JSC-08819
NASA CR-
140242

MISSION REQUIREMENTS

CSM-111/DM-2

JULY 29, 1974

APOLLO/SOYUZ TEST PROJECT

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National Aeronautics and Space Administration
LYNDON B. JOHNSON SPACE CENTER
Houston, Texas

(NASA-CR-140242) MISSION REQUIREMENTS CSM-111/LM-2 APOLLO/SOYUZ TEST PROJECT (TRW Systems) 129 p HC $9.50 CSCL 22A

N74-34271

Unclas
G3/30 48774

NASA

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Contract NAS 9-13834

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Prepared by TRW Systems

for

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1.0 PURPOSE

This document details the mission objectives and experiments for the Apollo-Soyuz Test Project (ASTP). The experiments are derived from the from the Mission Implementation Plan (Reference 1).

This Mission Requirements document provides mission planning support for the implementation and accomplishment of the detailed experiments. Constraints as related to each of the detailed experiments are provided in Volume I of the ASTP Operational Data Book (Reference 2).

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

2.0 INTRODUCTION

2.1 MISSION PURPOSE

The program objective is to develop and test systems for rendezvous and docking of future manned spacecraft and stations that would be suitable for use as a standard international system. This will include the rendezvous and docking of Apollo and Soyuz spacecraft, and crew transfer. Joint and unilateral experiments will be conducted. The conduct of the mission will include:

(1) testing of compatible rendezvous systems in orbit;
(2) testing of universal docking assemblies;
(3) verifying the techniques for transfer of cosmonauts and astronauts;
(4) performing certain activities by USA and USSR crews in joint flight; and
(5) gaining of experience in conducting joint flights by USA and USSR spacecraft, including, in case of necessity, rendering aid in emergency situations.

2.2 FLIGHT MISSION DESCRIPTION

2.2.1 General

The following paragraphs describing the flight operations pertain to a first opportunity nominal mission performed on July 15, 1975. Orbital parameters and rendezvous plans will change for the second through fifth launch opportunities (as described in paragraph 2.2.10).

2.2.2 Launch to Orbit

The Soyuz space vehicle is to be launched first from the Soviet launch complex at Baikonur, Kazakhstan at 0820 EDT into a 188 by 228 km orbit with an inclination of 51.8°. On the fourth orbit after liftoff, the Soyuz will initiate the first of two maneuvers to circularize the orbit at 225 km. The second maneuver will occur on the 17th Soyuz orbit.

At about 4-1/2 hours after Soyuz launch, the USSR will transmit their Soyuz orbital prediction to the US Control Center taking the Soyuz first maneuver into account. At about 6 hours after the Soyuz launch, updated orbital parameters for the Soyuz spacecraft will be transmitted by the USSR to the Apollo Mission Control Center - Houston, to permit final launch targeting of the Apollo space vehicle.

At approximately 7 hours and 30 minutes after the Soyuz launch, the Apollo space vehicle will be launched from the Kennedy Space Center launch complex 39B by a Saturn 1B launch vehicle. The Apollo will be inserted into a 167 by 150 km orbit with an inclination of 51.8°.

2.2.3 Transposition and Docking

Approximately one hour after Apollo liftoff, the SLA panels will be jettisoned and the CSM will detach from the S-IVB launch vehicle stage. Transposition, docking and extraction of the docking module (DM) will then follow and will be completed by approximately 2-1/2 hours after liftoff. The Apollo spacecraft will then perform a posigrade evasive maneuver to avoid recontact with the S-IVB stage.

Depending on the real time analysis of S-IVB propellant residuals, an attempt will be made to deorbit the S-IVB stage into a preselected area of the Pacific Ocean.

2.2.4 Apollo Maneuvers

The CSM will be the active vehicle for rendezvous and it will perform all the necessary phasing and closing maneuvers to accomplish the rendezvous. These maneuvers will be designed to establish a standard geometrical final approach to the Soyuz spacecraft for all launch opportunities.

2.2.5 Docked Phase

After Apollo/Soyuz docking, an attitude profile will be maintained which is consistent with the joint requirements for solar exposure, thermal considerations, and experiment pointing. The first crew transfer should be scheduled as soon as practicable after docking. To begin the crew transfer sequence, two USA crewmen will activate the docking module immediately after docking, and transfer through the docking module to the Soyuz. For about two hours, the two astronauts and two cosmonauts will perform joint activities in the Soyuz. Prior to the rest period, the USA crewmen will transfer back to the docking module and will enter the command module. Each crew member will rest in his own spacecraft.

During the second day, a total of three additional crew transfers may be performed. Each astronaut and cosmonaut should have an opportunity to visit and perform joint activities in the other's spacecraft. The amount of time spent in the docked configuration is approximately two days. During this time, joint scientific investigations will take place to include AR-002 (Microbial Exchange), MA-150 (USSR Multiple Material Melting) and MA-147 (Zone-Forming Fungi).

2.2.6 Post Undocking Joint Activities

After undocking, the Apollo and Soyuz will perform one additional docking test with the Soyuz as the active docking system. Experiments MA-059 (UV Absorption) and MA-148 (Artificial Solar Eclipse) will be conducted prior to the final separation maneuver between the CSM and Soyuz.

2.2.7 Post Joint Mission Activities

Based upon the results of the latest cryogenic consumables analysis, mission planning will be based on a mission duration of nine days. The CSM will have the capability of remaining in orbit for a maximum mission duration of eleven days to support a powered-down contingency mission. Additional experiments as well as other tasks will be performed during this time period. The DM will be left in orbit after completion of the Doppler Tracking experiment.

2.2.8 Deorbit and Recovery

The deorbit maneuver will be performed so as to permit the command module (CM) to land in the Pacific Ocean near Hawaii. Normal recovery operations will be planned for the Apollo CM water landing.

2.2.9 Post Landing Operations

Following splashdown, the recovery helicopter will drop swimmers and life rafts near the CM. The swimmers will install the flotation collar on the CM and attach the life raft. It is tentatively agreed that the crew and CM recovery procedures as conducted during the Skylab Program will be followed; this agreement pertains only to the retrieval of the crew and CM until aboard ship.

After crew and CM retrieval onboard the recovery ship, the film, flight logs, experiments and related data will be retrieved from the CM. The spacecraft will be offloaded from the ship and transported to an area where deactivation of the propellant system will be accomplished. The CM will then be returned to the contractor facilities.

2.2.10 Summary of Prime and Alternate Launch Times and Related Events

The Apollo launch windows shown in the following chart are based upon launch of Soyuz on July 15, 1975. Each launch window starts at two minutes prior to the optimum payload launch time as defined by Figure 4 of the JSC preliminary reference trajectory document (Reference 3). Additional details of the alternate launch opportunities are also provided in Reference 3.

If Soyuz is launched after July 15, the Apollo launch windows and time of related events may change but the general sequence of events will be similar to the plan for the prime and alternate launches. Additional launch window details are defined in joint USA/USSR document ASTP 40100, Launch Window Plan (Reference 4).

Summary of Prime and Alternate Launch Times and Related Events (Continued)

Launch Date	Soyuz Launch Time (EDT)*	Apollo Launch Time (EDT)*	Time Interval Between Soyuz and Apollo Liftoff (Hr:min)	Apollo Launch Window Approximate Duration (Min.)	Docking Time (Soyuz GET) Hr:Min	Apollo Rev No. for Rendezvous	Docked Duration (Hours)
July 15, 1975	0820	1550	7:30	8	51:55	29	43.8
July 16, 1975	--	1525	31:05	5	51:55	14	43.8
July 17, 1975	--	1459	54:39	8	75:40	14	43.8
July 18, 1975	--	1434	78:14	8	99:20	14	21.6
July 19, 1975	--	1409	101:49	8	121:30	13	7.5

*To convert to Moscow time, add seven hours. To convert to GMT, add four hours.

2.3 DEFINITIONS

A. Experiment - A technical investigation that supports science in general or provides engineering, technological, medical, or other data and experience for application to the Apollo/Soyuz or other programs and is recommended by the Manned Space Flight Experiments Board and assigned by the Associate Administrator for Manned Space Flight to the ASTP Program for flight.

B. Inflight Demonstration - A technical demonstration of the capability of an apparatus and/or process to illustrate or utilize the unique conditions of space flight environment. Inflight Demonstrations will be performed only on a non-interference basis with all other mission and mission related activities. Utilization, performance, or completion of these demonstrations will in no way relate to mission success.

C. Trajectory - The trajectory data (as shown under the Data Requirements for various detailed experiments) will be prepared for the users in accordance with details and format which are under considerati [illegible] remain to be defined. The trajectory data may be available in three [illegible]s: 1) magnetic tape; 2) microfilm; and 3) tab listing.

3.0 SUMMARY OF MISSION OBJECTIVES AND EXPERIMENTS

3.1 PRIMARY OBJECTIVES

The primary objectives are a statement of tasks associated with achieving the Program Objective as stated in paragraph 2.1. They are tasks that have been jointly agreed upon between the USA and USSR. The following primary objectives have been assigned by the Office of Manned Space Flight (OMSF) in the Mission Implementation Plan (Reference 1):

(1) Spacecraft Rendezvous
(2) Spacecraft Docking and Undocking
(3) Intervehicular Crew-Transfer
(4) Interaction of Control Centers
(5) Interaction of Spacecraft Crews

3.2 SUPPLEMENTARY OBJECTIVES

Supplementary objectives are those tasks that do not affect the achievement of the primary objectives of the mission. They are tasks that have been jointly agreed upon between the USA and USSR and are as follows:

(1) Docked Spacecraft Attitude Control
(2) Radio and Cable Communications
(3) Test Docking and Undocking

3.3 TECHNICAL INVESTIGATIONS

Technical investigations consist of experiments and inflight demonstrations as defined in paragraph 2.3. Some technical investigations are planned as joint activities with the Soyuz, and others are performed only by the Apollo crew.

Experiments as listed in Reference 1 are detailed and assigned priority in this document only in the event that they require crew action or otherwise impact the mission timeline. Those experiments requiring only pre- and post-flight activities (such as MA-031 Cellular Immune Response and MA-032 Polymorphonuclear Leukocyte Response) are briefly identified in Section 4.0 but are not detailed or assigned a priority.

3.4 TECHNICAL INVESTIGATION PRIORITIES

The priority assignment of experiments is as indicated below for use in planning the inflight activities. The priority assignment is based on the relative merit, urgency, or importance of accomplishing each item in the nominal timeline for insuring maximum return of valuable data. This does not preclude performing those activities having a lower priority first if there are valid reasons for so doing.

When realtime flight planning indicates that assigned technical investigations may not attain minimum scheduling or time requirements, the technical investigations will be considered for further reduction and/or cancellation in terms of their priorities. The Flight Director, Program Director and Program Manager will be briefed on any plans for reduction and/or cancellation of technical investigation activities prior to the taking of any action.

Technical Investigation Priorities

Priority	Experiment Number	Experiments
1	MA-083	Extreme UV Survey
2	MA-088	Helium Glow
3	MA-014	Electrophoresis - German
4	MA-060(FUR)*	Interface Marking in Crystals
5	MA-150(FUR)*	USSR Multiple Material Melting
6	MA-085(FUR)*	Crystal Growth from the Vapor Phase
7	MA-059	UV Absorption
8	MA-048	Soft X-ray
9	MA-106	Light Flash
10	MA-136	Earth Observations and Photography
11	MA-089	Doppler Tracking
12	MA-011	Electrophoresis Technology
13	MA-070(FUR)*	Zero-G Processing of Magnets
14	MA-044(FUR)*	Monotectic and Syntectic Alloys

Technical Investigation Priorities (Continued)

Priority	Experiment Number	Experiments
15	AR-002	Microbial Exchange
16	MA-131(FUR)*	NaCl-LiF Eutectic
17	MA-041(FUR)*	Surface Tension Induced Convection
18	MA-107	Biostack
19	MA-128	Geodynamics
20	MA-147	Zone-Forming Fungi
21	MA-007	Stratospheric Aerosol Measurement
22	MA-028	Crystal Growth
23	MA-148	Artificial Solar Eclipse
-	MA-031**	Cellular Immune Response
-	MA-032**	Polymorphonuclear Leukocyte Response

*The seven experiments labeled as "(FUR)" are included in Section 4.0 of this document as part of one detailed experiment titled "MA-010 Multipurpose Furnace".

**These two experiments require only pre- and post-flight activities. As a result, a priority assignment is not applicable.

3.5 JSC POINTS OF CONTACT

The JSC points of contact for the requirements of the experiments are:

	Experiments	Point of Contact
AR-002	Microbial Exchange	G. R. Taylor/DD5
MA-007	Stratospheric Aerosol Measurements	J. R. Bates/TN3
MA-010	Multipurpose Furnace	P. S. Jaschke/PH
MA-011	Electrophoresis Technology	P. S. Jaschke/PH
MA-014	Electrophoresis - German	P. S. Jaschke/PH
MA-028	Crystal Growth	J. R. Bates/TN3
MA-048	Soft X-ray	S. N. Hardee/TN3
MA-059	UV Absorption	W. F. Eichelman/TN3
MA-083	Extreme UV Survey	R. R. Baldwin/TN3
MA-088	Helium Glow	R. R. Baldwin/TN3

	Experiments	Point of Contact
MA-089	Doppler Tracking	P. E. Lafferty/TN3
MA-106	Light Flash	R. A. Hoffman/DD6
MA-107	Biostack	J. V. Bailey/DD6
MA-128	Geodynamics	P. E. Lafferty/TN3
MA-136	Earth Observations and Photography	S. N. Hardee/TN3
MA-147	Zone-Forming Fungi	G. R. Taylor/DD5
MA-148	Artificial Solar Eclipse	R. T. Giuli/TN23

	Pre- and Post-Flight Experiments	
MA-031	Cellular Immune Response	S. L. Kimzey/DB22
MA-032	Polymorphonuclear Leukocyte Response	S. L. Kimzey/DB22

4.0 EXPERIMENTS

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

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

Experiments that require only pre- and post-flight activities are as follows:

- MA-031 Cellular Immune Response

The purpose is to characterize lymphocytic types and to evaluate lymphocytes for their responsiveness pre- and post-flight. The experiment requires analysis of pre- and post-flight blood samples.

- MA-032 Polymorphonuclear Leukocyte Response

The purpose is to evaluate the ability of human polymorphonuclear leukocytes to function properly in the disease prevention process following spaceflight. The ability of the white blood cells to protect the body from bacterial infection will be evaluated. This test of the leukocyte functio. will be evaluated before, immediately after, and at selected intervals after recovery of the crew. The experiment complements the cellular immune response experiment and will be performed with pre- and post-flight blood samples.

AR-002 MICROBIAL EXCHANGE

Obtain microbial samples from all crew members and both spacecraft.

Purpose

The purposes are to qualitatively and quantitatively measure the microbial load of the Apollo and Soyuz crew members and of both spacecraft, in order to determine spaceflight mediated alterations and the degree of microbial exchange among crew members.

The functional test objectives are:

FTO 1) Take microbial samples from all crew members.

FTO 2) Take microbial samples from both spacecraft.

Test Conditions

FTO 1) FTO 2) Microbial samples will be collected from all five crew members and from both spacecraft during the flight.

The swabs used for collection of the microbial samples will be launched and stored in the Soyuz in four storage containers. Two of the containers with swabs will be transferred to the CSM for inflight sampling in the CSM and will be returned to the Soyuz for stowage and return to earth. The other two storage containers with swabs will be used for inflight sampling in the Soyuz.

Prior to sampling, the equipment must be stored at a temperature of 20° ±10°C. After sampling, the experiment must be stored at the coolest temperature possible, between 2° and 30°C for no longer than four days.

All of the samples will be collected as late as practical during the last joint activity - preferably during the last hour. All samples will be returned in the Soyuz in order to minimize the time from sample collection to analysis.

Test Requirements

FTO 1) Crew microbiological samples will be taken from the following areas:

- Hair on top of head
- Auditory canals
- Back of neck below hairline

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- Nostrils (Nasal cavity)
- Throat (Tonsil area)
- Hands (Palm)

FTO 2) A total of 15 samples will be taken from each spacecraft at the locations shown in Table 1.

Table 1. Sample Collection Locations

SAMPLING SOYUZ	SAMPLING APOLLO
• Commander couch	• Left X-X head strut
• Engineer couch	• Right X-X foot strut
• Control panel	• Right hand couch stabilizer beam
• Surface near panels of Soyuz descent vehicle	• Tunnel area
• Surface near hatch in descent vehicle	• Locker A 1
• Hatch cover in descent vehicle	• Lefthand rotational hand controller pistol grip (both sides)
• Surface of sanitary device	• Right girth shelf above panel 278
• Food locker in orbital module	• Panel 325
• Couch in orbital module	• Above lefthand girth shelf (above U3)
• Surface of rear panel in the orbital module	• Cover plate, Ordeal stowage locker (U3)
• Surface of the couch in the orbital module	• B6 door behind stowage bag
• Surface near fan	• Inside door of Food locker (L3)
• Surface over food locker in orbital module	• Top of VTR module
• Transfer hatch	• Panel 251, waste management dump
• Surface near transfer hatch	• Forward of panel 225

Data Requirements

1) Premission Data:

a) Microbial samples from all crewmen during the 45-day period prior to launch (Note: Similar data will be obtained for the 30-day period after splashdown).

b) Microbial samples from the CSM the day prior to launch (Note: Similar data will be obtained from the CSM as soon as possible after splashdown).

2) Mission Data:

None

3) Postmission Evaluation Data:

a) Telemetry Measurements:

None

b) Telemetry Tapes:

None

c) Onboard Astronaut Voice Transcript:

None

d) Astronaut Debriefing:

None

e) Trajectory:

None

f) Inflight microbial samples from each crewman and both spacecraft (Note: These samples will be returned to earth by the Soyuz and, hence, are not part of the CM return payload).

g) Laboratory analyses of all samples taken during the 45-day preflight period, the inflight period and the 30-day post-flight period.

Background and Justification

Significant postflight microbial alterations have been observed in samples obtained from astronauts and command modules after previous missions. Supporting ground studies indicate that such alterations may result in potentially harmful microbial imbalances. This experiment should provide a thorough evaluation of such alterations before, during, and after the flight. The use of two crews and two spacecraft allows for quantitative comparisons and identification of microbial exchange.

USSR scientists have reported microbial changes in cosmonauts that appear to have been influenced by space flight parameters. Similar changes have been reported by USSR scientists in dogs subjected to spaceflight. They reported that although acceleration and vibration on the ground has no effect on microflora, the "space" dogs demonstrated "intestinal bacilli" in their oral cavities after two days of flight. This was interpreted to be a result of spaceflight decrease in immunological activity of the subjects.

NASA studies of this type began with comparisons between pre- and postflight specimens collected on one of the Gemini flights. The analysis of these specimens indicated a decrease in types and an increase in the total numbers of microorganisms recovered postflight. Also there was evidence of microbial exchange transfer between crew members. When evaluating these specimens, it was indicated that the observed microbial changes may not be compatible with the health of the astronauts.

Analysis of pre- and postflight samples from Apollo 14 crew members revealed: 1) intercrew transfer of Staphylococcus aureus, 2) an 830% increase of aerobic bacteria, and 3) transfer of microorganisms from crew members to spacecraft. A dramatic postflight reduction in the number of mycological species recovered from Apollo 14 crew members was later verified with the Apollo 15 crew.

This particular sampling method was used previously in the USSR manned space program. An analygous system of sample collection was used in Skylab.

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ASTP offers a unique opportunity to conduct microbiological studies, with five crewmen and two spacecraft from different geographical locations.

Previous Mission Experience

Operational Objective Number	Title	Mission
20.10	Environmental Microbiclogy	Skylab SL-2,SL-3,SL-4

'1A-007 STRATOSPHERIC AEROSOL MEASUREMENT

Measure the concentration and vertical distribution of aerosols in the atmosphere.

Purpose

The purpose is to measure the concentration and vertical distribution of aerosols in the stratosphere. Measurements will be accomplished by a remote-sensing method in which the solar extinction will be measured by a photometer operating in the near infrared region of the spectrum during periods of spacecraft sunrise and spacecraft sunset.

The functional test objective is:

FTO 1) Measure the solar extinction resulting from aerosols at spacecraft sunrise and sunset by means of a photometer operating in the one micron wavelength region.

Test Conditions

FTO 1) All effluent dumps will be inhibited during the data collection periods. Data collection will take place no sooner than 30 minutes after an effluent dump. It is desirable that maximum time separation be allowed after effluent dumps (i.e., H_2O dumps, urine dumps, fuel cell purges, water boiler operation, or DM atmosphere dumps) and before data collection periods.

Spacecraft cabin lighting is to be minimum brightness during data collection periods. Flood lights must be OFF.

The SAM photometer will be mounted in the CM right hand side window. After installation of the photometer in the dovetail mount, and prior to the data collection period, the photometer alignment with respect to the CSM will be by pointing the CSM such that the solar disc is centered in the SAM target ring. The alignment will be verified before each data take and repeated if the photometer is removed from the mount and reinstalled.

The SAM photometer will be operated for five seconds as an operational verification prior to each data collection period. The telemetry data recorded or real time will be used to check the operational configuration prior to the data collection period. The check will be repeated if the photometer is disconnected and reconnected prior to data collection.

The RCS jets must be configured such as to minimize contamination of the SAM FOV during data collection periods. The SAM FOV should be free of contamination, during all data collection periods, in order to prevent degradation of the data.

At the start of each data collection period, the SAM FOV centerline will be pointed at the sun within the 2.0 degree target ring. During each data collection period, the entire solar disc must remain within the 10-degree field of view of the photometer.

Test Requirements

FTO 1) A minimum of one set of data will be collected. This set of data will consist of two data periods, with each period being approximately two minutes in duration. One data period will start at sunrise and will continue until the line of sight from the photometer to the lower limb of the sun is a minimum of 150 km (5.1°) above the earth's limb. The other data period will start when the line of sight to the lower limb of the sun is at a minimum of 150 km (5.1°) above the earth's limb and will continue until sunset.

It is highly desirable that a balloon-borne detector be used to provide ground truth data for at least one sunset or one sunrise data period. It is also highly desirable that data sets be taken on three consecutive orbits with the balloon-borne detector observations occurring during the first or second orbit.

It is highly desirable that six still photographs using the 35-mm Nikon camera be taken, at different angles, of the instrument mounted in the window to determine the alignment of the instrument with respect to the window surface.

It is highly desirable that motion pictures of the setting sun be made within two revolutions of a data collection period. The remaining portion of the one magazine of allocated film will be used to photograph the rising sun. The DAC will be used at 24 fps with IR film, filter and 75-mm lens. The photographs will be made through the CM right hand side window. The time of starting and stopping the DAC will be voice recorded or logged.

Data Requirem[illegible]

1) [illegible]on Data:

None

2) Mission Data:

a) Telemetry Data:

Measurement listed under 3 a).

PCM telemetry from the spacecraft to ground can be real time or recorded and dumped over the ground station.

3) Postmission Evaluation Data:

a) Telemetry Data:

Measurement Number	Description	S/S
CL 9790 U	SAM-Light Intensity (12 bits)	10
CH 3546 X	RCS Solenoid Activate C3/13/+X	200
CH 3547 X	RCS Solenoid Activate A4/14/+X	200
CH 3547 X	RCS Solenoid Activate A3/23/-X	200
CH 3549 X	RCS Solenoid Activate C4/24/-X	200
CH 3550 X	RCS Solenoid Activate B3/25/+X	200
CH 3551 X	RCS Solenoid Activate B4/26/+X	200
CH 3552 X	RCS Solenoid Activate B3/15/-X	200
CH 3553 X	RCS Solenoid Activate D4/16/-X	200
CH 3554 X	RCS Solenoid Activate E1/11/+Z	200
CH 3555 X	RCS Solenoid Activate D2/22/+Z	200
CH 3556 X	RCS Solenoid Activate D1/21/-Z	200
CH 3557 X	RCS Solenoid Activate B2/12/-Z	200
CH 3558 X	RCS Solenoid Activate A1/+Y	200
CH 3559 X	RCS Solenoid Activate C2/+Y	200
CH 3560 X	RCS Solenoid Activate C1/-Y	200
CH 3561 X	RCS Solenoid Activate A2/-Y	200

b) Telemetry Measurement Tape:

One copy of tapes containing the raw telemetry measurement as in 3 a), recorded and correlated with GMT (within ±0.5 second with respect to the PCM time tag) during periods of experiment operation.

c) Onboard astronaut voice transcript or log containing the time of starting and stopping the DAC.

d) Astronaut debriefing:

One copy of astronauts' postmission scientific debriefing transcript.

e) Trajectory and Special Data:

A computer-compatible tape containing CSM ephemeris data to a 3 sigma accuracy of 3 km, RCS firing history 2 minutes prior to and during the data takes, experiment sensor pointing to an accuracy of 2.0 degrees, CSM attitude to an accuracy of 1.0 degree and time correlated to 0.5 second.

f) Two copies of the film magazine of motion pictures of the setting and rising sun.

g) Two copies of six frames of 35-mm photographs showing the experiment hardware in the mounted position.

h) Camera filter used to photograph the sun.

i) SAM instrument and connecting cables.

MA-007 STRATOSPHERIC AEROSOL MEASUREMENT

Background and Justification

This experiment will demonstrate the feasibility of remote sensing of aerosols in the stratosphere from a low orbiting manned spacecraft. Increasing concern over pollution has led to investigation into methods of remote sensing from earth orbiting satellites. Implementation of the SAM experiment on ASTP will yield important information that can be utilized in design of remote sensing equipment for use in future satellites. Availability of a manned spacecraft enables the demonstration of the concept with less expense than would be the case if an unmanned satellite were used, since expensive pointing and control equipment is not required for the experiment itself.

Until recent times, little investigation of the stratosphere has been conducted. The lower atmosphere, the troposphere, has been extensively studied because of the importance of weather prediction, and study of the higher ionosphere has been conducted because of its importance to radio propagation. The lack of knowledge concerning the effects of large amounts of water vapor in the stratosphere became apparent during the SST controversy and resulted in an increased interest in the subject. Concentrations of trace gaseous constituents, volcanic dust, ozone, and water vapor have been studied, largely by means of high altitude balloons. However, the remote sensing technique is in an early stage of development, and the information to be provided by this experiment will greatly aid in rapid development in this important field.

The instrument package consists of a photometer and an electronics package to provide a signal to the CM telemetry system. The experiment technique involves making a direct measurement of solar intensity in the spectral region around one micron. Immediately before satellite night, as the spacecraft nears the earth's shadow, the line of sight to the sun passes first through the upper layers of the stratosphere and then steadily down into the lower layer of the troposphere. During the approximately 2 minutes it takes the instrument line-of-sight to pass through the lower 150 Km of the atmosphere, the solar intensity will be recorded by the photometer. The same set of measurements can be made at satellite dawn as the spacecraft emerges from the earth's shadow.

The total extinction coefficient will be obtained from the variation of the solar intensity as a function of total air mass distributed along the line of sight. At the effective wavelength of the photometer, the extinction will be principally produced by the aerosols in the atmosphere, and thus the measurement will enable the determination of the aerosol concentration.

To verify the performance of the SAM experiment, ground truth data will be acquired by means of an optical aerosol counter of the type used for the Global Monitoring balloon flights and a ground-based LIDAR system. The balloon-borne counter and the LIDAR system will make measurements near the location where a SAM observation is made, and will provide data on the aerosols and their sizes as a function of altitude up to 30 Km.

Previous Mission Experiments

Experiment Number	Title	Mission
ATM TOP-7	Atmospheric Extinction	Skylab SL-2,SL-3,SL-4
S063	UV Airglow Horizon Photography	Skylab SL-3,SL-4

MA-010 MULTIPURPOSE FURNACE

Perform materials phase change experiments using an electric furnace.

Purpose

The purpose is to perform experiments on solidification, crystal growth, and other procedures involving phase changes in various types of materials. Seven experiments are associated with the multipurpose furnace with one functional test objective assigned to each individual experiment.

The functional test objectives are:

FTO 1) Determine if surface tension induced convection caused by concentration differences occurs. Surface tension induced convection was observed in oil films on Apollo 14 and 17 due to thermal gradients in the liquids. (MA-041, Surface Tension Induced Convection)

FTO 2) Investigate the effects of zero gravity on the degree of immiscibility of monotectic Pb-Zn alloy and the homogeneity of mixing during solidification of syntectic Al-Sb compounds. (MA-044, Monotectic and Syntectic Alloys)

FTO 3) Obtain an unambiguous quantitative analysis of the microscopic segregation and growth behavior of germanium in space. (MA-060, Interface Marking in Crystals)

FTO 4) Determine the effect of convection on the solidification processes of undercooling and directional solidification, and its relation to microstructure and magnetic properties. (MA-070, Zero-G Processing of Magnets)

FTO 5) Determine the effects of zero gravity on the morphology, defect structure, electronic properties, and stability of single crystals grown from the vapor state. (MA-085, Crystal Growth From the Vapor Phase)

FTO 6) Determine the solidification behavior of an alkali halide eutectic composition under zero gravity conditions. (MA-131, NaCl-LiF Eutectic)

FTO 7) Determine the effects of zero gravity on the metallurgic processes and the properties of a composite, of powder, and of single crystals of compounds with markedly different specific weights. (MA-150, USSR Multiple Material Melting)

Test Conditions

FTO 1) thru FTO 7) Spacecraft vibration and acceleration should be kept to a minimum during the experiments. Spacecraft maneuvers will be limited to minimum impulse single jet control during soak, controlled cooldown, and the first portion of the passive cooldown.

The sample cartridges will be stowed in the CM such that the longitudinal axes are parallel with the CSM X-axis.

FTO 1) The heat soak period will be stopped manually at 1.5 ± TBD hours after initially starting the experiment. Helium injection will be started manually as soon as the heat soak period is stopped.

FTO 7) The experiment will be initiated during one of the joint USA-USSR activity periods. The cartridges will be launched in Soyuz and returned in the CSM.

Test Requirements

FTO 1) thru FTO 7) Three sample cartridges for each experiment will be heated to prescribed temperatures, heat soaked, cooled down, and injected with helium as defined in Table TBD.

FTO 3) During the cool down period, interface demarcation will be accomplished by Peltier heating associated with the transmission of current pulses (15 amps, 30 millisecond duration) at intervals of five seconds across the crystal-melt interface.

Data Requirements

1) Premission Data:

a) Telemetry Measurements:

Measurements listed in 3 a)

b) Calibration and Checkout Data:

TBD

2) Mission Data:

Measurements listed in 3 a) whenever ATS-6 and/or STDN coverage is available without recording and dumping from the DRR.

3) Postmission Evaluation Data:

a) Telemetry Measurements:

Measurement Number	Description	S/S
CC 0206 V***	DC Voltage Main Bus A	10
DF 9603 T	Temp No. 2 DM Cabin Inner Wall	10
DL 9601 T*	Multipurpose Furnace, Hot 1	10
DL 9602 T**	Multipurpose Furnace, Cold 1	10
DL 9687 T*	Multipurpose Furnace, Hot 2	10
DL 9688 T**	Multipurpose Furnace, Cold 2	10

*Either one of these two measurements is required.

**Either one of these two measurements is required.

***CC 0206 V is required only for the period of heat-up of each cartridge to the prescribed temperature.

b) Telemetry Measurement Tapes:

One copy of tapes containing raw telemetry measurements as listed in 3 a), recorded and correlated with GMT (within ±0.5 second with respect to the PCM time tag) during periods of experiment operation.

c) Onboard Astronaut Voice Transcript

d) Astronaut Debriefing

One copy of astronauts' postmission scientific debriefing transcript.

e) Trajectory:

None

f) All sample cartridges for each of the seven experiments.

g) Acceleration:

Requirements for low level acceleration data are TBD.

MA-010 MULTIPURPOSE FURNACE

Background and Justification

General

The MA-010 Multipurpose Furnace Experiment utilizes a furnace system comprised of three units: the multipurpose furnace, the control package, and a rapid cooldown system. The furnace provides three experiment chambers which have a hot zone, thermal gradient section and a heat extraction section. The control package regulates the temperature of the hot zone, permits selection of the amount of soak time desired, cools the furnace at a predetermined rate, and shuts down the system. The rapid cooldown system supplies gaseous helium to reduce the time required to cool the cartridges to a temperature such that they can be safely touched.

Results of the various multipurpose electric furnace experiments as conducted during Skylab SL-3 and SL-4 are TBD.

MA-041 Surface Tension Induced Convection

One of the most important effects of the zero gravity environment on metal forming processes is the absence of gravity induced convection currents in the molten state. However, given the absence of gravity induced convection currents, the possibility of convection effects caused by surface tension may become an important factor. Such surface tension induced convection effects due to thermal gradients were observed in oil films on Apollo 14 and 17. Surface tension gradients can be caused by thermal or concentration differences. This objective will evaluate surface tension effects due to concentration gradients in order to determine whether special precautions need to be taken to avoid these convective effects in space processes that depend on the suppression of convection currents. The experiment will consist of melting three samples of bi-metallic material samples (Pb/Pb with 0.05 atomic percent Au) in wetting (iron) and non-wetting (graphite) capsules in the multipurpose furnace, allowing them to interdiffuse, and then solidify. After return to earth, the capsules will be sectioned, and the distribution of gold will be analyzed by neutron activation to determine the effective liquid diffusion coefficient, and then detect the presence or absence of convective effects cause by surface tension.

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MA-044 Monotectic and Syntectic Alloys

Aluminum antimony compounds (Al-Sb) have promise as a high efficiency solar cell material, but technological difficulties associated with compound formation and single crystal growth have hampered development efforts. One of the underlying causes of these difficulties may be the large difference in specific gravities of the two elements. The absence of gravity should have pronounced effects on the solidification of this and other binary alloy systems having widely different specific gravities. Understanding of phase separation due to the difference in specific gravities may lead to new physical principles and new materials. In this experiment, two samples of Al-Sb will be prepared and vacuum encapsulated in quartz. After melting in the multipurpose furnace and solidifying, the samples will be returned to earth and analyzed to determine physical and electrical properties. Similar evaluation techniques will be applied to control samples processed on earth, and the results compared. As a companion experiment, a sample of Lead-Zinc (Pb-Zn) alloy will also be tested in space and compared to ground processed samples to determine the effects of zero gravity on the degree of immiscibility of this monotectic system.

These experiments are designed to yield information useful for planning future material investigation and metallurgical manufacturing in space. The development of a fundamental understanding of the effects described will make important contributions to material science.

MA-060 Interface Marking in Crystals

It is well known that defects limiting chemical and crystalline perfection are one of the major causes that make electronic devices (especially semi-conductor devices) perform below their theoretical levels. Gravity induced thermo-hydrodynamic perturbations in the melt have been identified as the primary cause for these defects. Thus semiconductor crystal growth is one of the most promising projects for commercial space exploitation. A new process, growth interface demarcation, used with differential etching and spreading resistance measurements make quantitative studies on the detailed growth and segregation behavior of electronic materials possible. In this experiment, single crystals of germanium (Ga doped) will be subjected to partial melting and regrowth in the multipurpose furnace. Throughout the growth process, "interface demarcation" will be achieved by Peltier heating associated with the transmission of electric current pulses across the crystal-melt interface. Interface demarcation will be revealed by differential etching. Absolute time reference can be obtained from the demarcation lines, and growth interface morphology and growth changes will be obtained from the shape of the demarcation line. These data will be combined with spreading resistance measurements in the analysis process. From these measurements, the dopant (carrier) concentrations corresponding to the microscopic growth rates at all points in the crystal can be determined, leading to the identification of growth rate and boundary layer effects on segregation, the thermo-hydrodynamic behavior of the melt, the thickness of the diffusion boundary layer at the growth interface, and the diffusion coefficient of the dopant element in the melt. Additional tests should disclose the degree of structural perfection, possible lattice strain, microprecipitates, and other crystal defects. Finally, an exhaustive study of the effects of zero gravity conditions during growth on the electronic properties of the material will be made, including the determination of carrier concentrations, carrier mobilities, minority carrier lifetimes and recombination velocities.

MA-070 Zero-G Processing of Magnets

Due to recent improvements in their properties, high coercive strength permanent magnets are being investigated for advanced technology applications such as levitators for high speed ground transportation systems, magnetic bearings for flywheels used in energy storage, gyros in deep space probes, and microwave power tubes for the Satellite Solar Power Station. At present, the major limitation to the use of high coercive strength cobalt/rare earth permanent magnets is the method of fabrication, i.e., sintering of powders. This is a process involving a large number of individual steps and the incomplete densification leads to degradation of the properties by oxidation. The processing of these magnetic materials in the low-gravity environment should, in one operation, eliminate the possibility of oxidation and increase the density and magnetic properties of the product.

Almost perfect magnetic crystals will be grown. An immiscible mixture of a magnetic phase in a non-magnetic matrix will be solidified without the separation due to density differences or the stirring caused by convection that are characteristic of earth-based processing. A highly aligned magnetic phase should result from the low-gravity environment.

Three separate parts of this experiment will be performed in each cartridge of the multipurpose furnace. In the hot, constant temperature zone, the immiscible system Mn-rich MnBi will be solidified. Using the temperature gradient zone of the furnace, the cobalt/rare earth alloy (CoCuF $_5$Ce will be directionally solidified to produce an almost perfect magnetic crystal. Finally, in the low temperature gradient zone, a Bi-rich MnBi eutectic will be processed by directional solidification.

MA-085 Crystal Growth From the Vapor Phase

It has been shown that single crystal growth by chemical vapor transport in a temperature gradient is macroscopically and microscopically affected by gravity induced convection currents. In addition, changes in surface morphology and defect structure have also been observed in ground-based experiments.

In solid solutions of GeSe and GeTe, there exists a one-phase region of hexagonal crystal structure, that is structurally different from either component; GeSe is orthorhombic and GeTe is rhombohedral. Alloy compositions of this hexagonal one-phase region can be transported with iodine to form single crystal platelets of hexagonal structure. However, inhomogeneities in terms of chemical composition and crystal perfection have been observed, and it is considered likely that these inhomogeneities are caused by gravity induced convection currents. Since these GeSe-GeTe alloys seem an ideal system to study the effects of convection current, this experiment will investigate this alloy system under zero-gravity conditions. Another area of investigation that will be addressed is the question of whether and to what extent surface defects on grown and pretreated crystals propagate during subsequent growth by vapor deposition. Investigations of this phenomena under zero-gravity conditions will determine the possible existence of gravity independent fluctuations in the gas phase in the vicinity of the crystal surface. Such fluctuations could be caused by localized thermal fluctuations due to the chemical reaction, and could be the reason for the existence of a lower limit for the density of crystal defects under practical growing conditions.

Recent studies involving the transport of GeSe with iodine have shown that the presence of an inert gas, argon, caused a significant change in the morphology of the grown crystals. Without the argon, the GeSe transport yielded linear dendritic type crystals; the addition of argon at one atmosphere yielded thinner crystals bent to eliptical or circular shape, giving rise to the supposition that localized convection "whirl pools" were caused by local convection currents due to the argon. Another supposition is that the argon acts as a modifier or amplifier of the chemical reaction, and that the effects were caused by thermochemical means. The experiment hopes to reveal the actual significance of thermochemically driven convection currents as compared to gravity caused convection.

The experiments are of technological importance for fabrication and processing of single crystals for solid state applications.

MA-131 NaCl-LiF Eutectic

When an eutectic liquid of NaCl and LiF solidifies, fibers of LiF form in a matrix of NaCl. This material is of interest for optics because of the ability of the fibers to transmit light and information from one end of the fiber to the other, as though in an optical waveguide. In particular, this eutectic was found to be a far-field infrared transmitting medium for wavelengths longer than the inter-fiber distance. However, defects in these materials grown on earth cause these solid-state devices to be inefficient. These defects are banded structure, discontinuity of the fibers, and faults due, in part, to the presence of vibration, and to convection currents in the melt during solidification. When this solidification process is performed in a space environment, where there are no gravity induced convection currents, and where vibration can be kept to a minimum, it is hoped that continuous fiberlike eutectic microstructures can be produced. Electrical, thermomagnetic, optical, and superconducting characteristics of this material are expected to make possible exciting device applications in the electronic and optical fields.

MA-150 USSR Multiple Material Melting

Convective stirring during solidification and segregation in the melt due to gravity contribute to inhomogeneities, voids and structural imperfections in materials when processed on earth. In zero gravity these phenomena will be absent and investigations will show the degree of material improvement that can be attained. This experiment will process three different material systems in each cartridge. In the hot isothermal region a sample of aluminum with tungsten spheres will be melted and resolidified. A germanium rod with 0.5% silicon will be partially melted and resolidified in the gradient region. An additional isothermal region will be created in the gradient zone to process an ampoule of powdered aluminum. The understanding of the effects of gravity and convection in the solidification of materials can be applied to improving the materials processing techniques on earth and most importantly could lead to manufacturing superior materials in space for use on earth.

Previous Mission Experience

Experiment Number	Title	Mission
M556	Vapor Growth of IV-VI Compounds	Skylab SL-3, SL-4
M557	Immiscible Alloy Compositions	Skylab SL-3, SL-4
M558	Radioactive Tracer Diffusion	Skylab SL-3
M559	Microsegregation in Germanium	Skylab SL-3
M560	Growth of Spherical Crystals	Skylab SL-3, SL-4
M561	Whisker-Reinforced Composites	Skylab SL-3, SL-4
M562	Indium Antimonide Crystals	Skylab SL-3, SL-4
M563	Mixed III-V Crystal Growth	Skylab SL-3, SL-4
M564	Halide Eutectics	Skylab SL-3
M565	Silver Grids Melted in Space	Skylab SL-3
M566	Aluminum-Copper Eutectic	Skylab SL-3, SL-4

Science Demonstration Number		
SD-20	Liquid Floating Zone	Skylab SL-4

In-Flight Demonstration Number		
6.2.1	Heat Flow and Convection	Apollo 17
N/A	Heat Flow and Convection	Apollo 14
N/A	Composite Casting	Apollo 14

MA-011 ELECTROPHORESIS TECHNOLOGY

Investigate new methods and procedures for electrophoresis.

Purpose

The purpose is to test new techniques for performing electrophoretic separations in space flight. Specifically, the problems to be investigated are: to test sample insertion techniques, to verify that electro-osmosis can be eliminated in a static fluid electrophoresis device, to evaluate the performance of two methods of electrophoresis, and to verify that the viability of biological samples prepared for electrophoresis can be maintained during a space mission.

The functional test objectives are:

FTO 1) Test the performance of static free fluid zonal cell electrophoresis using fixed red blood cells and live biological samples.

FTO 2) Test the performance of the isotachophoresis process using fixed red blood cells.

Test Conditions

FTO 1) The performance of zonal cell electrophoresis will be tested using the following six samples:

- Two samples of fixed red blood cells
- Two samples of live lymphocytes
- Two samples of live kidney cells

FTO 2) The performance of the isotachophoresis process will be tested using two samples of fixed red blood cells. (Note: These are not the same two samples of fixed red blood cells as used for FTO 1).

FTO 1)
FTO 2) Each of the six samples for FTO 1 will be precooled with the sample slide installed in its column. Precooling of each sample will be accomplished for ten minutes in the electrophoresis unit prior to initiating the electrophoresis process. The two samples for FTO 2 will not be precooled.

Spacecraft vibrations and accelerations will be held to a minimum during the eight tests, to include the period for refreezing (but not to include the precooling period). Single-jet RCS minimum impulse attitude control is permissible, if required.

A HEDC will be mounted on the bracket provided with the experiment at a distance of approximately 12 inches. A pre-focused 80-mm lens with extender, black and white type 3401 film and an intervalometer will be used.

Test Requirements

FTO 1) FTO 2) The initial sample to be tested will be one of the two samples of fixed red blood cells for use in the zonal cell electrophoresis process (i.e., for FTO 1). A crewman will monitor this initial test to establish the duration of each of the remaining seven samples (45 to 75 minutes). Crew comments will be transmitted to MCC-H in as near real time as feasible for this initial test regarding the position of the sample boundary within the column at the end of 60 minutes.

The minimum requirement is to test one of each of the four kinds of samples. It is highly desirable that the remaining four samples also be tested in the following descending order of priority.

Priority	Sample
1	One sample of fixed red blood cells for FTO 1
2	One sample of live lymphocytes for FTO 1
3	One sample of live kidney cells for FTO 1
4	One sample of fixed red blood cells for FTO 2

Photographs will be made at 180-second intervals during the test period for each of the four samples of fixed red blood cells. Photographs will not be taken during the test periods for the two samples of live lymphocytes or for the two samples of live kidney cells.

The six samples for FTO 1 will be refrozen during a 30-minute period and will be returned to earth. The two samples of fixed red blood cells for FTO 2 will not be refrozen and will not be returned to earth.

During the 30-minute periods for refreezing, photographs will be made at 180-second intervals for each of the six samples to be returned to earth.

Data Requirements

1) **Premission Data:**

TBD

2) **Mission Data:**

None

3) Postmission Evaluation Data:

a) Telemetry Measurements:

Measurement Number	Description	S/S
CC 0200 V	AC Voltage Main Bus 1 Phase A	10*
CC 0203 V	AC Voltage Main Bus 2 Phase A	10*

Also available at 1 S/S on LBR. Either HBR or LBR data are acceptable.

b) Telemetry Measurement Tapes:

One copy of tape containing telemetry data as listed in 3 a), recorded and correlated with GMT (within ±0.5 second with respect to the PCM time tag) during the test period for each sample.

c) Onboard Astronaut Voice Transcript:

One copy of the voice transcript including, as a minimum, comments related to the initial sample test.

d) Astronaut Debriefing:

One copy of astronauts' postmission scientific debriefing.

e) Trajectory:

None

f) TBD copies of up to 160 photographs of the various samples as recorded in one magazine of 70 mm film.

g) Six frozen experiment samples.

MA-011 ELECTROPHORESIS TECHNOLOGY

Background and Justification

Electrophoresis, i.e., the separation of biological materials such as cells by means of an electric field, is an important tool in biological and medical research. Most of the development in the field has been in an area described as zone electrophoresis in stabilized media. This technique separates a single narrow zone of sample mixture in an electrolyte medium into many zones containing a single component of the mixture and electrolyte between them. Since the densities of the separated zones generally differ from that of the intervening medium, such systems are gravitationally unstable and stabilization is required.

Electrophoresis was originally carried out in liquid media, or free solutions, but it was soon realized that problems arise due to disturbances in the bulk of the fluid. Two major causes of these disturbances during 1 g processing are the density of the particles or solute being separated and the thermal convection generated by the Joule heating of the column during electrophoresis. Although a variety of technique have evolved to overcome these problems on earth, none have been completely successful and the elimination of gravity-induced sedimentation and thermal convection can be accomplished best in space. The ASTP mission provides an opportunity to test techniques in a low gravity field with a potential improvement in the degree of separation.

The use of gravity stabilization methods should, of course, be unnecessary in space flight. Accordingly, electrophoresis experiments were conducted on Apollo 14 and Apollo 16. Though limited success was achieved in these experiments, several problems became apparent. Electro-osmotic streaming was a problem and bacterial growth destroyed the biological samples on Apollo 14. A need was indicated for further experimentation involving methods of reducing electro-osmosis, providing a better means of sample insertion, and providing means of storing viable biological specimens in space flight.

During the Skylab SL-4 mission, one whole blood sample was successfully processed using the isotachophoresis process. An attempt to process protein samples during SL-4 was unsuccessful, possibly due to a leakage

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of the sample from its container.

Experiment MA-011 will be a further development of technology begun in the Apollo 14 and 16 missions and continued during Skylab SL-4. The use of pre-frozen samples in Experiment MA-011 will avoid flocculation and sedimentation of the sample, and will preserve viability of the biological samples. Electro-osmotic action will be reduced by use of chemical compounds designed to neutralize the charge on the walls of the electrophoresis columns.

Two electrophoresis processes will be evaluated by Experiment MA-011: static free fluid zonal cell electrophoresis and isotachophoresis, which is a process characterized by self-sharpening boundaries. The experimental techniques for both methods are the same. At the conclusion of the experiment, the six columns of free fluid zonal cells and buffer solution will be refrozen and returned to the cryogenic freezer for return to earth.

Previous Mission Demonstrations

In-Flight Demonstration Number	Title	Mission
SD 35	Charged Particle Mobility	Skylab SL-4
N/A	Fluid Electrophoresis in Space	Apollo 16
N/A	Electrophoretic Separation	Apollo 14

MA-014

ELECTROPHORESIS-GERMAN

Investigate free-flow electrophoresis in zero gravity conditions.

Purpose

The purpose is to investigate the possibilities of improved performance of the free flow electrophoresis process in the absence of gravity.

The functional test objectives are:

FTO 1) Verify particle electrophoresis in the absence of gravity.

FTO 2) Test the quality of separation at high sample flow rates.

FTO 3) Demonstrate the possibility of separating cells for clinical applications.

Test Conditions

FTO 1)
FTO 2)
FTO 3)
Spacecraft vibrations and accelerations will be held to a minimum. Single-jet RCS minimum impulse attitude control during the experiment operation is permissible, if required.

Three samples will be launched in a non-frozen state and will be scheduled for test during a single 80-minute period. These three samples must be processed within a time period starting at preflight sample preparation and ending 135 hours later. In addition, one sample for Experiment MA-014 will be launched in the Experiment MA-011 freezer and will be scheduled for test during a single 40-minute period. This MA-014 sample from the MA-011 freezer will be processed before initiating any Experiment MA-011 activities.

Test Requirements

FTO 1)
FTO 2)
FTO 3)
Data will be recorded on the Experiment MA-014 recorder during the processing of each of the four samples. The experiment hardware, to include the tape, will be returned to earth.

In addition, a sample of the buffer solution will be obtained as soon as feasible aboard the recovery ship in order to permit a subsequent determination of the solution's contamination level.

Data Requirements

1) Premission Data:

a) Telemetry Measurements:

None

b) Calibration and Checkout Data

In accordance with KSC checkout procedures TBD

2) Mission Data:

None

3) Postmission Evaluation Data:

a) Telemetry Measurements:

None

b) Telemetry Measurement Tapes:

None

c) Onboard astronaut voice transcript containing crew comments on time of activation of each test period

d) Astronaut Debriefings:

One copy of the astronauts' postmission scientific debriefing

e) Trajectory and Special Data:

Low level acceleration data during experiment operation TBD.

f) Tape recording of experiment results from the Experiment MA-014 tape recorder

g) Sample of the buffer solution as obtained onboard the recovery ship

Background and Justification

Electrophoresis, i.e., the separation of biological materials such as cells by means of an electric field, is an important tool in biological and medical research. Free flow electrophoresis, in which the sample flows continuously through an electric field perpendicular to the flow, has become important in human medicine. Patients suffering from bone marrow disease could be treated by ablation of the diseased bone marrow and replacement with the marrow of a healthy donor. However, transplantation disease usually results. It is widely anticipated that this disease could be avoided by separating the bone marrow component that protects the patient from the immuno-reactive component which attacks the patient. Laboratory tests have indicated the capability of free-flow electrophoresis in this type of separation.

At present the efficiency of free-flow electrophoresis is limited by the resolution of the electrophoresis apparatus and the low output of separated cells. Higher output could be achieved by using higher flow-rate, wider separation gap, and higher electric field densities. This, however, increases the temperature with resultant increase in convection currents and sedimentation. In zero gravity, these conditions would not prevail.

In the experiment, the separation is accomplished by mixing the sample with a buffer which flows slowly and in a laminar manner along a channel perpendicular to the electric field. The sample is introduced continuously through a small hole on the upstream side of the channel and is separated in various angles according to buffer velocity, the electric field gradient, and the various mobilities which are typical for the components of the mixture. Each sample will be subjected to three combinations of buffer velocity and field gradient. At the downstream end, the deflection and density distribution will be analyzed by opto-electronic means and the results stored in digital form on the Experiment MA-014 tape recorder which will be returned to earth in the CM.

Previous Mission Demonstrations

In-Flight Demonstration Number	Title	Mission
N/A	Fluid Electrophoresis in Space	Apollo 16
N/A	Electrophoretic Separation	Apollo 14

MA-028 CRYSTAL GROWTH

Determine if crystals can be grown by diffusion through water in zero gravity conditions.

Purpose

The purposes are to determine if single crystals of slightly soluble compounds can be grown in zero gravity conditions by allowing reactant solutions to diffuse toward each other through a pure water region, to obtain single crystals superior to those heretofore available for research and commercial applications, and to obtain data for evaluating this and other zero gravity techniques for growing crystals.

The functional test objective is:

FTO 1) Grow single crystals by allowing reactant solutions to diffuse toward each other through a pure water region.

Test Conditions

FTO 1) As soon as possible after completing all maneuvers for the MA-059 Experiments and after the CSM burn for final separation from the Soyuz, the six experiment containers for Experiment MA-028 will be activated.

Test Requirements

FTO 1) After the containers have been activated, each container will be inspected visually at approximately twelve-hour intervals until the end of the mission. Comments regarding container crystal activation and growth will be recorded or logged in the astronauts' log. It is highly desirable that photographs be taken of the container at each time of inspection using the 35-mm Nikon camera with a 35-mm lens, Type SO-168 film, MA-028 framing device, and photographed at a distance of approximately twelve inches.

Data Requirements

1) Premission Data:

None

2) Mission Data:

None

3) Postmission Evaluation Data:

a) Telemetry Measurements:

None

b) Telemetry Measurement Tapes:

None

c) Onboard Astronaut Voice Transcript

d) Astronaut Debriefing:

None

e) Trajectory and Special Data:

Low level acceleration data during experiment operation TBD.

f) Three copies of all 35-mm photographs obtained during the experiment.

g) One copy of the astronaut log relative to this experiment to include time of inspections and cabin temperature at the time of each inspection.

h) Six Experiment MA-028 containers

Background and Justification

It is often difficult to grow large, single crystals free of defects and of the desired composition. Since the crystals are usually only slightly soluble in water or other convenient solvents, they cannot be grown from solutions by ordinary low temperature methods. High temperature melt, solution, or vapor growth methods are complicated by a number of undesirable effects, including phase transformations, volatility of one or more of the components, thermally and mechanically induced strain, and increased severity of contamination problems. These complications result in defects of various kinds including dislocations, grain boundaries, and departures from stoichiometry.

Superior crystals have been grown at low temperatures in normal gravity using gel methods. However, with a few exceptions, the crystals obtained were too small for most applications. Technologically important crystals grown by gel methods include crystals of CdS, PbS, HgS, MnS, CuCl, Ag I, and $[(CH_3)_4N]_2\ Ag_{13}I_{15}$.

In the gel method, it is believed that the principal functions of the gel are suppression of convective mixing and support of the growing crystal. In zero gravity, it is hypothesized that the gel can be replaced with a region of pure water and still result in growth of superior crystals of certain compounds. Pure water as a growth medium would allow more rapid diffusion and completely eliminate any mechanical constraint of the growing crystal. In addition, other detrimental effects associated with the gel such as contamination of the crystal by gel constituents, complication of the control of nucleation rates, and gel instability would be eliminated. The proposed zero gravity method, like conventional gel methods, is a low temperature method which minimizes problems of phase transformations, volatility, strain, and contamination which are inherent in the high temperature methods.

The experiment hardware is a result of research and experimentation over the past several years. Based on results obtained, several compounds have been tentatively chosen for the zero gravity, pure water method.

The following sample materials are being considered: PbS, $CaCO_3$, $CaC_4H_4O_6 \cdot 4H_2O$, AgI, PbI_2, CdS, and HgS. Selection of the final sample materials will be made prior to the mission.

The experiment hardware consists of six transparent reactors consisting of three compartments each. The outer two compartments will each contain a different salt solution which, when mixed, will form an insoluble compound. All other reaction products are soluble in water. The center compartment will contain pure water. During the experiment performance, the outer compartments will be opened to allow the salt solutions to mix in the center compartments. The crystals will then from in the pure water.

Previous Mission Experiments

None*

(*Note: There have been previous mission experiments related to crystal growth but they were all conducted in a multipurpose furnace during Skylab SL-3 and SL-4. Those experiments are listed in this document in the Background and Justification section of Experiment MA-010, Multipurpose Furnace.)

MA-048 SOFT X-RAY

Observe and map celestial and earth atmospheric soft X-ray emissions.

Purpose

The purpose is to map and observe celestial and earth atmospheric soft X-ray emissions.

The functional test objectives are:

FTO 1) Map celestial X-ray emission in the energy region of 0.1 to 1.0 Kev.

FTO 2) Observe discrete X-ray sources to obtain spectral and timing data in the range of 0.1 to 10.0 Kev.

FTO 3) Record the spatial dependence and time variability of atmospheric X-ray emission in the range of 0.1 to 10.0 Kev.

Test Conditions

FTO 1)
FTO 2)
FTO 3)

The instrument will be pointed within two degrees of the prescribed pointing direction.

The experiment door will be closed when spacecraft maneuvers bring the sun within ten degrees of the instrument field-of-view centerline.

SPS operation and RCS thrusters A2, A4, B1, and B4 will be inhibited when the experiment door is open.

The experiment door will be closed during spacecraft effluent dumps (H_2O, urine, FC purge, etc.) and will remain closed for 15 minutes thereafter.

The instrument must be pointed toward deep space (away from sun or earth) at turn on.

The experiment door will not be open more than TBD minutes with the experiment OFF.

The experiment will not be operated more than TBD minutes with the door closed.

The three plane scans shown in the Test Requirements for FTO 1) and FTO 2) must be performed during darkness. All other data collections should be planned during darkness, although partial lightside observations are acceptable.

Data collection is preferred between 30 degrees North latitude and 30 degrees South latitude, but is acceptable outside these latitudes.

All data will be collected while outside the South Atlantic Anomaly, defined for this experiment as the area bounded by longitude 45 degrees East to 70 degrees West and latitude 15 degrees South to 60 degrees South.

It is desirable that targets be observed only when the moon is more than 10 degrees away from the instrument field of view centerline.

It is highly desirable that the prime observations be conducted outside of TBD degrees of the sun.

FTO 2) Observations must be conducted when viewable with local zenith angles equal to or less than 90 degrees.

Test Requirements

FTO 1)
FTO 3) The minimum requirement for FTO 1 is three great circle scans from the following list of great circle scans. The scan duration will be approximately 15 minutes at a scan rate less than 0.5 degree per second. It is highly desirable that up to seven additional scans be performed. Scans are to be made with the X-axis pointed at the following celestial coordinates. For FTO 3), some earth viewing observations will be accomplished as part of the great circle scans.

Scan Priority	Right Ascension (α)	Declination (δ)
1	$3^h\ 50^m$	+41°
2	$4^h\ 30^m$	+44°
3	$5^h\ 16^m$	+45°
4*	$12^h\ 48^m$	+27°
5*	$12^h\ 28^m$	+31°
6	$5^h\ 16^m$	+38°
7	$5^h\ 56^m$	+38°
8	$5^h\ 56^m$	+30°
9*	$13^h\ 10^m$	+24°
10	$6^h\ 32^m$	+30°

*Note: Scans 4, 5, and 9 are plane scans, and must be performed at night to avoid the sun.

FTO 2) The minimum requirement is to observe three target groups from the following eleven target groups listed in descending order of priority. Within each target group, the minimum requirements for that specific group are the targets listed as high priority.

Centaurus Target Group - Priority 1

Source Name	UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
	3U 1022-55	10^h22^m	-55.5°	2 (Note 1)	-
Eta Carinae		10^h43^m	-59.4°	2	High
Cen X-3	3U 1118-60	11^h19^m	-60.3°	5	High
	3U 1134-61	11^h34^m	-61.6°	2 (Note 1)	-
	3U 1144-74	11^h45^m	-74.8°	2 (Note 1)	-
	3U 1145-61	11^h46^m	-61.9°	2 (Note 1)	-
	3U 1210-64	12^h10^m	-64.6°	2 (Note 1)	-
	3U 1223-62	12^h24^m	-62.6°	2	High
	3U 1247-41	12^h47^m	-41.0°	2 (Note 1)	-
	3U 1254-69	12^h54^m	-69.0°	2 (Note 1)	-
	3U 1258-61	12^h58^m	-61.3°	2	High
	3U 1320-61	13^h21^m	-61.7°	2 (Note 1)	-
Cen A	3U 1322-42	13^h22^m	-42.8°	2 (Note 2)	High
NGC 5253 (SN 1972e)		13^h37^m	-31.4°	2	High

Note 1: These targets are all strong sources and may be scanned from target to target without holding for the two-minute observation time per target. When the target is in the instrument's four-degree field of view, the scan rate may be up to 0.25 degree per second.

Note 2: On this particular target, it is highly desirable that a scan mode be used. Two scans will be made at a scan rate of 0.1 degree per second. The first scan will be made in declination from -35.0 degrees to -51 degrees with the right ascension being held at 13^h22^m. The second scan will be made in right ascension from 13^h00^m to 13^h50^m with the declination being held at -42.8 degrees.

Hercules Target Group - Priority 2

Source Name	UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
Her Cluster	3U 1551+15	15^h52^m	15.9°	2	High
	3U 1555+27	15^h55^m	27.2°	2	-
	3U 1639+40	16^h39^m	40.2°	2	High
	3U 1645+21	16^h45^m	21.5°	2	-

Hercules Target Group - Priority 2 (Cont.)

Source Name	UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
Her X-1	3U 1653+35	16^h56^m	35.4°	5	High
	3U 1706+32	17^h06^m	32.1°	2	-
	3U 1736+43	17^h36^m	43.0°	2	High
	3U 1809+50	18^h09^m	50.3°	2	-

Scorpius Target Group - Priority 3

Source Name	UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
Sco X-1	3U 1617-15	16^h17^m	-15.5°	5	High
	3U 1709-23	17^h09^m	-23.4°	2 (Note 1)	-
	3U 1727-33	17^h27^m	-33.7°	2 (Note 1)	-
SN 1604 (Kepler)		17^h27^m	-21.4°	2	High
	3U 1728-16	17^h29^m	-16.9°	2 (Note 1)	-
	3U 1728-24	17^h29^m	-24.7°	2 (Note 1)	-
	3U 1735-44	17^h35^m	-44.4°	2 (Note 1)	-
GCX	3U 1743-29	17^h44^m	-29.1°	2	High
	3U 1746-37	17^h47^m	-37.0°	2 (Note 1)	-
	3U 1755-33	17^h56^m	-33.8°	2 (Note 1)	-
	3U 1758-20	17^h59^m	-20.5°	2 (Note 1)	-
	3U 1758-25	17^h58^m	-25.1°	2 (Note 1)	-
	3U 1811-17	18^h12^m	-17.2°	2 (Note 1)	-
	3U 1813-14	18^h13^m	-14.1°	2	High
	3U 1820-30	18^h20^m	-30.4°	2 (Note 1)	-
	3U 1822-37	18^h22^m	-37.2°	2 (Note 1)	-
	3U 1832-23	18^h32^m	-23.2°	2 (Note 1)	-

Note 1: These targets are all strong sources and may be scanned from target to target without holding for the two-minute observation time per target. When the target is in the instrument's four-degree field of view, the scan rate may be up to 0.25 degree per second.

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Coma Target Group - Priority 4

Source Name	UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
	3U 1144+19	11^h44^m	19.7°	2	-
NGC 4151	3U 1207+39	12^h08^m	39.8°	2	High
3C 273	3U 1224+02	12^h25^m	2.3°	2	High
M 87	3U 1228+12	12^h28^m	12.7°	2	High
IC 3576	3U 1231+07	12^h32^m	7.1°	2	-
Coma C	3U 1257+28	12^h57^m	28.2°	2	High
	3U 1349+24	13^h49^m	24.4°	2	-

Magellanic Cloud Target Group - Priority 5

Source Name	UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
	3U 0055-79	00^h55^m	-79.7°	2	-
SMC X-1	3U 0115-73	01^h15^m	-73.7°	5	High
	3U 0400-59	04^h00^m	-59.0°	2	-
	3U 0426-63	04^h27^m	-63.5°	2	High
LMC X-2	3U 0521-72	05^h22^m	-72.0°	2	-
LMC X-4	3U 0532-66	05^h32^m	-66.6°	2	-
LMC X-3	3U 0539-64	05^h39^m	-64.1°	2	-
	3U 0549-69	05^h41^m	-69.8°	2	-

Cygnus Target Group - Priority 6

Source Name	UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
	3U 1921+43	19^h22^m	43.5°	2	-
	3U 1953+31	19^h54^m	31.9°	2	-
Cyg X-1	3U 1956+35	19^h56^m	35.1°	5	High
Cyg A	3U 1957+40	19^h57^m	40.6°	2	High
Cyg X-3	3U 2030+40	20^h31^m	40.8°	5	High
Cyg Loop		20^h48^m	30.2°	2	High
	3U 2052+47	20^h52^m	47.9°	2	High
	3U 2129+47	21^h30^m	47.0°	2	-
Cyg X-2	3U 2142+38	21^h43^m	38.1°	2	High

Lupus, Norma, and Circinus Target Group - Priority 7

Source Name	UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
SN 1006		15^h00^m	-41.7°	2	High
	3U 1510-59	15^h10^m	-59.0°	2 (Note 1)	-
Cir X-1	3U 1516-56	15^h16^m	-57.0°	5	High
Lupus Loop		15^h37^m	-39.6°	2 (Note 1)	-
	3U 1538-52	15^h38^m	-52.2°	2 (Note 1)	-
	3U 1543-62	15^h43^m	-62.4°	2 (Note 1)	-
	3U 1543-47	15^h44^m	-47.6°	2	High
	3U 1556-60	15^h57^m	-60.6°	2 (Note 1)	-
	3U 1626-67	16^h27^m	-67.4°	2 (Note 1)	-
	3U 1632-64	16^h33^m	-64.1°	2 (Note 1)	-
	3U 1636-53	16^h37^m	-53.7°	2 (Note 1)	-

Note 1: These targets are all strong sources and may be scanned from target to target without holding for the two-minute observation time per target. When the target is in the instrument's four-degree field of view, the scan rate may be up to 0.25 degree per second.

Vela Target Group - Priority 8

Source Name	UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
	3U 0624-55	06^h24^m	-55.1°	2	High
	3U 0705-55	07^h06^m	-55.2°	2	-
	3U 0750-49	07^h50^m	-49.4°	2	High
	3U 0804-53	08^h05^m	-53.0°	2	-
Pup A	3U 0821-42	08^h22^m	-42.7°	2	High
	3U 0833-45	08^h34^m	-45.0°	5	High
	3U 0900-40	09^h00^m	-40.4°	2	High
	3U 0918-55	09^h19^m	-55.0°	2	High

North Pole Target Group - Priority 9

UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
3U 1706+78	17^h07^m	78.5°	2	High
3U 1825+81	18^h26^m	81.3°	2	High

North Pole Target Group - Priority 9 (Cont.)

UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
3U 1843+67	18^h43^m	67.5°	2	-
3U 1904+67	19^h05^m	67.0°	2	High
3U 1956+65	19^h56^m	65.0°	2	-
3U 2041+75	20^h42^m	75.4°	2	-
3U 2128+81	21^h29^m	81.6°	2	-

Cas Target Group - Priority 10

Source Name	UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
	3U 2208+54	22^h09^m	54.5°	2	-
	3U 2233+59	22^h33^m	59.6°	2	-
Cas A	3U 2321+58	23^h21^m	58.6°	2	High
SN1572(Tycho)	3U 0022+63	00^h23^m	63.9°	5	High
	3U 0115+63	01^h15^m	63.6°	2	-
	3U 0143+61	01^h43^m	61.3°	2	High

Ophiuchus Target Group - Priority 11

UHURU Catalog Number	α	δ	Observation Time (Min.)	Priority
3U 1822-00	18^h23^m	0.0°	2 (Note 1)	High
3U 1832-05	18^h32^m	-5.3°	2 (Note 1)	-
3U 1837+04	18^h37^m	+5.0°	2 (Note 1)	High
3U 1901+03	19^h02^m	+3.0°	2 (Note 1)	-
3U 1906+09	19^h06^m	+9.7°	2 (Note 1)	-
3U 1908+00	19^h08^m	+0.5°	2 (Note 1)	High
3U 1912+07	19^h13^m	7.7°	2 (Note 1)	-
3U 1915-05	19^h16^m	-5.3°	2 (Note 1)	High
3U 1956+11	19^h57^m	11.6°	2 (Note 1)	-

Note 1: These targets are all strong sources and may be scanned from target to target without holding for the two-minute observation time per target. When the target is in the instrument's four-degree field of view, the scan rate may be up to 0.25 degree per second.

It is highly desirable that the following targets be observed once per day. There are no minimum requirements for the once-per-day targets.

Priority	Name	α	δ	Observation Time (Min.)
1	Her X-1	16^h53^m	+35.6°	5
2	Sco X-1	16^h17^m	-15.5°	5
3	Cen X-3	11^h19^m	-60.3°	5
4	SMC X-1	1^h15^m	-73.7°	5

It is highly desirable that the following targets be observed for long durations during crew rest periods. There are no minimum requirements for long duration observations.

Priority	Name	α	δ	Observation Time (Hrs.)
1	Cyg X-3	20^h31^m	+40.8°	TBD
2	Sco X-1	16^h17^m	-15.5°	TBD
3	Her X-1	16^h53^m	+35.6°	TBD
4	Cen X-3	11^h19^m	-60.3°	TBD

FTO 1)
FTO 2) The values of right ascension (α) and declination (δ), for each target listed above, are based on the equinox and equator of 1950, and on the epoch of 1950. Corrections for proper motion are not required.

In order to acquire as much supplementary data as possible, it is highly desirable that the MA-048 instrument be operated during the entire mission whenever hardware constraints are not violated.

FTO 1)
FTO 2)
FTO 3) Background measurements of one-minute duration, with the protective door closed, will be made approximately every three hours of experiment operation, except during crew rest periods and periods of collecting supplementary data.

A 20-second calibration will be performed approximately every three hours of experiment operation, except during crew rest periods of collecting supplementary data. It is preferred that the calibrations be performed prior to or following data takes. It is highly desirable that the calibrations be performed when real time data reception is possible on the ground. The calibrations may be performed with the instrument protective door open or closed.

A gas purge will be performed prior to initial operation of the experiment and as required by MCC-H up to approximately every three hours during experiment operation, except during crew rest periods. The protective door must be open prior to and during purges.

Data Requirements

1) Premission Data:

a) Telemetry Measurements:

Measurements listed under 3 a).

b) Calibration and Checkout Data

In accordance with KSC checkout procedures TBD.

2) Mission Data:

a) Telemetry Measurements:

Measurements listed under 3 a), as telemetered via ATS-6 over ground stations, or as recorded and played back as soon as possible.

3) Postmission Evaluation Data:

a) Telemetry Measurements:

Measurement Number	Description	S/S
SL 9670 R	X-Ray Data Rate	10*
SL 9671 R	X-Ray Background Rate	10*
SL 9672 R	X-Ray Coincident Rate	10*
SL 9673 V	X-Ray High Voltage Monitor	10*
SL 9674 V	X-Ray +5 VDC PS Volts	10*
SL 9675 V	X-Ray +15 VDC PS Volts	10*
SL 9676 V	X-Ray Gas Emergency Monitor	10**
SL 9680 P	X-Ray Tank Pressure	10*
SL 9681 P	X-Ray Detector Pressure	10*
SL 9683 T	X-Ray Bottom Base Temp	10*
SL 9684 T	X-Ray Top Retainer Bottom Base Difference	10*
SL 9685 K	X-Ray Spectral Data	50
SL 9686 K	X-Ray Scientific Data	N/A(FM 2,3)

* Included in the 4KB data system (SL 9686 K in the 51.2 KB PCM System.

**PCM System only.

Measurement Number	Description	S/S
SL 9800 W	X-Ray Time Word 1	N/A
SL 9801 W	X-Ray Time Word 2	N/A
SL 9802 V	X-Ray +20 VDC PS Voltage	N/A
SL 9807 X	X-Ray Door Position	N/A
SL 9808 X	X-Ray High Voltage PS 1 Enabled	N/A
SL 9809 X	X-Ray High Voltage PS 2 Enabled	N/A
SL 9810 X	X-Ray High Voltage Cut-out	N/A
SL 9811 X	X-Ray Tank Solenoid Valve Position	N/A
SL 9812 X	X-Ray Purge Solenoid Valve Position	N/A
SL 9813 V	X-Ray Calibrate Solenoid	N/A
SL 9815 X	X-Ray Purge Sequencer	N/A
SL 9816 X	X-Ray Purge Sequencer Clock	N/A
SL 9817 W	X-Ray Timing Data	N/A
SL 9818 T	X-Ray Bottom Ret. Bottom Base Difference Temp	N/A
SL 9819 T	X-Ray Top Bottom Base Difference Temp	N/A
SL 9820 V	X-Ray -15 VDC PS Voltage	N/A
SL 9823 V	X-Ray +28 VDC PS Voltage	N/A
SL 9824 V	PCM System +10 VDC	N/A
SL 9825 V	Purge Sequencer +10 VDC	N/A

b) Telemetry Measurement Tapes:

One copy of tapes containing raw telemetry measurements as listed in 3 a), recorded and correlated with GMT (within ±0.5 seconds with respect to the PCM time tag) during periods of experiment operation.

c) Onboard Astronaut Voice Transcript

d) Astronaut Debriefings:

One copy each of astronauts' postmission scientific and photographic debriefing transcript.

e) Trajectory and Special Data:

A computer compatible tape containing CSM ephemeris data to a 3 sigma accuracy of 3 km, experiment sensor pointing to an accuracy of 1.27 degrees, CSM attitude to an accuracy of 0.25 degree and time correlated to 0.5 second. Zenith angle and sun angle to an accuracy of 2 degrees must be provided. In addition the field of view is desirable.

f) One copy of the Experiment Operation Log generated by the real time Flight Operations Team.

Background and Justification

The first astronomical X-ray studies were carried out between 1962 and 1967, first using Geiger counters and later proportional counters. These detectors all had berylium windows and were sensitive to X-rays in the 2 to 20 Kev energy range. To date, about 160 sources have been observed in the 2 to 20 Kev range, most of these discovered by the UHURU satellite launched in 1970. In 1967-68, several groups began making observations with proportional counters using thin plastic windows which transmitted X-rays in a narrow band near 0.25 Kev and in the range 0.6 to 2 Kev as well. These soft X-ray studies produced several important results which form the background for the current experiment. First, a diffuse glow of X-rays was observed to be present in all directions. The flux appears to be a maximum when looking toward the poles of our galaxy, the Milky Way; but the flux looking right into disc of the galaxy is also appreciable. The second result was the detection of X-ray sources which only emit at energies below 2 Kev. There are currently about 10 of these sources known. Most appear to be associated with old supernova remnants and probably indicate the presence of plasmas produced by the shock waves from the original supernovas heating the surrounding interstellar gas. However, two or three of these sources are not associated with any known supernova remnants. It is possible that these are nearby remnants of large angular size whose optical and radio surface brightness are too low to be detected by conventional ground-based tech ques. The third important result of soft X-ray astronomy is the obser ation of turn-overs in the spectra of many X-ray sources at energies below 2 Kev. These features are attributed to absorption of soft X-rays either by a high density of matter in the source itself or by the interstellar material between the earth and the source. Measurements of the amount of interstellar matter are particularly important because they can be used to determine the distance to many of the X-ray sources.

Another interesting aspect of soft X-ray observations is the possibility of measuring atmospheric X-rays from precipitating electrons interacting high in the upper atmosphere. To date, no systematic observations of this phenomenon have been made. X-rays have been observed in auroral regions, but calculations show that even at lower geomagnetic latitudes appreciable X-ray fluxes may be observed during disturbed magnetic conditions. During a rocket flight in November 1973, such a flux was apparently observed at White Sands, New Mexico.

In the ASTP X-ray experiment, there will be several kinds of studies. The longer integration time available in a satellite experiment compared to a rocket flight makes it possible to use a narrower field of view. Thus, maps may be obtained of the soft X-ray background with better angular resolution and better sensitivity for detecting low contrast features. Ten hours of continuous data would be required to map the entire celestial sphere, but even 25% coverage with this sensitivity would provide a significant advance in our study of the background. In addition, the scanning part of the experiment will cover the appropriate portions of the sky in which to search for new X-ray emitting supernova remnants. The earth-looking positions of these scans will also provide the desired data on atmospheric X-rays.

The pointing capabilities of the CSM spacecraft will provide us with the opportunity to observe selected targets. These targets will be selected from catalogs of known sources for which several new types of measurements can be made with this experiment. Spectral information will provide data on absorption both in the sources and in the intervening interstellar matter. Several sources will be observed repeatedly during the mission to look for variability and particularly for changes in the soft X-ray absorption which would indicate that the absorption must be in the source itself. The experiment can also monitor viability on time scales as short as 3 msec.

All satellite X-ray experiments in the past, and those planned until the Shuttle becomes operational, have had very long lead times. Therefore, the satellite hardware has lagged behind the state-of-the-art as developed in sounding rocket programs. With the accelerated schedule for the ASTP mission, there is a unique opportunity to apply state-of-the-art techniques to a long duration satellite experiment. The unique features which will be used for the first time on a satellite experiment include: low energy capability; electronics to fully utilize the spectral resolution of the proportional counter, and fast timing capability. The ASTP mission is also occurring at a unique juncture in the development of X-ray astronomy. The UHURU satellite has located about 160 sources. These results point to further observations requiring the capabilities planned for the ASTP experiment. At the same time, the techniques and reliability of the detector and associated electronics have been improved during the past three years to the point where the rocket hardware is readily adaptable to this satellite mission. One further CSM capability of major importance to the X-ray experiment is the spacecraft attitude control which provides both inertial pointing and the required scans.

Previous Mission Experiments

Experiment Number	Title	Mission
S150	Galactic X-Ray Mapping	Skylab SL-3

MA-059

UV ABSORPTION

Measure the concentration of atomic oxygen and atomic nitrogen by optical absorption spectroscopy.

Purpose

The purpose is to measure the concentrations of atomic oxygen and atomic nitrogen in the atmosphere by optical absorption spectroscopy.

The functional test objectives are as follows:

FTO 1) Measure the densities of atomic oxygen and atomic nitrogen in earth's atmosphere at the orbital altitude by optical absorption spectroscopy, and determine the atmospheric gas temperature.

FTO 2) Measure the abundance of atomic oxygen and atomic nitrogen within the ambient cloud around the Soyuz spacecraft.

FTO 3) Measure the atomic oxygen/nitrogen variation within the orbital path.

FTO 4) Measure the resonant fluorescence background and sky airglow.

FTO 5) Measure ambient atmosphere gas pile up.

Test Conditions

FTO 1) During data gathering periods, the retroreflector mounted on the side of the Soyuz will be pointed to within ±7 degrees of a line normal to the Soyuz orbital plane.

The experiment will be accomplished at separation distances of approximately 150 ±50 meters, 500 ±60 meters, and 1 km ±100 meters between the two spacecraft during each data collection period.

The CSM VHF ranging system will be operated to aid in determining the 150 meter, 500 meter, and 1 km range.

FTO 1)
FTO 2) During data gathering periods, the CSM vehicle will point the spectrometer assembly to within ±1.5 degrees in spacecraft yaw and ±0.35 degree in spacecraft pitch of the line between the Apollo and the Soyuz spacecraft retroreflector, utilizing the COAS and Panel 101 meter.

FTO 1)
FTO 2)
FTO 3)
FTO 4) The experiment door will be closed during spacecraft dumps (H_2O, urine, FC purge, etc.) and will remain closed for 15 minutes thereafter.

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FTO 5) The sun must not be within 20 degrees of the instrument line-of-sight when the door is open.

RCS jets B3, C4, and D4 will be inhibited during data collection periods. In addition, SM RCS jet impingement on the Soyuz retroreflector will not be permitted whenever the separation distance is less than TBD.

The instrument lamps must be turned ON 20 minutes prior to use.

Instrument alignment, utilizing a first magnitude or brighter star by use of the COAS and CSM test meter on Panel 101, will be made prior to obtaining scientific data.

Test Requirements

FTO 1)
FTO 4) The CSM will sweep at approximately three degrees per minute through an angle of $\pm 15°$ with respect to a line normal to the Soyuz orbital plane during each data collection period while maintaining the alignment requirements of FTO 1 test conditions.

One night-time data collection period is required at each of the three separation distances. It is highly desirable that the data be taken as near the equator as feasible.

Instrument calibration will be conducted after each data collection period in the following sequence (minimum of 30 seconds each):

a) Lamp ON, door OPEN
b) Lamp ON, door CLOSED

FTO 2) With the CSM/DM $-X_{A4}$ axis pointed along the velocity vector, the CSM/DM $+X_{A4}$ axis will be aligned within 7 degrees with respect to the Soyuz $+X_{C6}$ axis and the experiment LOS will be pointed toward the Soyuz aft retroreflector. Data will be obtained for approximately five minutes during night time at a nominal vehicle separation of 150 meters.

FTO 3) Approximately one complete orbit of data is required. The CSM/DM X-axis will be normal to the velocity vector and the Y-Z plane will be parallel to the velocity vector.

FTO 5) While the CSM/DM is being rolled 360 degrees about the X-axis at 0.5 degree per second with the X-axis normal to the velocity vector, and with the Y-Z plane parallel to the velocity vector, data will be taken to determine the atmosphere gas pile up. This is the minimum data requirement for FTO 5.

It is highly desirable that data also be taken while the CSM/DM is being pitched about the Y-axis at 0.5 degree per second with the +X-axis forward along the velocity vector, through a 90 degree arc (±45 degrees with respect to local horizontal).

Data Requirements

1) Premission Data:

   a) Telemetry Measurements:

      Measurements listed under 3 a)

   b) Calibration and Checkout Data:

      In accordance with KSC checkout procedures TBD.

2) Mission Data:

   a) Telemetry Measurements:

      Measurements listed under 3 a), as telemetered over ground station, or as recorded and played back over a ground station as soon as possible.

3) Postmission Evaluation Data:

   a) Telemetry Measurements:

Measurement Number	Description	S/S
CK 1043 X	70-mm Camera Shutter Open	100
DL 9630 T	UVA - Housing Temp	10
DL 9631 H	UVA - Startracker Tracking Error	10
DL 9632 V	UVA - PMT High Voltage	10
DL 9633 V	UVA - Regulated Voltage	10
DL 9634 T	UVA - N Lamp Temp	10
DL 9635 U	UVA - Startracker Brightness	10
DL 9636 T	UVA - O Lamp Temp	10
DL 9637 U	UVA - N Lamp Intensity	10
DL 9638 U	UVA - K Lamp Intensity	10
DL 9639 U	UVA - O Lamp Intensity	10
DL 9640 C	UVA - Converter Current #1	10
DL 9641 C	UVA - Converter Current #3	10
DL 9642 X through DL 9657 X	Bit No. 1 thru Bit No. 16	10

b) Telemetry Measurement Tapes:

Four copies of tapes containing raw telemetry measurements as listed in 3 a), recorded and correlated with GMT (within ±0.5 second with respect to the PCM time tag) during periods of experiment operation.

c) Three copies of Onboard Astronaut Voice Transcript

d) Astronaut Debriefings:

Three copies each of astronauts' postmission scientific debriefing transcript.

e) Trajectory and Special Data:

Three computer-compatible tapes containing CSM ephemeris data to a 3-sigma accuracy of 3 km, experiment sensor pointing to an accuracy of 0.8 degree, CSM attitude to an accuracy of 1 degree and time correlated to 0.5 second. VHF ranging, sun angle to an accuracy of 2 degrees and experiment line of sight to the sun must be provided.

Background and Justification

At present, the abundances of atomic oxygen and atomic nitrogen in the earth's upper atmosphere are not accurately known. The oxygen abundance is uncertain by a factor of five to ten, and the nitrogen abundance has never been measured. Mass spectroscopy has been used to measure such abundances, but this technique contains inherent sources of ambiguity, such as loss of atoms by recombination on the walls of the instrument or direct contribution of atomic ions from molecules by electron bombardment-induced "dissociative ionization." At an altitude of 225 Km, the latter effect may not be so important for oxygen because the atomic specie is much more abundant than the molecular specie. However, for nitrogen, the latter effect may present severe restrictions for mass spectroscopy because the molecular specie is much more abundant than the atomic specie at that altitude. Some experimenters feel it is possible to calibrate out these effects for mass spectroscopy, but this issue is not settled; an independent technique is required to measure the constituent abundances of the atmosphere.

One such technique is optical absorption spectroscopy. The amount of absorption of a beam of resonance line radiation from a known source over a known path length will indicate the density of the particular specie. The absorption line profile can be obtained by scanning with respect to the angle between the lamp beam and the velocity vector, thereby the temperature of the particular specie can be obtained.

The ASTP mission presents a unique opportunity to apply optical absorption spectroscopy to the investigation of neutral atomic oxygen and nitrogen abundances (as low as 2×10^6 cm^{-3}) and their temperatures in the earth's upper atmosphere. Also, abundances in the ambient atmosphere associated with the Apollo and Soyuz spacecraft can be obtained. The technique will be to send monochromatic light beams whose wavelengths correspond to neutral atomic oxygen and nitrogen resonance lines (1304 Å and 1200 Å, respectively) from the CSM to the Soyuz, where they will be retroreflected into a scanning grating Ebert-Fastie spectrometer on the CSM. The major doppler effects will be avoided by positioning the two spacecraft so the beam travels perpendicularly to the "relative wind." The line profiles are obtained by reintroducing minor doppler effects via spacecraft maneuvering. For the earth-atmosphere investigations, the effects of the out gas contaminents surrounding the spacecraft will be accounted for by varying the spacecraft separations and studying the near field resonant scattering signal. Also, a special spacecraft atmosphere investigation can be conducted with the two spacecraft oriented parallel to the "relative wind"; the effects of the earth's atmosphere will then be doppler shifted out of the wavelength range of the experiment.

From the foregoing paragraph, it is clear that this optical absorption spectroscopy experiment is particularly appropriate for the ASTP mission because of the presence of two vehicles and because of the precise attitude and positioning maneuvers made possible by manned operation of the CSM. The timing of the ASTP mission is also particularly appropriate since results from the Atmospheric Explorer satellites, which are scheduled to be flying at that time will provide complementary data. Finally, this experiment will serve to develop an important technique for application on Shuttle missions. Of all feasible techniques, optical absorption spectroscopy contains the greatest promise for high-accuracy investigations of the constituents of earth's upper atmosphere.

Previous Mission Experiments

Experiment Number	Title	Mission
S063	Ultraviolet Airglow Horizon Photography	Skylab SL-3,SL-4
S201	UV Electronographic Camera	Skylab SL-4

MA-083

EXTREME UV SURVEY

Search for extreme UV (EUV) discrete sources in the night sky.

Purpose

The purpose is to search for radiation sources of EUV in the region between 50 and 1000 Å.

The functional test objectives are:

FTO 1) Study EUV discrete sources (coronas of nearby stars, accreting matter stars) and the time variations associated with soft X-ray ($50 < \lambda < 1000$ Å) sources. Make spectral studies of discrete and extended sources with the objective of determining the emission mechanism.

FTO 2) Make random survey scans of the sky to discover additional discrete sources and/or defunct pulsars.

Test Conditions

FTO 1) The instrument will be pointed within one degree of the specified target.

FTO 1)
FTO 2) The experiment door will be closed prior to spacecraft vent operations, and will remain closed for a period of 60 minutes after any spacecraft dump. This constraint is not applicable to venting associated with Experiment MA-010 operation. In addition, the experiment door will be closed during the Experiment MA-048 purge and only for five minutes thereafter.

The experiment door will be closed any time the sun is within ten degrees of the EUV telescope field-of-view centerline.

The instrument will not be operated when the experiment door is closed and not for at least ten seconds after the door is opened.

SPS operation and RCS thrusters A2, A4, B1, and B4, will be inhibited when the experiment door is open.

Observations should be planned only when viewable with local zenith angles of less than 70 degrees.

It is highly desirable that the experiment observations be performed outside the South Atlantic Anomaly, defined for this experiment as an area bounded by longitude 10 degrees East to 60 degrees West and latitude 20 degrees South to 55 degrees South.

Test Requirements

FTO 1) An in-flight raster scan of four degrees by six degrees will be made across the target in Table 1 prior to the observation period to determine pointing errors. The raster scan will be performed using the two-degree FOV in order to determine if this mode of operation is feasible for the mission. Five or more continuous scans will be executed in pitch or yaw displaced from each other by no more than one degree in yaw or pitch. The scan rate should not exceed 0.2 degree per second to ensure seeing the star; 0.1 degree per second is desirable. The length of each of the scans should exceed five degrees; a ten-degree scan is preferable. The center of the raster scan will coincide with the target selected from Table 1.

The raster scan data will be provided to the Principal Investigator about six hours or more prior to commencing observations listed in subsequent tables. If data using the two-degree FOV are degraded, the four-degree FOV will be used for subsequent observations and the observation times shown in Tables 2 through 7 will be quadrupled. In this event, a new priority schedule will be uplinked to the crew.

Tables 2 through 7, and the targets within each table, are listed in descending order of priority. For each target in Tables 2 through 7, the target will be within the instrument field-of-view (FOV) for one-half of the viewing time. The other one-half of the viewing time will be spent with instrument line-of-sight (LOS) pointing close to the target but with the target not in the FOV. The minimum requirement is the observation of 25 targets.

If the viewing time is not greater than one minute, the instrument LOS will be pointed at the target for one-half minute. Sufficient background data will be obtained as the instrument FOV moves toward the target, and as it moves away from the target after observing it.

If the viewing time is greater than one minute, the instrument LOS will be directed to a point three degrees away from the target, and observation will be made for one-fourth of the viewing time. The LOS will then be directed at the target and the target will be observed for one-half of the viewing time. Finally, the LOS will be directed to a point three degrees away from the target on the opposite side from the first point, and observations made for the remaining one-fourth of viewing time.

FTO 2) Non-target scans are highly desirable but are not included in Tables 1 through 7.

The values of right ascension (α) and declination (δ) for each target in Tables 1 through 7 are based on the equinox and equator of 1950, and on the epoch of 1950. Corrections for proper motion are not required.

The target selected from Table 1 will be planned for night time observation. It is desirable that all other targets be planned for night time observation, except that it is highly desirable that one target listed in Table 2 be observed in daylight and that the data be used for emperical studies of sunlight observations for subsequent programs.

The instrument line of sight during experiment data collection shall provide a sun elevation angle equal to or greater than 90 degrees.

Table 1 - Initial Raster Scan

One target is to be selected from the following stars which are listed in descending order of priority.

Star	α	δ
θ Oph	$17^h18^m56^s$	-24°57'05"
ι Agl	$19^h34^m08^s$	-01°23'56"
θ^1Sgr	$19^h56^m29^s$	-35°24'48"
θ Agl	$20^h08^m43^s$	-00°58'16"
λ Agl	$19^h03^m36^s$	-04°57'33"
μ Sgr	$18^h10^m46^s$	-21°04'25"
o Agr	$22^h00^m44^s$	-02°23'51"
ε Del	$20^h30^m49^s$	11°07'56"

Table 2 - Bright Stars - Priority 1

It is highly desirable that two or three bright targets selected from Table 2 be used for repeated observations in order to determine temporal variations of a particular target, or to determine degradation in instrument sensitivity as a function of mission time. The number of targets for repeated observations and the priority of these repeated observations are TBD.

Star	α	δ	Viewing Time (Minutes)
NGC 7293	22^h27^m	-21°6'	1
NGC 6853	19^h57^m	22°35'	1

O Cen	14^h04^m	-36°07'	1
α Oph	17^h33^m	12°36'	1
ε Sco	16^h47^m	-34°12'	2
α Cen	14^h36^m	-60°38'	1
R548	01^h34^m	-11°36'	2
Hz29	12^h32^m	37°55'	3
i Boo	15^h02^m	47°51'	1
VW Cep	20^h38^m	75°25'	1
β Per	03^h05^m	40°46'	7
ζ Pup	08^h02^m	-39°51'	5
γ Vel	08^h08^m	-47°11'	5
α Boo	14^h13^m	19°28'	1
α CMa	06^h43^m	-16°38'	1

Table 3 - Planetary Nebulae - Priority 2

Star	α	δ	Viewing Time (Minutes)
A35	12^h50^m	-22°36'	15
NGC 246	00^h44^m	-12°09'	15

Table 4 - Red Giant Priority 3

Star	α	δ	Viewing Time (Minutes)
η Boo	$13^h52^m18^s$	18°38.9'	4
α Ser	$15^h41^m48^s$	6°34.9'	4
β Tra	$15^h50^m43^s$	-63°16.7'	6
η Dra	$16^h23^m18^s$	61°37.6'	6
ζ Her	$16^h39^m24^s$	31°41.5'	6
λ Sgr	$18^h24^m53^s$	-25°27.1'	6
γ Cep	$23^h37^m17^s$	77°21.2'	10
η Sco	$17^h8^m34^s$	-43°10.5'	10
σ Lib	$15^h01^m08^s$	-25°5.2'	12
μ Her	$17^h44^m30^s$	27°44.9'	12

η Ser	$18^h18^m43^s$	-2°54.8'	15
δ Aql	$19^h22^m59^s$	3°0.8'	15
η Her	$16^h41^m11^s$	39°1.0'	22
β Aql	$19^h52^m51^s$	6°16.8'	25
ν Oct	$21^h36^m0^s$	-77°36.8'	25
γ Aps	$16^h25^m43^s$	-78°47.3'	25
τ Cyg	$21^h12^m48^s$	37°49.9'	25

Table 5 - Subgiants and Dwarfs - Priority 4

Star	α	δ	Viewing Time (Minutes)
α Aql	19^h48^m	8°44'	1
α Cep	21^h17^m	62°22'	15
β Cas	00^h06^m	58°52'	15
α PsA	22^h55^m	-29°53'	15

Table 6 - Pulsating White Dwarfs - Priority 5

Star	α	δ	Viewing Time (Minutes)
Hl-Tav-76	$4^h15.9^m$	27°11.2'	8
DQ Her	$18^h06.1^m$	45°51'	12
UxUMa	$13^h34.7^m$	52°10.1'	12
AH Her	$16^h42.1^m$	25°20.5'	12
G61-29	$13^h03.8^m$	18°17'	12
CoD-42°	$19^h44.2^m$	-42°7.6'	12

Table 7 - Contact Binaries - Priority 6

Star	α	δ	Viewing Time (Minutes)
YY Eri	4^h10^m	-10°36'	15

Data Requirements

1) Premission Data:

a) Telemetry Data:

Measurements listed under 3 a).

b) Calibration and Checkout Data:

In accordance with KSC checkout procedures TBD.

2) Mission Data:

a) Telemetry Data:

Measurements listed under 3 a), as telemetered over ground station or as recorded and played back over ground station as soon as possible.

3) Postmission Evaluation Data:

a) Telemetry Measurements:

Measurement Number	Description	S/S
SL 9606 V	EUV Telescope - DAC Register	10
SL 9607 C	EUV Telescope - System Current	10
SL 9608 K	EUV Telescope - No. 1 Detector	10
SL 9609 K	EUV Telescope - No. 2 Detector	10
SL 9782 X	EUV Telescope - Door Position 1	10*
SL 9783 X	EUV Telescope - Door Position 2	10*

*Also available at 1 s/s on LBR. Either HBR or LBR data are acceptable.

b) Telemetry Measurement Tapes:

One copy of tapes containing raw telemetry measurements as listed in 3 a), recorded and correlated with GMT (within ±0.5 second with respect to the PCM time tag) during periods of experiment operation.

c) Onboard Astronaut Voice Transcript:

d) Astronaut Debriefings:

One copy each of astronauts' postmission scientific and photographic debriefing transcript.

e) Trajectory and Special Data:

A computer-compatible tape containing CSM ephermis data to a 3 sigma accuracy of 3 km, experiment sensor pointing to an accuracy of 0.75 degree, CSM attitude to an accuracy of 0.25 degree and time correlated to 0.5 second. Zenith angle and sun angle to an accuracy of 2 degrees must be provided. In addition, the field of view is desirable.

Background and Justification

Spaceborne instrumentation has made possible astronomical observations previously prevented by the fact that the earth's atmosphere is opaque to portions of the electromagnetic spectrum. Many celestial X-ray sources have been discovered, and much progress has been made toward a theoretical understanding of their behavior. Furthermore, the technology of observing in these high-energy portions of the spectrum has become well-developed and reliable. Yet one important portion of the high-energy spectrum has been neglected by astronomers - the extreme ultraviolet between roughly 50 and 500 Angstroms.

An early interpretation of the complex nature of the interstellar gas led to the false conclusion that absorption by neutral hydrogen would prevent extreme ultraviolet light from traveling sufficiently far through interstellar space to be of much use to astronomy. More recent data indicate that the interstellar gas is sufficiently inhomogeneous to permit extreme ultraviolet observations of sources up to several hundred parsecs away, in at least some directions -- and within such distances there are several million stars.

Thus, there exists an outstanding opportunity to use the well-developed technology of X-ray and optical astronomy for a ground-breaking survey of a wholly new field. There are many kinds of objects whose calculated and observed behavior suggest they might be extreme ultraviolet sources. These objects include certain bright stars, planetary nebulae, red giants, subgiants, dwarfs, pulsating white dwarfs, and contact binaries. There has been no previous systematic survey of any of these objects in the extreme ultraviolet. Experiment MA-083 will perform such a survey.

The Apollo-Soyuz mission provides a good opportunity to perform such a survey, for two reasons. First, the apparatus required for extreme ultraviolet survey observations is within the state-of-the-art and does not require the long development time characteristic of many satellite programs. This experiment was thus well-suited to the short time between the decision to fly on ASTP and the mission itself, and it is well-suited to the goal of

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getting high scientific return in a pioneering field at an early date. Second, the maneuvering and attitude-holding capabilities of the CSM are appropriate for an instrument which must be pointed steadily at specific targets.

Previous Mission Experiments

None

MA-088 HELIUM GLOW

Search for helium line radiations.

Purpose

The purpose is to measure the intensity and spatial distribution of the interplanetary helium and in-flow velocity of the interstellar medium within the solar system.

The functional test objectives are as follows:

FTO 1) Measure helium line radiations (λ304 Å and λ584 Å) over as much of the sky as possible.

FTO 2) Inspect those regions where the helium spectral lines are predicted to be strongest.

FTO 3) Obtain information about the shape of the spectral lines and the motion of their sources by means of the Doppler shift caused by the spacecraft's orbital velocity.

Test Conditions

FTO 1) The instrument pointing vector must be known within $\pm$2 degrees.
FTO 2)
FTO 3) SPS operation and RCS thrusters A2, A4, B1, and B4 pointing towards the SM Section 1 will be inhibited whenever the experiment door is open.

The experiment door will be closed prior to spacecraft venting operations, and will remain closed for a period of 60 minutes after any spacecraft dump. This constraint is not applicable to venting associated with Experiment MA-010 operation. In addition, the experiment door will be closed during the Experiment MA-048 purge and for 5 minutes thereafter.

The instrument will not be operated when the experiment door is closed or for a period of at least 10 seconds after the door is opened.

Due to thermal reasons, the instrument will be activated no later than TBD seconds after door is opened.

The quick roll minimum data for FTO 2) will be taken outside the South Atlantic Anomaly, defined for this experiment as the area bounded by longitude 10 degrees East to 60 degrees West and latitude 20 degrees South to 55 degrees South. It is desirable that all the data be taken outside the South Atlantic Anomaly.

Observations will be made only with local zenith angles of 80 degrees or less. It is desirable that observations be made with local zenith angles of 70 degrees or less.

Test Requirements

FTO 1) In the random drift mode, the instrument will be turned ON at times when the operational constraints are met, but with no requirement for the instrument line of sight to be in a specific direction.

The minimum data consist of two hours of random drift mode operation during the entire flight.

It is highly desirable that the instrument operate in the random drift mode at all other times during the flight when the instrument is not being operated in the quick roll mode, and when the operational constraints are met.

It is possible that the residual atmosphere will damage the filter by the process of erosion. Therefore, in order to insure that the best possible data are obtained, the instrument will not be operated in the random drift mode until after the minimum requirements for quick roll data (as in FTO 2) have been satisfied. In addition, it is preferred that the highly desirable quick roll data (as in FTO 2) be obtained prior to obtaining any of the above highly desirable random drift mode data.

FTO 2)
FTO 3) In the quick roll mode, the instrument will be operated while the instrument's field of view is scanned along a specified great circular arc of the celestial sphere.

It is highly desirable that the scan rate be 2.0 degrees per second or less.

It is highly desirable that the instrument always point within two degrees of the moving spot on the scan path which defines its theoretically exact pointing direction.

The quick roll maneuvers will be accomplished by rolling the spacecraft 360 degrees about its X-axis with the X-axis being located in nine different positions in the plane normal to the earth-sun line. These nine positions are as follows:

a) The most important position of the X-axis is the one perpendicular to the ecliptic. While rolling about the X-axis in this position, the instrument will thus scan in the ecliptic.

b) The second most important position of the X-axis is the one which is rotated 80 degrees clockwise from position a) described above, as viewed from the earth looking toward the sun.

c) The third and fourth most important positions of the X-axis, in either order, are the two positions which are rotated 20 degrees clockwise and 160 degrees clockwise from position a) described above, as viewed from the earth looking toward the sun.

d) The remaining five positions of the X-axis are of equal importance. These are the five positions which are rotated 40 degrees, 60 degrees, 100 degrees, 120 degrees and 140 degrees clockwise from position a) described above, as viewed from the earth looking toward the sun.

The minimum data set is defined as one complete sky survey mode with no redundant information, as represented by a great circle scan about each of the nine axes perpendicular to the earth-sun line as defined above.

The data provided by these scans will be used to obtain information relative to the shape of the spectral lines and the motion of their sources by means of the Doppler shift caused by the spacecraft's orbital velocity.

It is highly desirable that two additional data sets be acquired.

FTO 1) It is highly desirable that a detailed scan of one region of the sky, which is most important in that is contains maximum 584 Å intensity, be made. This region is a spherical rectangle, 70° by 90° in extent, bounded by great circular arcs drawn between the following four points (given in ecliptic coordinates, longitude first, then latitude): (30°, 30°), (30°, -40°), (120°, 30°), (120°, -40°).

Desired coverage of this spherical rectangle consist of scanning the region at a rate not exceeding 2 degrees per second (0.5 degree per second preferred). The scans should proceed along approximately parallel tracks spaced not more than 20 degrees apart (10 degrees apart preferred). Orientation of these scans is immaterial.

The spherical rectangle coverage is to be in addition to coverage provided by the all-sky survey which is already part of the HGD observing program.

A repeat of the spherical rectangle coverage, using scan tracks perpendicular to those used in the first coverage, would be useful.

FTO 1) It is highly desirable that an extended survey of a 30° by 60° patch of the earth's shadow (antisolar) region for 304 Å data be made. This is the most important region for interstellar ionized helium, since skyglow obliterates most of the 304 Å emission in other regions.

The antisolar observations should be made at a roll rate not exceeding 2 degrees per second (0.5 degrees per second preferred). Maximum separation between scan tracks should be 10° (5° preferred). Other details of scan tracks are irrelevant.

Data Requirements

1) Premission Data:

a) Telemetry Measurements:

Measurements listed under 3 a)

b) Calibration and Checkout Data

In accordance with KSC checkout procedures TBD.

2) Mission Data:

a) Telemetry Measurements:

Measurements listed under 3 a) as telemetered over ground stations, or as recorded and played back over ground station as soon as possible.

3) Postmission Evaluation Data:

a) Telemetry Measurements:

Measurement Number	Description	S/S
SL 9610 P	He Glow Detector Tank Pressure	10
SL 9611 T	He Glow Detector Temp	10
SL 9612 P	He Glow Detector No. 1 Pressure	10
SL 9613 C	He Glow Detector System Current	10
SL 9614 P	He Glow Detector No. 2 Pressure	10
SL 9615 K	He Glow Detector No. 1 Rate	10
SL 9616 K	He Glow Detector No. 2 Rate	10
SL 9617 K	He Glow Detector No. 3 Rate	10
SL 9618 K	He Glow Detector No. 4 Rate	10
SL 9784 X	He Glow Detector Door Position 1	10*
SL 9785 X	He Glow Detector Door Position 2	10*

*Also available at 1 s/s on LBR. Either HBR or LBR data are acceptable.

b) Telemetry Measurements Tapes:

One copy of tapes containing raw telemetry measurements as listed in 3 a), recorded and correlated with GMT (within ± 0.5 second with respect to the PCM time tag) during periods of experiment operation.

c) Onboard Astronaut Voice Transcript:

None

d) Astronaut Debriefings:

One copy each of the astronauts' postmission scientific and photographic debriefing transcript.

e) Trajectory and Special Data:

A computer compatible tape containing CSM ephemeris data to a 3 sigma accuracy of 3 km, experiment sensor pointing to an accuracy of 1.27 degrees, CSM attitude to an accuracy of 0.25 degree and time correlated to 0.5 second. Zenith angle and sun angle to an accuracy of 2 degrees must be provided.

MA-088 HELIUM GLOW

Background and Justification

The interstellar gas is the medium from which celestial objects form and into which many of them dissipate their constituent elements when their lives are ended. It is also the medium through which the radiations, whereby we study these objects, must travel. Clearly, then, a detailed knowledge of the structure and properties of the interstellar gas is of vital importance to astronomers. Yet because the gas is extremely tenuous, and because it is sometimes difficult to distinguish radiations emitted by the gas from radiations emitted by other celestial objects, it is difficult to determine even such basic parameters as gas temperature and density with any certainty.

Radiation which is emitted by the sun in wavelengths which do not readily penetrate the interstellar medium may be used to investigate the composition of the interstellar medium. Thus the interstellar gas near the sun may be studied by the radiation it reflects back toward the observer. Since the gas is not very transparent to the radiation, one is less often confused by similar radiation from more distant celestial objects. The situation is similar to looking at dense fog by the light scattered back from a car's headlights.

The helium glow detector of MA-088 will perform such an experiment, using ultraviolet light at wavelengths of 584 and 304 Angstroms. A resonant frequency of neutral helium is 584 Angstroms. A resonant frequency of singly-ionized helium is 304 Angstroms. Ultraviolet light produced by the sun will be scattered by these two states of helium wherever they are present.

The interstellar medium is not the only source of helium in the vicinity of the solar system. The solar wind contains helium, as does the very tenuous outer atmosphere of the earth. To derive the most data from the observations, means must be provided for distinguishing among these three sources of scattered radiation.

In the case of the 584 Angstrom radiation, a complete solution is available. The helium in the earth's outer atmosphere is known to be sufficiently cool, and will be moving at a sufficiently low speed relative to the orbiting spacecraft, that a "gas filter", a container of neutral helium placed

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in front of the 584 Angstrom detector will absorb all of the 584 Angstrom radiation scattered by the atmospheric helium, by resonant absorption. But there will be sufficient relative velocity between the spacecraft and the solar wind or interstellar helium that scattered radiation from these latter sources will be sufficiently doppler shifted to avoid absorption by the gas filter. Furthermore, the distribution of scattered radiation around the celestial sphere is calculated to be substantially different for scattering by the solar wind than for scattering by the interstellar gas. Thus a series of observations of different parts of the sky will allow the relative strength of these two sources to be determined.

At 304 Angstroms the situation is less simple, for there is no way to make a gas filter using ionized helium. Hence there is no way to avoid seeing 304 Angstrom radiation scattered by the earth's atmospheric helium (except perhaps by looking straight down the earth's shadow, directly away from the sun). Nonetheless, 304 Angstrom data correlated with 584 Angstrom data will provide valuable additional information.

The ASTP provides an excellent opportunity for this experiment, for several reasons. First, the spacecraft's maneuvering and pointing capabilities allow the experiment to collect a large amount of data, from widely separated parts of the sky, in a short time. Such rapid data collection is important both because the changing position of the earth in its orbit changes the observed pattern of scattered radiation and thereby complicates data reduction, and because the experiment requires a consumable, i.e., helium, for gas filters.

Second, the doppler shift provided by the spacecraft's motion in orbit slightly varies the position in the spectrum of the gas filter's absorption, and allows information to be gathered which could not be obtained with a sounding rocket.

Third, inasmuch as MA-088 uses state-of-the-art technology, the ASTP launch opportunity allows a quick return of scientific data which could not be realized if the experiment were in the more common situation of waiting for a spacecraft paced by long-development items.

Previous Mission Experiments

None

MA-089 DOPPLER TRACKING

Detect and record relative accelerations between co-orbiting spacecraft.

Purpose

The primary purpose is to map earth gravity field anomalies of magnitude 10^{-5} g and larger. The secondary purpose is to investigate the feasibility of constructing vertical ionospheric profiles by inversion of spacecraft-to-spacecraft two-frequency radio refractivity data.

The functional test objective is:

FTO 1) Collect CSM-to-DM doppler data in earth orbit.

Test Conditions

FTO 1) The MA-089 transmitter and receiver will be turned to WARMUP at least 50 hours prior to DM jettison. The receiver will be turned to OPERATE within four to five hours prior to DM jettison. The transmitter will be turned to OPERATE at least one hour prior to DM jettison and as close as feasible to that time. It is highly desirable that the transmitter and receiver remain in the OPERATE mode throughout the entire MA-089 data collection period.

The DM Tunnel 1, between the CSM and DM, must be vented to 0 psi prior to DM jettison.

The DM will be jettisoned such that it will rotate about an axis parallel to the longitudinal axis of the MA-089 transmitter antenna and perpendicular to the orbital plane. The coning angle about the axis of rotation shall be no more than 10 degrees. The DM rotation rate will be 5 degrees per second.

Within three orbits after DM jettison, the CSM will complete the maneuvers necessary to place it 500 ±150 km behind and in the same orbit as the CM.

MA-089 frame count information will be transmitted from the CSM once every 730 seconds for approximately 6 seconds as telemetry measurement SL 9659 X. This MA-089 frame count information must be recorded by the STDN in real time high bit rate at least once after the MA-089 transmitter and receiver are turned to OPERATE. If the receiver is turned OFF and then back to OPERATE, measurement SL 9659 X must again be recorded by STDN.

Non-gravitational contribution to the experiment data must be minimized. All activities that impart translation to the spacecraft will be inhibited during the experiment to include dumps, venting operations, SPS burns and uncoupled RCS thruster firings. It is highly desirable that the doppler data be collected during crew rest periods in order to minimize the effects of any crew motion.

In order to avoid ground reflections during the data collection period, the CSM doppler antenna axis will be pointed 25 degrees vertically above the CSM-to-DM line of sight with the CSM in an attitude hold deadband of 5 degrees. [Note: These requirements assume that the antenna will have a circularly symmetric pattern with a 60-degree half-power beam width. Therefore, the pointing requirements will change if the measured antenna pattern is different than the assumed pattern.]

The FDAI rate scale will be in the one degree per second full scale position during data collection periods.

Test Requirements

FTO 1) After the DM is jettisoned, but preceding the separation maneuver, the CSM rate of roll, pitch and yaw will be damped as much as practical to permit the DM rate of rotation to be determined from motion picture photography data. A bracket-mounted DAC will photograph the DM through the right hand rendezvous window for a minimum of two complete DM rotations. The DAC will be operated at two frames per second, using an 18-mm lens and color exterior film.

During a minimum of six orbits, doppler data will be recorded on the MA-089 recorder at a nominal separation of 500 km. Doppler data are highly desirable from the time of initial CSM/DM separation until the nominal separation of 500 km is achieved. Doppler data are also highly desirable for as many additional orbits at a separation of 500 km as the transmitter battery will allow. [Note: The transmitter battery life is expected to be approximately 24 hours after the transmitter is turned to OPERATE.]

Data Requirements

1) Premission Data:

a) Telemetry Measurements:

Measurement Number	Description	S/S
SL 9658 X	Doppler Tracking-Receiver Lock	10
SL 9659 X	Doppler Tracking-Frame Count	10

b) Calibration and Checkout Data:

In accordance with KSC procedures TBD.

2) Mission Data:

a) Telemetry Measurement:

Measurement Number	Description	S/S
SL 9658 X	Doppler Tracking-Receiver Lock	10

b) CSM state vector updates will be teletyped to SAO, Cambridge approximately twice per day beginning 4 days prior to MA-089 experiment operation and ending with the last update generated on the final day of the mission. State vector updates will also be teletyped to SAO, Cambridge after each maneuver appreciably changing the CSM ephemeris during this time period.

3) Postmission Data:

a) Telemetry Measurements:

The following measurements, except for CG 0001 V and CK 1040 X, are required only for those periods when ATS-6 and/or STDN coverage are available to record high bit rate telemetry data, and do not require recording on the data recorder reproducer (DRR). It is highly desirable that measurement CG 0001 V also be recorded on the DRR at low bit rate whenever ATS-6 and/or STDN coverage is not available, and that the CG 0001 V data be dumped to STDN to provide spacecraft attitude data. Measurement CK 1040 X is required for the period of photographing the two rotations of the DM, as described under Test Conditions.

Measurement Number	Description	S/S
CG 0001 V	Computer Digital Data 40 Bits	50
CH 3503 R	FDAI SCS Body Rate Pitch	100
CH 3504 R	FDAI SCS Body Rate Yaw	100
CH 3505 R	FDAI SCS Body Rate Roll	100
CH 3546 X	RCS Solenoid Activate C3/13/+X	200
CH 3547 X	RCS Solenoid Activate A4/14/+X	200
CH 3548 X	RCS Solenoid Activate A3/23/-X	200
CH 3549 X	RCS Solenoid Activate C4/24/-X	200
CH 3550 X	RCS Solenoid Activate B3/25/+X	200

Measurement Number	Description	S/S
CH 3551 X	RCS Solenoid Activate B4/26/+X	200
CH 3552 X	RCS Solenoid Activate B3/15/-X	200
CH 3553 X	RCS Solenoid Activate D4/16/-X	200
CH 3554 X	RCS Solenoid Activate E1/11/+Z	200
CH 3555 X	RCS Solenoid Activate D2/22/+Z	200
CH 3556 X	RCS Solenoid Activate D1/21/-Z	200
CH 3557 X	RCS Solenoid Activate B2/12/-Z	200
CH 3558 X	RCS Solenoid Activate A1/+Y	200
CH 3559 X	RCS Solenoid Activate C2/+Y	200
CH 3560 X	RCS Solenoid Activate C1/-Y	200
CH 3561 X	RCS Solenoid Activate A2/-Y	200
CK 1040 X	16 mm Data Acq Camera Shutter Open	100
SL 9658 X	Doppler Tracking Receiver Lock	10
SL 9659 X	Doppler Tracking Frame Count	10

b) Telemetry Measurement Tapes:

One copy of tapes containing telemetry measurements as listed in 3 a), recorded and correlated with GMT during periods of experiment operation, except that the CG 0001 V data will be in the form of decoded CMC words on a computer compatible tape. The data for measurements SL 9658 X and SL 9659 X will be raw data.

c) Onboard Astronaut Voice Transcript for the period from MA-089 receiver turned to OPERATE until the receiver is turned to OFF for the final time.

d) Astronaut Debriefings:

One copy of astronauts' postmission scientific and photographic debriefing transcript.

e) Trajectory and Special Data:

(1) A computer-compatible tape containing CSM ephemeris data to a 3-sigma accuracy of 3 km.

(2) A computer-compatible tape containing refined CSM ephemeris data to a 3-sigma accuracy of 600 m and attitude data to an accuracy TBD time correlated to <50 msec. Camera timing pulses, RCS firing history, SL 9658 X, SL 9659 X, and Kepler orbit elements at 1/min will be provided. [Note: Smithsonian to derive CSM rate and acceleration data.]

(3) Time-correlated DM position and attitude data (to be obtained by the PI from the TRANET satellite tracking system and the SAO Baker-Nunn network).

f) Tape recordings from the Experiment MA-089 recorder unit.

g) Approximately 15 feet of DAC photographs of the DM to include a minimum of approximately two CM rotations.

Background and Justification

In recent years great interest has focused on consideration of mass density anomalies in the earth's asthenosphere with scale sizes of 100 to 700 km. Study of such anomalies is expected to contribute greatly to the knowledge of the physics of the mantle and of plate tectonics, which in turn is expected to be helpful in reconstructing important aspects of earth's evolution such as continental drift. The earth's mass distribution cannot be uniquely determined from studies of its gravitational field, but such studies are very useful in providing constraints to the distributions which are incorporated into global models.

The detailed structure of the earth near the surface has been studied for many years by surface gravimetry investigations of gravitational anomalies. However, surface gravimetry techniques are adequate only for studies of anomalies of scale size up to tens of kilometers, due to practical limitations of deploying uniformly calibrated and uniformly operated instrumentation over large regions in short periods of time. Large scale anomalies with sizes greater than approximately 3000 km have been investigated during the past two decades by studies of gravitationally induced perturbations of the orbits of artificial satellites. This technique is applicable only to the larger scale anomalies primarily because the perturbations must be extracted from data integrated over sizeable portions of the orbits. Thus, a new technique is required to measure gravitational anomalies in the range of interest, 100 to 700 km.

An experimental technique which is expected to be sensitive to gravitational anomalies with scale sizes of 100 to 1000 km is doppler measurement of the gravitationally induced small accelerations between two suitably separated artificial satellites traveling in the same or nearly same orbits. The current state of technology for VHF oscillator frequency stability is approximately one part in 10^{12} for a time period of 100 seconds, which is sufficient for range-rate determinations of relative speeds between vehicles to within 1/2 mm per second. Gravity anomalies will perturb satellite motions to at least that extent if the satellite orbital altitude is not greater than the scale size of the anomaly. Doppler measurements between

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two vehicles can thus be used to measure anomalies larger than the orbital altitude, provided also that the vehicle separation is comparable to the largest anomaly to be measured.

The ASTP mission provides a unique opportunity to demonstrate the feasibility of global mapping of earth's gravity anomalies larger than 200 km. A suitably stable VHF receiver will be located in the CSM and an appropriate transmitter mounted on the DM. Nine hours of continuous operation will be sufficient to demonstrate feasibility of the technique for application to subsequent satellites, and 24 hours of continuous operation would provide sufficient mapping to incorporate the results into global models.

Ionospheric refraction to the VHF transmission is expected to be significant. The refraction effects can be measured by employing two-frequency transmission, and their investigation will provide bottomside ionosphere mapping on a global scale.

Previous Mission Experiments

None

MA-106 LIGHT FLASH

Obtain data on the visual light flash phenomenon.

Purpose

The purpose is to observe quantitatively the character and frequency of visible phenomena caused by the passage of ionizing particles through the visual apparatus of human observers in earth orbit.

The functional test objective is:

FTO 1) Measure the flux of ionizing particles that have energy losses greater than 15 Mev $gm^{-1}cm^{2}$ and determine the frequency and character of visual events perceived by two observers.

Test Conditions

FTO 1) Flux measurements will be made during two orbits: one while the astronauts are observing for light flashes, and one without astronaut participation but with the equipment deployed in approximately the same locations as during the astronaut participation period.

During the manned portion of the experiment, two astronauts will don the light-tight masks for a period of approximately 110 minutes. The first period of approximately 20 minutes will be for dark-adaptation measurements. The remaining period of approximately 90 minutes will be for light flash observations. The third astronaut will operate the MA-106 equipment and record verbal comments from the two astronauts wearing the masks.

During the manned portion of the experiment, it is highly desirable that the spacecraft internal lighting be reduced to the minimum level required by the third astronaut.

The manned portion of the experiment may occur either before or after the unmanned portion.

There is no requirement for the manned and unmanned data-taking periods to occur on successive orbits.

The ground track will include passage through the South Atlantic Anomaly (SAA) for at least five minutes once during each of the two 90-minute periods. The five-minute time periods within the SAA must occur within the area from 15 degrees South latitude to 45 degrees South latitude and from 50 degrees West longitude to 15 degrees West longitude.

The manned portion of the experiment will be conducted with the two observing astronauts in the outside couches. Their heads will be in the normal position such that their eyes are pointed in the general direction of the +X axis. During the entire 90-minute manned period of data recording, the angle between the astronauts' line of sight and the zenith will remain constant within 5 degrees. In addition, when in the SAA, the line of sight of the participating astronauts will be approximately parallel to the magnetic lines of force and in a direction away from the earth. To implement the attitude requirement for the period while in the SAA, the CSM will be in a retrograde position with the -Z axis 60 degrees from the zenith, the +X axis 30 degrees from the zenith, and the XZ plane rotated 35 degrees from the orbital plane such that the +X axis is rotated toward the North.

The spacecraft attitude during the entire 90-minute unmanned portion of the experiment has the same minimum requirement as the manned portion of the experiment while outside of the SAA.

CSM attitude control will not be required during the 20-minute dark adaptation period.

Passages through the SAA for both the manned and unmanned portions of this experiment will be descending passes (i.e., from northwest to southeast) in order to provide data at the maximum available geomagnetic latitude as well as SAA data.

Test Requirements

FTO 1) Data will be recorded on the MA-106 tape recorder for one continuous orbit without the light-tight masks being worn by two astronauts.

Data will be recorded on the MA-106 tape recorder for a continuous period of approximately 110 minutes with the light-tight masks being worn by two astronauts. Verbal comments from these same two astronauts will be recorded in a log book by the third astronaut during this 110-minute period.

Data Requirements

1) Premission Data:

None

2) Mission Data:

None

3) Postmission Evaluation Data:

a) Telemetry Measurements:

Measurement Number	Description	S/S
CJ 0060 J*	Astro 1 EKG AX 1 LH Couch	200
CJ 0061 J*	Astro 2 EKG AX 1 Ctr Couch	200
CJ 0062 J*	Astro 3 EKG AX 1 RH Couch	200
CJ 0200 R*	Astro 1 Resp Rate LH Couch	50
CJ 0201 R*	Astro 2 Resp Rate Ctr Couch	50
CJ 0202 R*	Astro 3 Resp Rate RH Couch	50

*Measurements are required only for the two participating astronauts on a highly desirable basis only. Thus if the two participating astronauts use the center and right hand couches, then measurements CJ 0060 J and CJ 0200 R are not required. Data are to be provided on a strip chart at a chart speed of TBD.

b) Telemetry Measurement Tapes:

None

c) Onboard Astronaut Voice Transcript:

None

d) Astronaut Debriefings:

One copy of the astron[illegible]stmission scientific debriefing transcript.

e) Trajectory:

One tab listing of spacecra[illegible]ris and attitude data only when ground station co[illegible]ge is available for the two 90-minute test periods.

f) One copy of the MA-106 onboard tape recorder data.

g) One copy of the log book containing the time of experiment initiation and the characteristics and time of occurrence of the observed flashes for the 110-minute manned portion of the experiment.

h) The two light-tight masks

i) The detector packages

MA-106 LIGHT FLASH

Background and Justification

In addition to providing fundamental data in the study of sensory phenomena, this experiment should furnish practical information concerning the possible hazard of ionizing particles on long term space flight.

It was originally thought that the radiation dose from interaction of cosmic particles with space travelers was of little significance because the integrated dose over the whole body from protons to very heavy particles is only a fraction of a rad for anticipated space expeditions. Recent studies, however, indicate that the energy deposited from a single particle passing through or near a cell nucleus might be sufficient to kill the cell, particularly if the linear energy transfer is greater than 1000 Mev gm^{-1} cm^2.

The importance of these studies was emphasized by the light flash phenomena observed during the Apollo 11 and subsequent lunar missions and during the Skylab missions. The discrete star-like flashes and streaks, occurring as often as two per minute when the astronauts were in darkness, are most likely due to ionizing particles from galactic cosmic rays interacting with the human retina. Experiments using the cyclotron and Bevatron at the University of California at Berkeley have produced phenomena in human subjects which are similar in all respects to those reported by the astronauts.

That ionizing particles offer a potential hazard for long-term space flight is emphasized by the realization that on a three-year mission, it is estimated that between two per cent and ten per cent of the body will be struck by atomic nuclei of carbon, nitrogen, oxygen, and heavier elements. During one day, 160 iron nuclei transverse each square centimeter [illegible] body. These particles are present also during portions of eart[illegible]

This experiment is designed to determine the frequency of [illegible] that have sufficient energy to elicit a light flash perception (>[illegible] ev gm^{-1} cm^2). The mechanism employed is to use light-tight masks which contain detectors to measure ionizi[illegible] particulate radiation, and light sources to check observers efficiency.

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The character and efficiency of perception of these particles at zero gravity, and the variation of frequency of occurrence with earth's magnetic shielding, will be observed. Also to be closely monitored are the frequency and character of flashes during passage through the South Atlantic Anomaly. These quantitative observations will add to the knowledge necessary to determine radiation protection on long-term orbital and interplanetary missions. Because of accelerator limitations, ground-based experiments have not included tests with some of the high atomic number particles at velocities that are expected to be encountered by the astronauts.

Previous Mission Objectives

Special Test Objective Number	Title	Mission
20.31	Visual Light Flash Phenomenon	Skylab SL-4
Operational Test Objective Number		
4.2	Visual Light Flash Phenomenon	Apollo 17
4.2	Visual Light Flash Phenomenon	Apollo 16
4.12	Visual Light Flash Phenomenon	Apollo 15

MA-107 BIOSTACK

Investigate the biological effects of cosmic radiation on selected materials.

Purpose

The purpose is to investigate the biological effects of individual heavy ions (multicharged) of cosmic radiation on selected biological materials.

The functional test objective is:

FTO 1) Energize the light-activated radiation detectors for a period of approximately 48 hours.

Test Conditions

FTO 1) The Biostack containers will be stowed in an area of the CM where there is minimal shielding to ambient cosmic radiation. They will be maintained in the same location and orientation during flight.

The AgCl radiation detectors will be energized only while the CSM is docked with the DM; however, the AgCl radiation detectors will not be energized while the CSM/DM is docked with the Soyuz.

Test Requirements

FTO 1) The lights which energize the AgCl radiation detectors in the active unit will be energized for a period of approximately 48 hours. A minimum of 12 hours of the total of 48 hours will occur prior to CSM/DM docking with the Soyuz.

The crew will record or transmit by voice the following items:

- Time (GET) of switching the detectors ON and OFF.
- Status of the indicator light (i.e., ON or OFF) at time of turning the detectors ON and OFF and also at approximately 40 and 44 hours of experiment operating time.

Data Requirements

1) Premission Data:

None

2) Mission Data:

None

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3) Postmission Evaluation Data:

a) Telemetry Measurements:

Two copies of the following measurements are required in the thrift format (microfiche). At least one sample of temperature data are required for every one hour of experiment operation:

Measurement Number	Description	S/S
CF 0002 T	Temp Cabin	1

b) Telemetry Measurement Tapes:

None

c) Astronaut log or voice record of experiment ON and OFF time and indicator light status as defined in the Test Requirements.

d) Astronaut Debriefing:

One copy of astronauts' postmission medical debriefing.

e) Biostack Containers

f) Trajectory and Special Data:

A computer-compatible tape containing CSM ephemeris data, in B&L coordinates, to a 3 sigma accuracy of 3 km, and time correlated CSM attitude data.

MA-107 BIOSTACK

Background and Justification

The flux of very heavy particles and high energy heavy particles in space is very small. Nevertheless, during long duration space missions the total number of these particles can become very large. The response of a biological system to an incident particle depends on the function the hit (damaged) region has for the integrity of the biological system. A single event can produce tremendous damage if it occurs in an essential part of this system. A Skylab special test objective indicated that heavy ions occur at greater flux densities than had been previously determined.

Currently in manned space flight, the physical data of incident heavy particles are determined by using physical ion detectors. The simultaneous determination of the biological effect produced becomes a useful supplement.

The Biostack experiment will provide data on the biological effects of individual heavy nuclei of cosmic radiation during space flight. These effects will be determined by flying biological materials interleaved with dosimeters in one unit (passive). In addition, a second unit (which is active) containing silver chloride dosimeter material, yellow light sources, and some biological material will be flown in the same location in the CM. The light sources will be activated by the crew for a specified time to energize the silver chloride dosimeters. The test materials will be evaluated for response changes and compared to the tracks of heavy nuclei particles as detected by the dosimeters. Additional information concerning the biological effects of specific radiation sources will also be obtained.

The results of this experiment will contribute to the solution of several problems in basic research, namely:

- The biological effects produced by individual high energy heavy ions and very heavy ions, which are not obtainable from sources on earth.
- The combined and relative influence of heavy ions and background radiation by evaluating hit and unhit regions of the Biostack.

- The validity of the existing theories of microdosimetry by relating the local doses due to the different individual heavy ions to the biological lesion.
- The combined influence of heavy ions and space flight factors, especially weightlessness, by comparing the results of a space flight experiment with those of balloon-borne experiments and of experiments using accelerators.

The results of this experiment will also contribute to the information available for estimating the hazards for man during long-duration space missions during high altitude commercial aircraft travel.

Previous Mission Objectives and Experiments

Special Test Objective Number	Title	Mission
20.31	Visual Light Flash Phenomenon	Skylab SL-4
Passive Experiment Number		
M-211	Biostack II-A	Apollo 17
M-211	Biostack	Apollo 16

MA-128

GEODYNAMICS

Detect and record relative accelerations between a low altitude and a high altitude spacecraft.

Purpose

The purpose is to demonstrate the feasibility of recovering high frequency components of the geopotential by use of a synchronous relay satellite tracking a low altitude spacecraft.

The functional test objective is:

FTO 1) Collect CSM-to-ATS-6 doppler data.

Test Conditions

FTO 1) Non-gravitational contributions to the data must be minimized. All dumps and venting operations will be inhibited during the experiment collection periods. It is highly desirable that SPS burns and uncoupled thruster firings be avoided and that Doppler data be collected during periods of restrained crew activity (e.g., crew rest periods and eating periods). However, all experimental data collected during crew activity periods is acceptable.

The FDAI rate gyro range will be ±1 degree per second during the data collection periods.

The PM data transmission mode is required during each doppler data pass in order to provide a fully coherent carrier.

Test Requirements

FTO 1) CSM-to-ATS-6 doppler data will be collected throughout a minimum of six preselected passes of the CSM with ATS-6 coverage. It is highly desirable to increase the number of passes to include all those passes where the CSM ground tracking requirement is satisfied.

Ground tracking of the CSM by at least three different USB and/or C-Band tracking stations will be required during the time periods beginning 10 minutes preceding each ATS-6 doppler data collection pass and ending 10 minutes after the pass.

Acquisition of tracking data by the Madrid USB site is required during each pass when contact is possible. Whenever two or more USB sites are available, three-way doppler should be the tracking mode employed.

It is highly desirable that the ATSR station at Madrid track the ATS-6 for approximately five minutes just before and after each doppler pass in order to verify ATS-6 position data.

Continuous high bit rate telemetry data are required from onset of ATS-6 coverage or onset of CSM tracking by the first tracking station (whichever occurs first) to loss of ATS-6 coverage or loss of CSM tracking by the third tracking station (whichever occurs last). These data are required to determine trajectory perturbations due to RCS firings and to determine CSM attitudes and rates.

During each pass, it is preferred that the CSM be in the inertial hold attitude mode; however, the orbital rate mode is acceptable. The CSM attitude deadband will be ±5 degrees.

Table 1 lists the revolutions for the prime and supplemental data collection passes which satisfy the tracking constraints.

Table 1

Prime Revolutions

TBD

Supplemental Revolutions

TBD

Data Requirements

1) Premission Data:

None

2) Mission Data:

None

3) Postmission Evaluation Data:

a) Telemetry Measurements:

The following telemetry measurements are required throughout each MA-128 experiment period.

Measurement Number	Description	S/S
CG 0001 V	Computer Digital Data 40 Bits	50
CH 3503 R	FDAI SCS Body Rate Pitch	100
CH 3504 R	FDAI SCS Body Rate Yaw	100
CH 3505 R	FDAI SCS Body Rate Roll	100
CH 3546 X	RCS Solenoid Activate C3/13/+X	200
CH 3547 X	RCS Solenoid Activate A4/14/+X	200
CH 3548 X	RCS Solenoid Activate A3/23/-X	200
CH 3549 X	RCS Solenoid Activate C4/24/-X	200
CH 3550 X	RCS Solenoid Activate D3/25/+X	200
CH 3551 X	RCS Solenoid Activate B4/26/+X	200
CH 3552 X	RCS Solenoid Activate B3/15/-X	200
CH 3553 X	RCS Solenoid Activate D4/16/-X	200
CH 3554 X	RCS Solenoid Activate B1/11/+Z	200
CH 3555 X	RCS Solenoid Activate D2/22/+Z	200
CH 3556 X	RCS Solenoid Activate D1/21/-A	200
CH 3557 X	RCS Solenoid Activate B2/12/-Z	200
CH 3558 X	RCS Solenoid Activate A1/+Y	200
CH 3559 X	RCS Solenoid Activate C2/+Y	200
CH 3560 X	RCS Solenoid Activate C1/-Y	200
CH 3561 X	RCS Solenoid Activate A2/-Y	200
CT 9634 V	ATS-6 S-Band Receiver AGC	10
CT 9635 T	ATS-6 S-Band Receiver Base Temp	10
ST 0152 H	High Gain Ant Pos Pitch	10
ST 0153 H	High Gain Ant Pos Yaw	10
ST 0161 X	HGA Beam Width Sw Pos-Nar	10
ST 0163 X	HGA Track Sw Pos-Auto	10
ST 0164 X	HGA Track Sw Pos-Reacq	10
ST 9630 T	ATS-6 Pwr Ampl No. 1 Temp	10
ST 9631 T	ATS-6 Pwr Ampl No. 2 Temp	10
ST 9632 X	ATS-6 Pwr Ampl No. 1 ON/OFF	10
ST 9633 X	ATS-6 Pwr Ampl No. 2 ON/OFF	10

b) Telemetry Measurement Tapes:

One copy of the tapes containing the telemetry measurements listed in 3 a), correlated with CMT except that the CG 0001 V data will be in the form of decoded CMC words on a computer-compatible tape.

c) Onboard Astronaut Voice Transcript:

None

d) Astronaut Debriefings:

One copy of the astronauts' scientific debriefing transcript.

e) Trajectory:

CSM and ATS-6 ephemeris data. [Note: These data will be provided by NASA/GSFC direct to the PI.]

Background and Justification

Recent developments in the plate-tectonics hypothesis of the earth's structure has placed added emphasis on the need for information concerning the internal distribution of mass in the earth. The structure of the earth's gravity field provides one of the few clues to this mass distribution. This experiment will provide measurements of intermediate wavelength (200 to 300 km) features in the gravity field which are fundamental to advancing our understanding of plate tectonics.

Considerable knowledge of the structure of the earth's gravity field has been determined via orbital dynamics from accurate tracking of artificial satellites. However, orbital dynamics is not suitable for obtaining intermediate - or short - wavelength gravity-field features, being limited by practical reasons to gravity features with horizontal anomalies greater than 3000 km. As a rule of thumb, a density anomaly within the earth will produce a lateral variation in the external gravity field whose scale is comparable to the depth of the anomaly. Thus, the density field within the upper mantle of the earth's crust at depths of the order of 200 to 300 km will generally be reflected in horizontal variations of the gravity field with wavelengths of 200 to 300 km.

This experiment will provide data on the earth's gravity field by detecting gravity induced accelerations as evidenced by doppler frequency shifts derived from the coherent radio carrier during the ATS-6/ASTP relay mode.

Due to the fact that the orbits to be flown on ASTP are low (230 km at the maximum) earth gravity anomalies can be detected using a satellite-to-satellite link between the low orbiting spacecraft and an "Orbiting Tracking Station", in this case ATS-6. It should be noted that the ratio of increase in gravity sensitivity is about 13:1 going from GEOS-C (1000 km) type orbit to the 230 km orbit of the ASTP experiments. Gravity field resolutions in the order of 230 to 350 km will thus be obtained.

The results of this experiment will complement those of ASTP experiment MA-089, Doppler Tracking, where sensitivity to detect gravity anomalies is expected to be in the 200 to 500 km range.

Previous Mission Experiments

None

Observe and photograph earth features.

Purpose

The purpose is to make visual observations and obtain photographic data pertaining to the fields of geology, hydrology, oceanography and meteorology from earth orbit on ASTP.

The functional test objectives are:

FTO 1) While in earth orbit, the crew will make visual observations of particular earth features, processes, and phenomena.

FTO 2) The crew will obtain photographs of mapping targets of prime scientific interest, and other photographs in support of the observations defined in FTO 1.

Test Conditions

FTO 1) FTO 2) The spacecraft will be maneuvered so that the appropriate spacecraft windows are pointed toward earth.

FTO 2) Mapping targets of prime scientific interest will be photographed with a 70-mm HEDC using either a 100-mm or a 250-mm lens and TBD film. The HEDC will be bracket-mounted in the right hand side window. An intervalometer will be used. The time of opening the HEDC shutter will be provided at high bit rate via telemetry for each of the mapping targets photographed. If ATS-6 and/or STDN are not available for real time telemetry coverage, the data recorder reproducer will be used.

Photographs of observation tragets will be made with a hand-held HRC, using a 50-mm lens and a 250-mm lens with filters and TBD film.

Test Requirements

FTO 1) Visual observations and voice commentary will be made in accordance with a list of targets TBD.

Crew comments will be recorded using the onboard tape recorder except when real time voice communications with the MCC are possible.

Where appropriate, the eye will be aided by TBD-power binoculars, and the observations will be recorded by annotating onboard charts and graphics.

FTO 2) Mapping targets are as defined in Table TBD. [Note: It is anticipated that three periods, of approximately ten minutes duration each, will be required to photograph the mapping targets.]

Observation targets to be photographed are as defined in Table TBD.

Telemetry data are required for the mapping targets but are not required for the observation targets.

The specific lens, intervalometer settings and filters, if any, will be as listed in the above two tables.

Data Requirements

1) Premission Data:

None

2) Mission Data:

It is highly desirable that crew comments be provided in real time or near real time regarding potential observation targets.

3) Postmission Evaluation Data:

a) Telemetry Measurements:

Measurement Number	Description	S/S
CK 1043 X	70-mm Camera Shutter Open	100

b) Telemetry Measurement Tapes:

None

c) Two copies of the onboard astronaut voice transcript as described in FTO 1.

d) Astronaut Debriefing:

Two copies of the postmission scientific and photographic debriefing.

e) Trajectory and Special Data:

A computer-compatible tape containing refined CSM ephemeris to a 3 sigma accuracy of 600 m, CSM attitude to an accuracy of 0.2 degree and time correlated to 50 msec. Sun angle, altitude, subvehicle latitude and longitude, center of frame exposure and field of view, and a tab listing of the measurements in 3 a) for the period when the mapping photographs were obtained must be provided.

f) TBD copies of all 70-mm photographs of the targets as described in FTO 2.

g) TBD copies of all HRC photographs of the targets as described in FTO 2.

h) Two copies of astronaut logs or voice records containing comments related to both the visual observations and the photographic periods.

Background and Justification

The value of astronaut observations from orbit was established on the Apollo program in the case of the moon, and on the Skylab program in the case of the earth. The human eye's extensive dynamic range and color sensitivity, and the observer's vantage point in space offers the opportunity to discover new phenomena of interest and to view old phenomena in a new light. Visual observations will complement photographs as an aid to better regional mapping, understanding, and characterization of earth's features, processes, and phenomena.

The ASTP mission offers the first opportunity to reexamine selected features of interest from Skylab earth observations and to view these features from a different altitude and two years later in time. The results of this investigation are expected to further establish the value of such observations as a routine objective on operational Space Shuttle flights.

The types of features to be considered in this investigation include the following subjects:

Geology: A study will be made of major active strike-slip fault zones in the eastern and western hemispheres. Extensions of the fault systems may be discovered by studying vegetation or drainage patterns.

Hydrology: A study will be made of closed basin water circulation and shore lines, and application thereof to hydrological problems; e.g., the Great Salt Lake, and the Black Sea. Snow cover studies based on photographs taken of the Himalayas, and hydrological studies based on photographs taken of the plains of India and land areas inundated by rivers are of special importance.

Oceanography: A study will be made of ocean upwellings and their hydrological and biological effects; of major trends of ocean currents and applications to such things as trade, shipping, and fishing; and of near shore environments and the extent of water pollution.

Meteorology: A visual investigation will be made of topical weather

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problems such as frontal waves, tornadoes, storm centers, and localized atmospheric circulation.

Previous Mission Experience

- Handheld Photography and Visual Observations from the Command Module - Apollo 7 through 17
- Visual Observations and Photography - Skylab SL-2, SL-3, SL-4

MA-147 ZONE-FORMING FUNGI

Observe and photograph zone-forming fungi growth patterns.

Purpose

The purpose is to determine the effect of the complex of space flight factors on zone-forming fungi.

The functional test objective is:

FTO 1) Photograph specimens of zone-forming fungi periodically during flight.

Test Conditions

FTO 1) The test containers (Rhythm 1 devices) will be installed in the spacecraft no more than 48 hours prior to launch.

Two containers, each containing two Petri dishes inoculated with zone-forming fungi, will be located in the LEB wall to the right of panels 120 and 121 in the CM. Two identical containers will also be placed in the Soyuz.

Cabin interior lighting must be on during all photography periods.

Test Requirements

FTO 1) One photograph of each of the two Petri dish containers (with two Petri dishes per container) in the CM will be made every 12 ± 3 hours for the duration of the mission. Thus approximately 40 photographs will be obtained using a 35-mm Nikon camera, a 35-mm lens and color interior film (type SO-168) at a distance of approximately 12 inches. The cosmonauts will also photograph the two containers in the Soyuz.

The crew will exchange experiment containers (one each from the Apollo and the Soyuz) during the first visit of the astronauts to the Soyuz spacecraft.

Data Requirements

1) Premission Data:

None

2) Mission Data:

None

3) Postmission Data:

a) Telemetry Measurements:

None

b) Telemetry Measurement Tapes:

None

c) Onboard Astronaut Voice Transcript:

Annotated voice tape or astronaut log

d) Astronaut Debriefings:

None

e) Trajectory:

None

f) Two Rhythm 1 devices in the CM and two Rhythm 1 devices in the Soyuz

g) TBD copies of approximately 40 frames of 35-mm film

MA-147 ZONE-FORMING FUNGI

Background and Justification

The ASTP flight offers the first opportunity to study the effect of the complex space flight factors on the synchronized zone-forming rhythms of fungus cultures. This will provide information on the effect of circadian rhythms, with a half-phase shift by starting at different points on the earth (in the USSR and USA). Another objective is to determine the effect of local radiation factors (heavy particles and high energy andrones) on zone forming rhythm, growth assymmetry, and regions of zone breaks. In addition to comparing the space flown specimens with the control specimens on the ground, selected spores from the space flown specimens will be cultured. The zone forming characteristics of the secondary fungal cultures of space specimens will be compared with secondary cultures of the control specimens.

The Puschino strain of Actinomyces levoris Kzas (group Globisporus) is used as the object of this study. By using the correct nutritional medium and the proper period of light-dark conditions, any desired zone forming rhythm may be imposed. As part of the experiment, zone-forming rhythms will be synchronized with the circadian rhythms in the USSR and USA (with the half-phase shift). These cultures will be placed in the Apollo and Soyuz spacecraft where they will remain during the flight. During the flight, they will be photographed periodically, and one container from each of spacecraft will be exchanged during the docked portion of the flight.

Previous Mission Experiments

None

MA-148

ARTIFICIAL SOLAR ECLIPSE

Test new methods of studying solar corona and contamination surrounding a spacecraft.

Purpose

The purpose is to observe the 1975 solar corona and the spacecraft induced environment around the Apollo spacecraft in order to determine the coronal structure for distances as great as possible from the solar disk. An attempt will be made to correlate the coronal results with the disk activity observed simultaneously with ground-based observations.

The functional test objectives are:

FTO 1) Photograph the solar corona in order to obtain its relative photometric characteristics in the 1975 timeframe.

DTO 2) Determine the effects of spacecraft-associated environment on the measurements of FTO 1.

Test Conditions

FTO 1) FTO 2) Prior to undocking, the CSM control system will be utilized to place the spacecraft $-X_{D6}$ axis towards the sun.

The undocking of the two spacecraft will be made approximately one minute after sunrise.

At the moment of undocking, the Z_{A4} axis and the $-Y_{C5}$ axis will be in the plane defined by the spacecraft, the earth and the sun, and will be oriented toward the earth. The necessary accuracy of the docked Apollo/Soyuz orientation will be no greater than ± 0.7 degrees in pitch and yaw, and ± 1.0 degree in roll.

After undocking, both spacecraft will be in inertial stabilization mode. (The Soyuz inertial stabilization mode will be started when the Apollo commander states that undocking is complete.)

The separation rate of the two spacecraft will be approximately one meter per second.

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MA-148

Test Requirements

FTO 1) FTO 2) Photographs of the solar corona will be obtained from the Soyuz for approximately five minutes, although occultation of the sun by the CSM is expected to cease at a considerably earlier time. Experiment support photography from the CM will also continue for approximately five minutes for post-flight analysis of Soyuz shadow conditions. A DAC will be used in the CM to obtain photographs of the Soyuz at two frames per second using color exterior film (type SO-368) and a 75-mm lens.

Data Requirements

1) Premission Data:

None

2) Mission Data:

None

3) Postmission Evaluation Data:

None

a) Telemetry Measurements:

None

b) Telemetry Measurement Tapes:

None

c) Onboard astronaut voice transcript of experiment period to include time of undocking and time of starting the DAC

d) Astronaut Debriefing:

None

e) Trajectory:

None

f) Two copies of approximately 15 feet of motion picture film taken of the Soyuz during the experiment

MA-148 ARTIFICIAL SOLAR ECLIPSE

Background and Justification

The Apollo-Soyuz flight provides an opportunity to observe the solar corona in the 1975 time frame and the spacecraft induced environment around the Apollo spacecraft. The use of Apollo to provide occultation of the sun for the Soyuz spacecraft (providing an artificial solar eclipse) will provide an opportunity to photograph the coronal structure, possibly to substantial angular distances from the solar disk.

In addition to registering the general pattern and obtaining photometric characteristics of the outer corona of the sun, data can be obtained pertaining to the environment around the spacecraft arising from outgassing of sealed compartments, degassing and sublimation of outer structure materials, and attitude control thruster burns.

Previous Mission Experiments

Experiment Number	Title	Mission
S052	White Light Coronagraph	Skylab SL-2, SL-3, SL-4

5.0 INFLIGHT DEMONSTRATIONS

Inflight demonstrations have been approved in concept for the following:

1. Gyroscopic motion
2. Magnetic forces
3. Fluid dynamics

It is anticipated that inflight demonstrations in other areas will be identified and that more detail will be provided for each demonstration. The demonstrations will be planned to provide:

1. Visual phenomena, uniquely demonstrable in zero gravity, which may be of interest to the general public and therefore may be suitable for real time television coverage during the joint activities or during solo activities.
2. A number of scientific phenomena occurring in zero gravity and recorded by television for use in making educational films for classrooms.

The JSC point of contact for the requirements of the inflight demonstrations is J. P. Allen/CB.

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6.0 TELEVISION

6.1 GENERAL

The goals and objectives of television, in order of priority, are as follows:

(1) To provide a highly visible demonstration of international cooperation with maximum real-time news coverage to the networks of this unique international news event.

(2) To obtain real-time information for evaluation and analysis purposes to assist in resolution of anomalies arising during the conduct of the mission.

(3) To record events for historical purposes.

• Television requirements have high priority and a maximum effort will be made to adjust mission timeline events, for which television coverage is desired, to occur where ground station or ATS-6 coverage is available.

The JSC points of contact for television programming are Capt. E. A. Cernan/PA and B. W. James/AP2.

6.2 EQUIPMENT SUMMARY

The Apollo hardware capability will include the following:

(1) Four color cameras
(2) Five television locations (two in the CM, two in the DM and one in the Soyuz)
(3) Ground control capability of selection of the video source, but with an onboard override
(4) ATS-6 is to provide the primary air-to-ground interface for approximately 55 minutes per revolution
(5) STDN coverage is to be provided via five ground stations
(6) One onboard video tape recorder with a 30-minute recording capability
(7) Onboard monitors for use with the four color cameras
(8) Miscellaneous items such as cue lights and a master synchronizer

6.3 TELECAST SCENES

Activities to be televised from the Apollo spacecraft include the following scenes:

(1) Launch
(2) CSM transposition, docking and extraction of the DM
(3) DM checkout
(4) Final approach during rendezvous
(5) Stationkeeping
(6) Docking
(7) Intervehicular crew-transfers and joint activities
(8) Undocking and docking tests
(9) Undocked experiments
(10) Separation

It is anticipated that requirements for other scenes will be identified. In addition, more detail will be provided relative to the specific requirements for each scene.

It is anticipated that television of the Soyuz and Apollo launches will be exchanged between the USA and USSR.

Television of control center activities during the mission will be exchanged.

All Apollo television, and all Soyuz television which is retransmitted to the USA, will be released to the news media immediately.

7.0 PHOTOGRAPHIC REQUIREMENTS

7.1 EXPERIMENTS

The photographic requirements for each of the inflight experiments to be performed by the astronauts are in Section 4.0 of this document. The photographic equipment in support of these experiments is included in Table 7-1.

7-2 DOCUMENTARY

Documentary motion pictures and still photographs are required for release to the general public. The following summary of inflight scenes is under consideration. After agreement is reached with the USSR, additional details will be provided.

All documentary motion picture photography will be at 24 frames per second.

The photographic equipment to be used by the astronauts in support of the documentary requirements is included in Table 7-1.

The JSC point of contact for documentary photography is D. K. Ward/ AP3.

Summary of Documentary Scenes

Scene No.	Description
1	CSM transposition, docking and extraction of the DM
2	General view of Soyuz from TBD distance until docking
3	Transfer of astronauts into Soyuz - in Docking Module - in Soyuz
4	Tour of Soyuz, various views inside the Orbital Module and the Descent Vehicle
5	Joint dinner in Soyuz Orbital Module
6	Joint activities in Soyuz
7	Astronaut return to Command Module
8	Cosmonaut transfer into Apollo - in Orbital Module - in Docking Module - in Command Module

Summary of Documentary Scenes (Continued)

Scene No.	Description
9	Tour of Command Module
10	Joint activities in Apollo
11	Cosmonaut return to Soyuz - in Command Module - in Docking Module
12	Tour of Docking Module
13	General view of Apollo after undocking
14	General view of Soyuz after undocking
15	DM jettison
16	Miscellaneous out-of-window photographs from CM

Table 7-1. Summary of Photographic Equipment Allocation

Experiment	Camera (Note 1)	Film Type (Note 2)	Film Quantity (Note 3)	Lens	Remarks
AR-002	None	N/A	N/A	N/A	
MA-007	DAC	IR	1 magazine	75-mm	
MA-007	35	CIN	6 frames	35-mm	Note 4
MA-010	None	N/A	N/A	N/A	
MA-011	HEDC	BW	1 magazine	80-mm	
MA-014	None	N/A	N/A	N/A	
MA-017	None	N/A	N/A	N/A	
MA-028	35	CIN	60 frames	35-mm	Note 4
MA-048	None	N/A	N/A	N/A	
MA-059	None	N/A	N/A	N/A	
MA-083	None	N/A	N/A	N/A	
MA-088	None	N/A	N/A	N/A	
MA-089	DAC	CEX	15 feet	18-mm	Note 5
MA-106	None	N/A	N/A	N/A	
MA-107	None	N/A	N/A	N/A	
MA-128	None	N/A	N/A	N/A	
MA-136	HEDC	TBD	2 magazines	100 and 250-mm	
MA-136	HRC	TBD	5 magazines	50 and 250-mm	
MA-147	35	CIN	40 frames	35-mm	Note 4
MA-148	DAC	CEX	15 feet	18-mm	Note 5

Table 7-1. Summary of Photographic Equipment Allocation (Continued)

Documentary Scene No.	Apollo Camera (Note 1)	Film Type (Note 2)	Film Quantity (Note 3)	Lens	Remarks
1	DAC	CEX	TBD (Note 6)	TBD	
2	TBD	CEX	TBD (Note 6)	TBD	
3	TBD	CIN	TBD (Note 6)	TBD	Soyuz cameras to be used in Soyuz.
4	TBD	CIN	TBD (Note 6)	TBD	Soyuz cameras also to be used in Soyuz OM and DV.
5	None	N/A	N/A	N/A	Soyuz cameras to be used in Soyuz OM.
6	TBD	CIN	TBD (Note 6)	TBD	Soyuz cameras may also be used.
7	TBD	CIN	TBD (Note 6)	TBD	Soyuz cameras also to be used.
8	TBD	CIN	TBD (Note 6)	TBD	Soyuz cameras to be used in OM.
9	TBD	CIN	TBD (Note 6)	TBD	
10	DAC	CIN	TBD (Note 6)	TBD	Three DAC magazines of CIN film will be dedicated for use by the cosmonauts.
10	35	CIN	TBD (Note 6)	35	
11	TBD	CIN	TBD (Note 6)	TBD	Soyuz cameras may also be used in DM.
12	TBD	CIN	TBD (Note 6)	TBD	
13	None	N/A	N/A	N/A	Soyuz camera to be used.
14	DAC	CEX	TBD (Note 6)	TBD	
15	DAC	CEX	TBD (Note 6)	TBD	
16	HRC	CEX	1 magazine	50-mm	

Table 7-1. Summary of Photography Equipment Allocation (Continued)

Note 1: Camera Nomenclature

DAC - 16-mm data acquisition camera
35 - 35-mm Nikon camera
HRC - 70-mm Hasselblad reflex camera (without reseau plate)
HEDC - 70-mm Hasselblad electric data camera (with reseau plate)

Note 2: Film Nomenclature

BW - Black and white (3401)
CEX - Color exterior (SO-368)
CIN - Color interior (SO-168) (ASA 500)
IR - Infrared (Type TBD)
LBW - Low speed, high definition black and white (3414)

Note 3: For planning purposes, a DAC film magazine has approximately 140 feet of usable film. A 35-mm Nikon camera film cassette has approximately 70 usable frames. A HEDC film magazine has approximately 160 usable color frames or approximately 170 usable black and white frames. A HRC film magazine has approximately 140 usable color frames.

Note 4: Two 35-mm Nikon film cassettes are available. Since MA-007, MA-028 and MA-147 require a total of only 106 frames, 34 frames remain to be allocated.

Note 5: One 140-foot DAC magazine with CEX film is available. Since MA-089 and MA-148 require a total of only 30 feet of film, approximately 110 feet of DAC CEX film remains to be allocated.

Note 6: A total of four magazines of DAC CEX film, eight magazines of DAC CIN film, and seven cassettes of 35-mm CIN film are available to the astronauts for these documentary scenes. In addition, three magazines of DAC CIN film are dedicated for use by the cosmonauts for documentary scene No. 10.

8.0 CONTINGENCY AND BACKUP MISSIONS

8.1 CONTINGENCY MISSIONS

If an anomaly occurs after liftoff which would preclude intervehicular crew-transfer, all remaining portions of the nominal mission will be accomplished, where feasible, to include spacecraft docking and undocking.

If an anomaly occurs after liftoff which would preclude Apollo/Soyuz docking, all remaining portions of the nominal mission will be accomplished, where feasible, to include rendezvous.

If an anomaly occurs after liftoff which would preclude rendezvous, all remaining portions of the nominal mission will be accomplished, where feasible.

Details of the agreements between the USA and USSR, related to the joint activities of the above contingency missions, are included in joint USA/USSR document ASTP 40500 , Contingency Plan (Reference 5 - to be published).

8.2 BACKUP MISSION

In case CSM-111 becomes unavailable to perform the primary objectives of the mission, a backup mission will be accomplished using CSM-119, DM-1, and DM/CM experiment backup hardware. No provisions will be made, however, for a backup ATS-6 capability, for augmented TV capability or for SM experiments.

The flight experiments to be included in the backup mission are as follows:

AR-002	Microbial Exchange
MA-007	Stratospheric Aerosol Measurement
MA-010	Multipurpose Furnace
MA-011	Electrophoresis Technology
MA-014	Electrophoresis - German
MA-028	Crystal Growth
MA-059	UV Absorption

MA-106	Light Flash
MA-107	Biostack
MA-136	Earth Observations and Photography
MA-147	Zone-Forming Fungi
MA-148	Artificial Solar Eclipse

REFERENCES

1. OMSF unnumbered document, Mission Implementation Plan for the ASTP Mission, April 8, 1974, as amended.

2. JSC document MSC-07765, Apollo/Soyuz Test Project, Operational Data Book, Volume I - CSM/DM Data Book, Part I - Constraints and Performances.

3. JSC document JSC-08679, Internal Note No. 74-FM-3, Apollo-Soyuz Test Project Preliminary Reference Trajectory, January 14, 1974.

4. Joint USA/USSR document ASTP 40100, Launch Window Plan.

5. Joint USA/USSR document ASTP 40500, Contingency Plan (to be published).

6. JSC document MSC-96823, Internal Note No. 72-FM-116, The RTCC Star Catalogue for Skylab, May 4, 1972.