Resupply and Return System of the IMSS.

FO 3) Two air samples shall be obtained from sites TBD and returned to earth via the CM Resupply and Return System of the IMSS.

Evaluation

FO 1)
FO 2)
FO 3) Initial processing of samples will be performed on the recovery vessel. The samples will be returned to the Manned Spacecraft Center for identification of the micro-organisms present and for further study. Technical reports will be made available as appropriate. (Astronaut records, other data)

Data Requirements

Refer to Appendix A.

REFERENCES

REFERENCES

1. NASA Headquarters Program Directive No. 43A, M-D ML 3200.125, dated March 26, 1971.

2. Cluster Requirements Specification No. RS003M00003, dated August 8, 1969.

3. Preliminary Earth Resources Experiment Package Detailed Test Objectives, Earth Observation Division Science and Application Directorate (MSC), dated November 1970.

4. Skylab A EREP Users Handbook, Science Requirements and Operations Branch, Science and Applications Directorate (MSC), dated March 1971.

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